BS EN 3197:2010

BSI Standards Publication

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

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National foreword

This British Standard is the UK implementation of EN 3197:2010.

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A list of organizations represented on this committee can be obtained on request to its secretary.

This publication does not purport to include all the necessary provisions of a contract. Users are responsible for its correct application.

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

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

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

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

CEN members are bound to comply with the CEN/CENELEC Internal Regulations which stipulate the conditions for giving this European Standard the status of a national standard without any alteration. Up-to-date lists and bibliographical references concerning such national standards may be obtained on application to the CEN-CENELEC Management Centre or to any CEN member.

This European Standard exists in three official versions (English, French, German). A version in any other language made by translation under the responsibility of a CEN member into its own language and notified to the CEN-CENELEC Management Centre has the same status as the official versions.

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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of an identical text or by endorsement, at the latest by June 2011, and conflicting national standards shall be withdrawn at the latest by June 2011.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.

5.11 Materials considerations

5.11.1 General

As a minimum, the selection of EWIS and OFIS materials shall take into account requirements of rule 25.603.

5.11.2 Environmental Directives

Directives, such as EU (RoHS-REACH), relative to electrical components or equipments evolved and call from now for the prohibition of the use of substances considered to be hazardous, such as lead, cadmium, mercury and hexavalent chromium, contained in these components or equipments. For particular cases where no substitutive solution exists, derogation shall be obtained from the authorities.

Some technical reports apply to the aerospace and defence industries and their supply chains:

TR 9535, *Aerospace series — Substance declaration*

TR 9536, *Aerospace series — Declarable Substances Recommended Practice*

5.11.3 Metals

The metals used shall be corrosion-resistant or suitably protected for resistance to corrosion throughout the expected service-life. The maximum potential difference between any two metals in mutual contact should be 300 mV to minimize the risk of electrolytic corrosion unless the junction shall be protected to avoid electrolyte presence. See Annex C for potential differences between common metals.

5.11.4 Non-metals

All non-metals used, including plastics, fabrics and protective finishes, shall not support micro-organic or fungus growth, and should not be adversely affected by weathering, applicable fluids, temperature and ambient conditions encountered while the aircraft is in service.

So as to avoid any hazards to the occupants, they shall:

— meet the relevant flammability requirements of the Design Authority,

— not emit, when burning, a smoke density higher than a specified limit,

— not emit toxic gases with a concentration exceeding specified values.

Cable insulation and protective parts using PVC (Polyvinyl chloride) are absolutely prohibited.

Polyamide materials can be used for cable ties and fitting parts.

Attention is brought on some fluoro-elastomers for which decomposition residus, after fire for example, can be hazardous.

Wire insulation shall have an arc resistance capability as defined in their own standard.

5.12 Quality

5.12.1 Components Qualification

EWIS and OFIS components shall be qualified for airborne use or specifically assessed as acceptable for the intended use and be appropriate for the environment in which they are installed, through for example the ASD Quality management systems and Qualification Procedures defined in EN 9133.

Aircraft manufacturers list approved components in their manuals, such as the standard wiring practices manual (ATA Chapter 20). Only the components listed in the applicable manual or approved substitutes should be used for the maintenance, repair, or modification of the aircraft. EWIS and OFIS modifications to the original type design should be designed and installed to the same standards used by the original aircraft manufacturer or other equivalent standards acceptable to the Authorities. This is because the manufacturer's technical choice of an EWIS and OFIS component is not always driven by regulatory requirements alone. In some cases specific technical constraints would result in the choice of a component that exceeds the minimum level required by the regulations.

5.12.2 Processes Qualification

All processes, used for production shall be qualified for airborne use or specifically assessed as acceptable for the intended use, when available through European Standards such as example EN 2812 for stripping of electric cables or EN 2242 for crimping of electric contacts.

During maintenance, repair or modification, processes must come from the same standards used by the original aircraft manufacturer or from other equivalent standards acceptable to the Authorities.

Some particular processes may required qualified operators and this qualification shall be periodically re-validated.

5.12.3 Test Methods

Test methods used for qualification, validation, expertise, technical comparison should come from recognized standards and particularly when available from European standards such as examples EN 2591, EN 3475…

(See list of existing standards in Annex B).

5.13 Specific Requirements

5.13.1 Advice

In this particular chapter, only requirements specific to power plants, helicopters and light planes are highlighted. All other requirements are in accordance with this standard.

5.13.2 Power plant

5.13.2.1 General

Engines have no pressurized zones, but normally operate below an altitude of 50 000 feet for civil aircraft or 100 000 feet for military aircraft.

Engines are generally equipped with several harnesses which can be removed separately and are considered as equipment. Generally there is no need for functional identification on individual wire or cable.

5.13.2.2 Connectors

a) Selection

Sealed version of connectors and connecting devices are required.

b) Sealing

Contacts shall be fitted in all cavities. All cavities in the rear grommet shall be filled with either a wire, a filler plug or a wire stub.

c) Mechanical locking

Plugs shall have a self locking device.

Wire locking of coupling nuts is not recommended.

5.13.2.3 Wiring and fastening

a) Minimum bend radius recommended

For solid harness (when cables are strongly clamped together) and interconnection harnesses, minimum bend radius recommended are:

— 5 times to 10 times the diameter of assembly depending on harness technology

— 10 times the diameter of the largest cable contained in the bundle.

For particular dynamic installations and design, the minimum bend radius shall be 3 times or 6 times the bundle during the sequence. (open Nacelle door, pylon / nacelle liaison).

Except with permanent relatives movements

b) Harness clamps

The use of plastic cable ties with internal metallic locking serrations can be used on engine harness bundles when metallic braids or heat-shrinkable sleeves are covering the cables.

Generally harnesses shall be fixed on engine either together or individually using “P” clamps. Broomhandle (“W” clips / omega / terry clips) may be used for straight harness runs.

5.13.2.4 Installation

Harnesses should be installed so that they can be removed and refitted without the need to remove other engine components, such as brackets, pipes etc.

When a harness crosses butting flanges in hot area of engine main casings, sufficient care shall be brought such that no possible hot gas leakage can damage cable insulation.

The harness shall not be routed parallel to and on top of engine main flanges junction where a hot gas leakage may destroy the cable insulation.

Consideration shall be given to the following when deciding a cable route:

a) Avoidance of, or protection from, damage during engine installation and maintenance.

b) Avoidance of areas where crash-landing damage would constitute a hazard.

c) Accessibility for maintenance testing, inspection and repair.

d) Avoidance of any position and/or shape which would encourage the use of the harness for handholds or footrests.

e) Common mode failure of duplicated functions.

f) Minimise physical damage that may result from fire, turbine burst, starter burst, duct burst or fluid contamination

g) Failure Mode Effect Analysis (FMEA) on signal separation.

h) Removal of harness without disturbance to another system that would necessitate a re-test to that system.

i) Removal of LRU accessories with minimal harness disturbance.

j) Relative movement between connectors/terminations and fixed points, such as clipping points, terminal blocks etc.

In the area of fan blade-out containment, special attention shall be taken for the minimum clearance in order to avoid any hazardous damage.

The connections to accessories which are mounted on vibration isolators shall be carefully considered. The clipping and harness shall not add loads to the installed accessory outside of defined limits. The accessory manufacturer shall take into account the connecting hardware (harness and associated clipping) and its spring rate for the requirements of the anti-vibration system.

5.13.2.5 Separation

On dual channel, electronically controlled engines, harnesses for the two separate channels shall be allocated to different connectors and the separation shall comply with the following:

a) Whenever possible, the maximum lane separation shall be maintained for the entire harness run.

b) For civil extended twin operations (ETOPS), a lane to lane separation shall be maintained in those areas designated "cross-engine debris areas", where uncontained debris from one engine can impact the remaining engine.

c) Lane to lane Separation may be relaxed outside "cross engine debris areas" providing there is no risk of common mode failure. The minimum segregation distance allowed shall be conform to airworthiness requirements and should be quoted in the relevant specification. If the requirement of the relevant specification is not achievable due to space restraints, agreement shall be obtained from the relevant authority.

In order to minimise the transmission of radio frequency interference from the High Energy (HE) igniter leads to the engine harness, cables shall not be run parallel with the HE leads closer than 100 mm (4.00 ins). Where cables have to cross HE leads this shall be done as near 90° as possible with a minimum air gap of 10 mm (.39 ins). If the above two conditions cannot be met, then a HF shield shall be interposed between the HE lead and the cable or the HE-leads shall be shielded.

5.13.3 Helicopters

5.13.3.1 General

Helicopters have no pressurized zones, but the operative flight altitude remains under 20 000 Feet.

5.13.3.2 Connectors

a) Selection

Sealed version of connectors and connecting devices with interfacial seal are preferred.

b) Sealing

Unused cavities of sealed connectors shall be sealed at the rear grommet side to maintain the interfacial seal efficiency.

c) Polarization

The polarization master key should be situated on top of receptacle (front view of equipment).

The electrical connectors shall be angularly indexed especially when elbowed rear connector accessory is used.

5.13.3.3 Wiring and fastening

The sentences “Wires should not be routed between aircraft skin and fuel lines. Avoid running wires along the bottom of the fuselage, over the landing” from Subclause 8.3.4 is not applicable for helicopters.

Lane to lane separation for the same engine of the Subclause 5.13.2.5 is not applicable for helicopters, but for different engines this will be applied.

Following Subclauses do not apply for helicopters:

— For Subclause 8.13.4, the examples for routing classes are not applicable for helicopters due to space limitation. EMC-separation is not required when the interference impact is permitted by the design.

— Subclause 8.13.6 is not applicable for helicopters.

— The Subclause 9.3.4 is not applicable for helicopters.

— The Subclause 9.13 is not applicable for helicopters.

— Critical system fuel of Subclause 7.5.1 is not applicable for helicopters, as no wires cross the tanks.

5.13.4 Light aircraft

Reserved

5.13.5 APU

See Subclause 5.13.2.

5.13.6 Composite structure

5.13.6.1 Electrical implication

Metallic fuselage inherently handles the following functions:

1- Signal and Power Current Return (Grounding)
2- Fault Current Return Path (Bonding)
3- Signal Electrical Reference (Low Impedance Ground Plane)
4- Lightning Protection: Systems, Structure, Passengers, ...
5- Electro-Magnetic Field Protection (HIRF)
6- Antenna Ground Plane

If a composite structure with carbon inside can ensure functions 5 and 6, function 4 use at least for the introduction of “metal”, such as expanded foil, inside the structure and the three remaining ask for the implementation of a single reference metallic network, today called for example ESN (Electrical Structure Network) or MBN (Metallic Bonding Network).

5.13.6.2 Thermal implication

Thermal characteristics of composite structure are not at the same level than those of metal structure.
So particular care shall be taken to avoid:

— a current injection as a result of an abrasion between electrical bundle and conductive composite part.

— a thermal effect of a short circuit in the immediate vicinity.

Such mode failures can generate fire, smoke, smell of burning and in addition for current injection arcing and local hot spot.

5.13.6.3 Installation considerations

From implications described before, at least the following requirements should be applied:

— routings of cables or harnesses should be defined so as to take advantage of the protection given by surrounding metallic structures.

— any contact between cables/harnesses and or carbon fibre-composite panels/structure/surface, conductive or not, shall be prohibited. A clearance has to be provided in order to avoid any reciprocal damage.

— if this clearance cannot be maintained, an additional protection shall be provided on the harness or on the conductive composite part.

— electrostatic protection: See EN 3371.

5.13.6.4 Electrical structure network

The ESN integrity shall be maintained during the service life. For this the maintaining of the electrical resistance value between any two points of the ESN shall be guaranteed.

6 Selection of EWIS and OFIS Components

6.1 Applicable Rulemaking

As a minimum, the selection of EWIS and OFIS components shall take into account EASA Certification requirements such as example rule 25.1703 and its associated AC.

6.2 Special requirements

6.2.1 Commonality

An objective in the selection of parts shall be to maximize commonality and minimize the variety of components and related servicing tools required for the construction, installation and maintenance of the interconnection system.

6.2.2 Maintenance, repair or modification

EWIS and OFIS components shall be chosen according to requirements given in 5.12.

6.2.3 Materials

Materials used for EWIS and OFIS components shall take into account materials consideration from 5.11.

6.3 Wire and Fibre Optic cable Selection

6.3.1 Environment

Careful attention should be applied when deciding on the type of wire needed for a specific application. Consideration should be given whether the construction of the wires and cables are suitable for the application environment. For each installation select wire construction type suitable for the most severe environment likely to be encountered in service. As examples, use a wire type that is suitable for flexing for installations involving movement; use a wire type that has a high temperature rating for higher temperature installations.

When considering the acceptability of wire refer to the industry standards defining acceptable test methods for aircraft wire (e.g. EN 3475/EN 3745 or alternative manufacturer standards).

Wires in systems that must operate during and after a fire, such as fire detection, fire extinguishing, fuel shutoff, and fly-by-wire flight control, must be selected from wire types qualified to provide circuit integrity after exposure to fire for a specified period.

In addition to the necessary flammability requirement of EN 3475-407 (self-extinguishing test), the selection of electrical and optical cables must take into account known characteristics in relation to particular installation and application so as to minimize the risk of cable damage including any arc-tracking phenomena.

For use in pressurized zones, smoke and toxicity characteristics of the insulation must be taken into account.

Wire shall be selected so that the rated maximum temperature is not exceeded for any combination of electrical loading, ambient temperature, and heating effects of bundles, conduit and other enclosures. Typical factors to be considered in the selection are voltage, current, ambient temperature, mechanical strength, abrasion, flexure and pressure altitude requirements, and extreme environments such as Severe Wind and Moisture Problem (SWAMP) areas or locations susceptible to significant fluid concentrations.

Different wire types installed in the same bundle should withstand the wire-to-wire abrasion to which they will be subjected. Consideration should be given to the types of insulation mixed within wire bundles, especially if mixing a hard insulation type with a relatively softer type, and particularly when relative motion could occur between the wires. Such relative motion between varying wire insulation types could lead to accelerated abrasion and subsequent wire failure.

The marking process used to add a “Function Identification Number” must take into account the thickness and the notch propagation characteristic of the insulation or outer jacket. The process used to apply user marking to the insulation or outer jacket shall not degrade the insulation or outer jacket (see 9.6.2).

6.3.2 Type of Cable

The type of electrical and optical cable used should meet the requirements of the relevant ISO standard or European standard aerospace series.

The type of cable selected will depend upon the application. For existing European Standards, see B.2 of Annex B.

The various types of cable by application shall be as described in 6.3.5 to 6.3.12.

6.3.3 Construction

6.3.3.1 Conductors

6.3.3.1.1 General

For equipment cables, the conductors shall be copper, including size 002 (24 AWG) and smaller.

For airframe cables the conductors shall be copper, copper clad aluminum or aluminium. Size 002 (24 AWG) and Size 001 (26 AWG) shall be a high-strength or reinforced construction.

For feeder cables, the conductors shall be copper or aluminium or copper clad aluminium.

Fire-proof and fire-resistant cables, such as in EN 2346, shall have nickel clad copper alloy conductors throughout all the applicable sizes.

The construction of copper and copper alloy conductors shall be as defined in EN 2083 or EN 4434.

The construction of aluminium conductors shall be as defined in EN 3719.

The construction of copper clad aluminium conductors shall be as defined in EN 4651.

Aluminum and copper clad aluminium conductors need specific connection devices and the use of size 20 and smaller sizes should be restricted in high vibration areas. Aluminium material has less flexibility and a reduced flexible endurance compared to copper material.

Small size aluminium cable shall not be attached to engine mounted accessories or installed in other areas of severe vibration or flexin.

6.3.3.1.2 Conductor platings

Various platings are used on the copper and copper alloy conductors to improve corrosion resistance and the electrical resistance of terminations.

The platings can themselves limit the conductor operating temperature but although these maximum continuous operating temperatures are given below, it shall be understood that they may be further reduced by the type of insulating material used:

a) tinplate: maximum temperature of 135 °C;

b) silverplate: up to a continuous temperature of 200 °C (see 5.7 regarding proximity of ethylene glycol);

c) nickel plate: up to a continuous temperature of 260 °C;

d) nickel cladding: up to 315 °C;

e) thermocouple: up to 315 °C.

Aluminium or aluminium alloy cable conductors, without plating, shall be limited to 150 °C.

Silver or nickel plated aluminium or copper clad aluminium cable conductors shall be limited to 180 °C.

Copper clad aluminium and aluminium conductors shall only be used when the termination method incorporates environmental sealing, due to the possibiity of corrosion caused by dissimilar metals (see 5.11.2 and Annex C).

6.3.3.2 Insulating materials

The insulation of electrical cables shall be suitable for the applications for which they are designed and may consist of one or more layers or coatings. Addition of a special sheath is sometime necessary for particular purpose.

The dielectric is that part of the insulating material surrounding the conductor and provides the essential electrical characteristics of the cables. The sheath is an integral part of the insulation applied as a protective covering over the whole cable. It may be of a different material from the dielectric to improve the mechanical and/or fluid-resistant properties and may be used to identify the cables.

OPTICAL CABLES

The jacket of optical fibre cables shall be coloured to differentiate from electrical cables. The coatings of an optical fibre are single or multiple polymeric layers which are added to prevent mechanical damage to the fibre. In an optical fibre cable a strength member could be wound between the core cladding and the jacket to provide additional strength.

6.3.3.3 Screen

Braided screens give normally 85 % minimum optical coverage, unless otherwise specified in the relevant product standard. Spiral screens give normally 90 % minimum optical coverage, unless otherwise specified in the relevant product standard.

Particular screen construction, such as double braids, special tape, may be used to obtain necessary surface transfer impedance (Zt).

For screen platings refer to 6.3.3.1.2

6.3.3.4 Jacket

The outer jacket of electrical cables shall be suitable for the applications for which they are designed and may consist of one or more specific materials or coatings.

The jacket may be used for facilitation of marking, environmental or mechanical protection, electrical insulation of screen or colour coding.

6.3.4 Current rating

EN 2853 gives directives for the continuous current in each electrical cable.

This does not justify disregarding other requirements for the selection of cables (see 6.5.2.4 Rating choice).

6.3.5 Equipment Cable

These cables are designed for use within equipment or in areas where total protection from mechanical abuse is ensured.

6.3.6 Airframe Cable

These cables are of sufficiently robust construction to satisfy the requirements for open aircraft cabling and cabling in engine compartments.

6.3.7 Fireproof and fire resistant Cable

These cables shall always be of the "airframe" type with the additional requirement that they continue to operate, at a reduced performance level, for a period during fire as defined in ISO 2685 (fireproof 15 mn. and fire resistant 5 mn.).

6.3.8 Coaxial Cable

These radio-frequency cables are used to connect high frequency circuits. Various types are available according to the operating frequency of the circuit, e.g. VHF, UHF, etc.

6.3.9 Data Bus Cable

These data bus cables are used in the interconnecting of data transmission systems.

They can be of twin or quadrax construction.

6.3.10 Thermocouple or extension Cable

These cables are used for interconnecting temperature measuring systems.

6.3.11 Optical fibre Cable

Fibre optic cables are used for optical signal transmission systems particularly where high bandwidth is required or as a method of achieving EMI immunity.

Where electrical and fibre optic cables are routed in the same bundle attention should be taken to ensure that:

— materials used for the outer jacketing of electrical and fibre optic cables are compatible,

— heat generated by power cables does not exceed the maximum operating temperature of the fibre optic cables.

If either of these criteria cannot be met then the fibre optic cables shall be routed separately.

For existing standards, see B.2 of Annex B.

6.3.12 Special Cable

Some particular needs call for special assembly of various types of cables. Conditions of qualification for such cables must follow requirements given in 5.12.

6.4 Connector Selection

6.4.1 Environment

Connectors are classified according to the environmental conditions in which they are to be located, taking account of materials, plating, surface finish, the design of sealing, etc.

6.4.2 Types of connectors

Various types of connectors, both circular and rectangular, shall be available. They can be sealed, unsealed or hermetic (for the receptacle only). The type selected and the method of installation shall depend on its intended function and its location and shall, where possible, be selected from relevant ISO standards or from the aerospace series of existing European Standards. For existing European Standards, see Annex B4.

6.4.2.1 Circular types

Different types of circular connectors are proposed as follows:

a) with arrangements including electrical contacts for power, signal, coaxial, twinax, triaxial, quadrax and optical contacts (termini);

b) with coupling devices (bayonet, threaded, push pull, …);

c) high temperature for engine;

d) single way coaxial; twinax, triaxial and quadrax;

e) multi way coaxial; twinax, triaxial and quadrax;

f) single optical;

g) etc.

6.4.2.2 Rectangular types

Different types of rectangular connectors are proposed as follows:

a) with arrangements including electrical contacts for power, signal, coaxial, triaxial, quadrax and optical contacts (termini);

b) rack and panel or with coupling devices;

c) modular;

d) single optical.

e) etc.

6.4.3 Construction

6.4.3.1 Housing

6.4.3.1.1 Materials

Connectors are manufactured with housings in the following materials; aluminium alloy, mild steel, stainless steel, titanium, plastic composites or composite/metallic hybrid. All these materials may have a plating or other protective surface finish, which may or may not be electrically conductive.

Factors involved in the choice of materials and/or plating shall be environmental conditions, electrolytic corrosion, temperature, vibration and Electromagnetic Interference - Electromagnetic Pulse (EMI-EMP) requirements.

6.4.3.1.2 Types

The free connector (plug) is that part of the connector assembly, which mates with the fixed or in-line connector (receptacle).

For circular connectors, receptacles can be available in the following mounting configurations:

a) square flange;

b) jam nut;

c) hermetic solder mount;

d) hermetic square flange;

e) hermetic jam nut.

For rectangular connectors, mounting configurations are associated with the use and defined in each product standard.

6.4.3.2 Inserts

6.4.3.2.1 Design

The inserts carrying the male and female contacts shall be in hard material and have a cross section and radii such that no cracks, flaking or breaks can occur in normal operation. The insert for contact shall be mechanically held in the housing. The mechanical contact retention system shall be integrated in the hard insert.

For the sealed connectors, the front face of the insert shall be such that the sealing is ensured when the connectors are coupled. The grommet shall permit sealing for all cable diameters indicated in the product standard.

Insert with cavities for removable contact shall use standard tools dedicated to the relevant connectors standard whatever the contact retaining system, for example metallic or plastic clip.

6.4.3.2.2 Material

The materials used for insert, seals and grommets shall have hardness and mechanical and electrical characteristics consistent with the required use.

6.4.3.3 Polarization of connectors

Precautions shall be taken to prevent inappropriate mating of plugs and receptacles.

Connectors shall be polarized to prevent incorrect mating of connectors with identical size shells.

Mechanical polarization by key or keyways is preferred. For circular connectors polarising by insert position is not recommended.

Rectangular connectors shall be polarized by means of their shells and / or a system of codification posts.

6.4.4 Electrical contacts

Contacts may be of the fixed type (always for hermetic connectors) or may be removable from the insert. Removable contacts may be either rear release or front release. Rear release connectors shall be preferred for new designs. Preference shall be given to contacts specified in EN 3155.

6.4.5 Optical contacts

Standard contacts shall be of the removable type and shall be keyed to prevent rotation of the contact within the connector housing in order to maintain minimum Insertion Losses. The contact design shall include a spring mechanism to provide sufficient force to the mated contacts to maintain physical contact and reduce the effects of vibration and shock causing separation of the contacts.

6.4.6 Cable outlet accessories

A range of cable outlet accessories shall be available to provide cable support, environmental sealing and continuity of screening for EMI-EMP protection etc. (EN 3660). In fibre optic connectors the cable support shall be designed to retain the strength member, while still allowing spring terminations the freedom of movement.

6.5 Circuit Protective Devices Selection

6.5.1 Type of Protective Devices

Circuit protective devices shall meet the requirements of the appropriate aerospace standard, e.g. EN standard. They shall be able to provide protection against short circuits, arc tracking and other electrical phenomena. See 5.8.

The type of protective devices will depend upon the application and particularly on the electrical distribution architecture and networks characteristics.

Various types of existing protective devices are described in 6.5.3 to 6.5.9.

For existing European Standards see B.5 of Annex B.

6.5.2 Electrical protection

6.5.2.1 General

a) Electrical cables shall be protected from overload or overheating by appropriate circuit protection devices;

b) The purpose of the circuit protection device is to protect the EWIS rather than the equipment, which shall be separately protected;

c) When selecting a protective device, the loading and protection of the circuits supplying the protective device under consideration shall be taken into account;

d) The current rating of the circuit protective devices shall be selected to protect the lowest rated element of the EWIS;

e) Increasing the current rating of any circuit protective device shall not be allowed unless the above points are taken into account;

f) To protect CB or AFCB actuating means from unintended operation, suitable protection shall be applied, e.g. safety clips.

6.5.2.2 Essential characteristics of protection devices

Protection devices shall be selected considering the following points:

Tripping time with respect to the intensity of the current;

Tripping times issued from tripping curves $t = f\,(I,\ T_{amb})$ stated in the standards or appropriate specifications. The curves give a range of tolerances required for the protective devices to open the circuit for all the possible over-intensities and for all those ambient temperatures applicable.

a) short-circuit intensity directly linked to the generator power which have to be interrupted by an inline protection devices (and not by the generator protection);

b) vibration capabilities with regard to the zones where they are installed;

c) compensation with respect to the ambient temperature for thermal CB.

In addition:

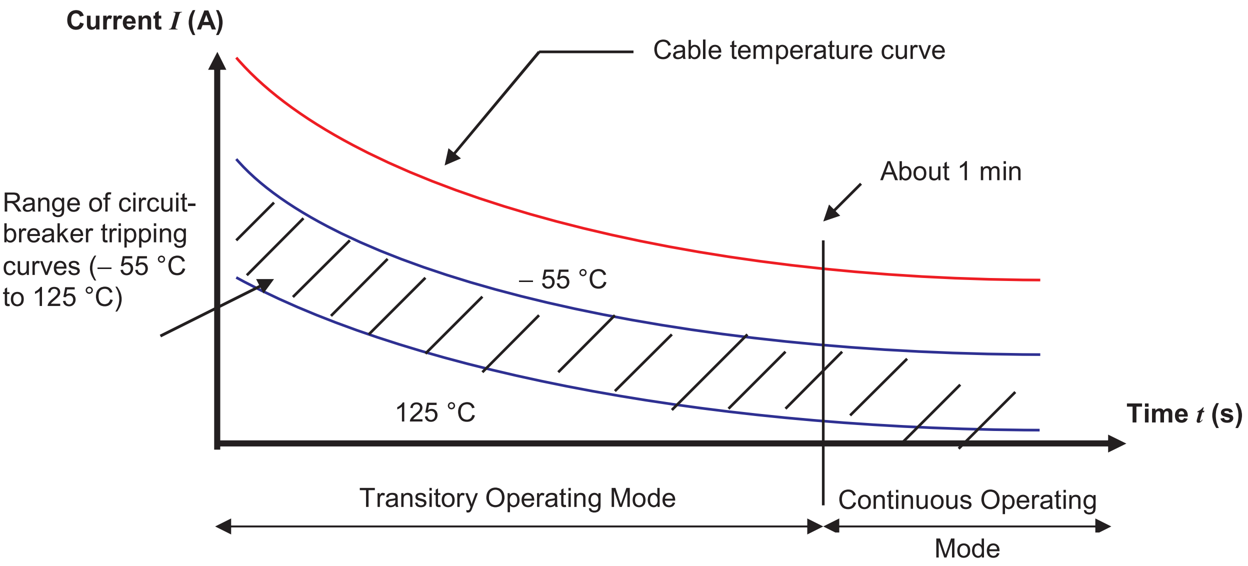
d) Any protection devices used shall be of the "trip free" type so that there is no override facility allowing a circuit overload to be maintained;

e) Any protection devices used shall be “fail safe “so that any hidden defect shall not be able to affect the expected performances;

f) For CB or AFCB, there shall be an anti-rotation spigot (or key), generally positioned on the above part of the mounting plate.

6.5.2.3 Cable/protection devices compatibility principle

The compatibility cable/protection devices is achieved when the cable temperature curve is located above the circuit-breaker threshold curve all along the time scale (transitory + continuous operating mode) as illustrated in Figure 1 below.



NOTE The cable temperature curve is obtained using the maximum possible cable temperature without degradation, for examples 300 °C for a high temperature cable or 210 °C for an aluminium cable.

Figure 1

6.5.2.4 Rating choice

6.5.2.4.1 General case

In order to avoid untimely tripping of the circuit protection device, it is recommended to choose a higher rating (for example between 15 % and 20 % higher) with respect to the nominal current (Nominal current defined with nominal voltage, for example 115 V ac or 28 V dc).

Generally, by using the lowest rating compatible for current carried (not the maximum admissible current) in the cable, short-circuits shall be isolated more quickly and the damage they cause be limited.

6.5.2.4.2 High length lines and very low voltage power

It is recommended to check that in case of short-circuit at the end of the line, the ohmic resistance of the circuit does not limit the current at a value below the protection device threshold (frequent case on large aircraft for circuit using low voltage).

The short-circuit current is calculated as follow:

- Icc = V/R
- Icc: short-circuit current (A)
- V: voltage (V)
- R: overall line resistance (Ω)

The values of the resistance per metre for each cable gauge at 20 °C are given in the appropriate cable standards.

6.5.2.4.3 Circuit requiring high starting current

For systems requiring high starting current (electrical motor starting, locked rotor condition, for example), the protection devices must accept those peaks of currents.

In that case, the associated thermal circuit-breaker must be specified against overload which may lead to increase the cable section.

6.5.2.4.4 Circuit requiring in-rush current

For systems requiring in-rush current (transitory operating mode asking for current higher than nominal one during few hundreds of ms), the protection devices must accept those level of currents during this short time period.

In that case, the associated thermal circuit-breaker must be specified against overload which may lead to increase the cable section.

6.5.2.4.5 Thermal circuit-breaker installation principles

The thermal circuit-breaker might have, depending of the models, a specific axis sensitive to vibrations. It should be then accurate during the installation design not to orient the breaker in this axis.

6.5.2.4.6 Compensation of the Thermal C/B Tripping Thresholds

The ambient temperature has a sensible influence on the breaker tripping and non-tripping thresholds. It is therefore necessary to ensure the compensation of the breaker tripping and non-tripping times with respect to the ambient temperature to prevent any untimely tripping of the breakers. The minimum and maximum thresholds may be evaluated by means of curves given in the Standards specific to each breaker.

6.5.2.4.7 Determination of cables and protection devices

In order to ensure cable/protection devices compatibility, for equipment powered under a given voltage with a given current, it is recommended to follow the method below:

1 - Choose the most appropriate protection device rating with respect to the need of the supplied systems.

- General case: take a rating between 15 % and 20 % above the nominal current to be carried
- In-rush current, high starting current or multi-starting current: if necessary, over specify the protection device and the cable to avoid untimely tripping.

2 - Choose the appropriate cable size given an acceptable increase of temperature (Joule effect), typically 40 °C maximum for a cable alone (see EN 2853).

- The cable overheating (joule effect) + ambient temperature of the zone must not exceed the maximum in service temperature of the cable for all transitory operating modes (starting current, etc.).
- Take care of the harness fixation devices.

3 - Examine the line voltage drop, which must stay compatible with the operational voltage of the equipment.

- If the drop is too high, take a higher cable size (see EN 2282).

4 - Verify that the minimum short-circuit current allows the tripping of the protection device (in case of default near to the equipment). See illustration in Figure 2.

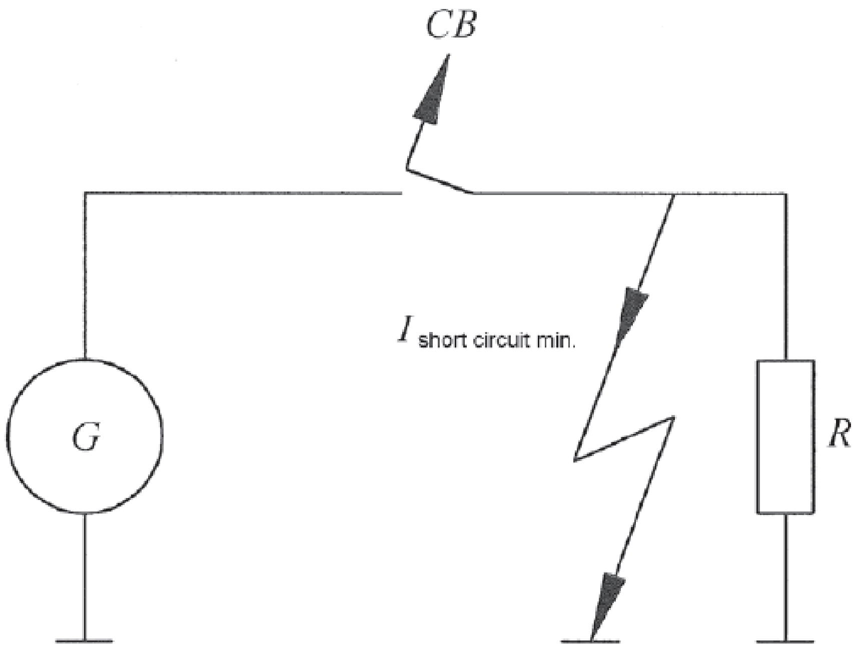


Figure 2

5 - When two protective devices are in-line, there must be a significant difference of rating calibre between them to ensure that the nearest to the concerned equipment will trip first in case of need.

6 - When the circuit design includes both aluminium and copper cables, it is mandatory to check the correct specification between the gauge and the protection device for each kind of cable.

6.5.3 Circuit Breaker

A Circuit Breaker (CB) is a mechanical switching device, capable of carrying and breaking currents under normal circuit conditions and also carrying for a specified time and breaking currents under specified abnormal circuit conditions such as those of short- circuit.

The electrical disconnection function is obtained through the deformation of a calibrated bimetal due to Joule effect.

Current range is normally from 3 Amps to 50 Amps.

6.5.4 Arc Fault Circuit Interrupter

An Arc Fault Circuit Interrupter (AFCI) is a circuit, generally incorporated in another device, designed to mitigate overheating or fires by detecting non-working electrical arcs and to interrupt current. Electronics inside an AFCI detect bursts of electrical current within low milliseconds, long before tripping a regular circuit breaker or fuse. The AFCI is designed to distinguish between normal and abnormal current wave forms.

The normal wave forms include: in-rush current, standard and electronic switching and other normal transients,

The abnormal wave forms include: parallel arcs, signs of insulation defects identified by analysis and series arcs initiated by faulty connection.

6.5.5 Arc Fault Circuit Breaker

An Arc Fault Circuit Breaker (AFCB) is a device that implements a circuit breaker function and an AFCI function.

Current range is normally from 3 Amps to 50 Amps.

6.5.6 Remote Control Circuit Breaker

A Remote Control Circuit Breaker (RCCB) is a device that implements a protection function and a contactor function. Optionally a current sensing function can be implemented.

The protection function is provided by a thermal CB or more recently from an electronic analysis of the current able to act if necessary on the contactor. The contactor is of electro-mechanic type.

Current range is normally from 30 Amps to 100 Amps.

Next generation of RCCB will have probably also the AFCI function.

6.5.7 Solid State Circuit Breaker

A Solid State Power Controller (SSPC) is a device that implements a protection function and a contactor function, both being realized electronically. The AFCI function can be added too.

Current range is normally from 3 Amps to 15 Amps.

NOTE Compared to CB, SSPC are more precise devices and are less sensitive to temperature variations.

6.5.8 Residual Current Circuit Breaker (RCCB)

A RCCB is a device that implements a residual current sensing able to detect a current leakage coming from an insulation defect and an associated current interrupting function.

Current range is normally from 3 Amps to 15 Amps.

Nominal residual current from 0,03 Amps to 0,5 Amps.

6.5.9 Fuse

A fuse is a device that is capable of carrying current under normal condition. It is designed to break current, exceeding rated value of the fuse element. This process is irreversible as the fuse element ruptures.

Current range is normally from 0,5 Amps to 300 Amps.

6.6 Switching Devices Selection

6.6.1 Type of Switching Devices

The type of switching devices used shall meet the requirements of the relevant ISO standard or European standard aerospace series or users specifications.

Various types of switching devices are existing and their use will depend upon the expected application. For EN existing standards see B.6 of Annex B.

The various types of existing protective devices are described in 6.6.3 to 6.6.7.

6.6.2 Electrical switching

6.6.2.1 General

a) The switching capacity is defined by the different current values that a switching device contact can successively open or close based on the following parameters:

- supply voltage,
- number of operation,
- power factor,
- time constant,
- in-rush current,
- type of load (resistive, inductance, light, capacitive, motors, etc.),
- etc.

b) Each product standards or specifications must specify the current values to be complied with for each product by quantifying the above parameters.

c) For most of the switching devices with several contacts (or contacts stages), simultaneous switching of all contacts is not guaranteed. For example, on a relay with two changeover contacts, it may arise during switching that one contact is still in the break position while the other is already in the rest position.

6.6.2.2 Low level switching

In order to guarantee a correct electrical continuity, cautions must be taken when a switching item is used with small currents and under reduced voltages. Contacts intended for controlling these low power levels can be damaged and loose their quality for a switched power higher than around 60 mVA DC, resistive. This value being highly dependant on the quality of the retained materials for the contacts.

So, we strongly recommend the following practices:

a) The same contact cannot alternately switch power levels lower than and higher than 60 mVA. If this occurs, <u>even only once,</u> operation at $P < 60$ mVA is no longer guaranteed.

b) To guarantee the quality of contacts for use at a low power level less than 60 mVA, it is indispensable to use products that are either new or that have never operated at power levels higher than 60 mVA.

c) Due to the risk of contamination between contacts on switching items without electrical arc cut-off chambers; the use of adjacent contacts in the same product where one switches $P < 60$ mVA and the other $P > 60$ mVA must be avoided.

6.6.2.3 Essential characteristics of switching devices

a) It is current practice to define reliability of switching devices according to number of possible failures for the specified number of operations (MCBF: Mean Cycle Between Failure) or per flight hour (MTBF: Mean Time Between Failure). In some cases, the designer can specify the probability of a specific failure when he judges that a defined type of failure can affect aircraft safety.

b) Particular attention must be paid to the use of non-hermetically sealed products that are more sensitive to environmental constraints.

c) Adjacent relays and microswitches must be installed with same coil orientation and minimum spacing to avoid mutual interactions linked to magnetic fields and to the temperature emitted by the coils that can affect operations.

d) Particular attention must be paid to vibration capabilities with regard with the zones where they are installed.

6.6.3 Interrupter

Reserved

6.6.4 Switch

Reserved

6.6.5 Push-button

Reserved

6.6.6 Relay and microcontactor

6.6.6.1 Definition

A monostable electromechanical relay or microcontactor is composed of an electromagnet (coil + air gap magnetic circuit) that controls the switching from a "R" break position to a "T" or "W" make position of one or more contacts (generally 2, 3 or 4). These products are normally represented in the break position, coil not energized.

These products shall be mechanically polarised or electrically protected in order to avoid possible errors.

In order to ensure the safety of personnel, all these devices must be grounded through the support plates.

6.6.6.2 Configuration examples

Various configurations may exist, some of them are illustrated in the following figures as example of products represented with non-energized coils:

C = Common;

R = Rest (also called NC = Normally Closed);

T or W = Work (also called NO = Normally Open).

<u>Relays with two changeovers contact (2RT)</u>

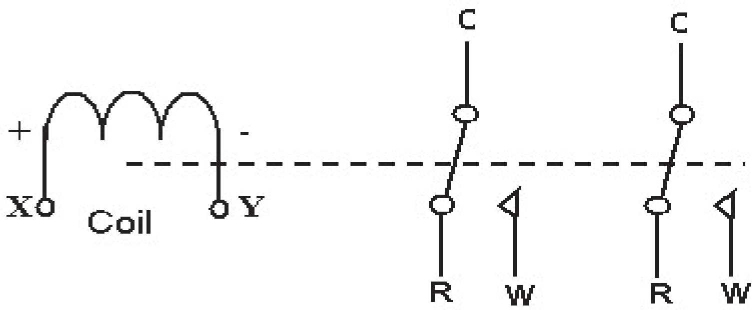


Figure 3 — 2RT relay

Relays with four changeovers contact (4RT)

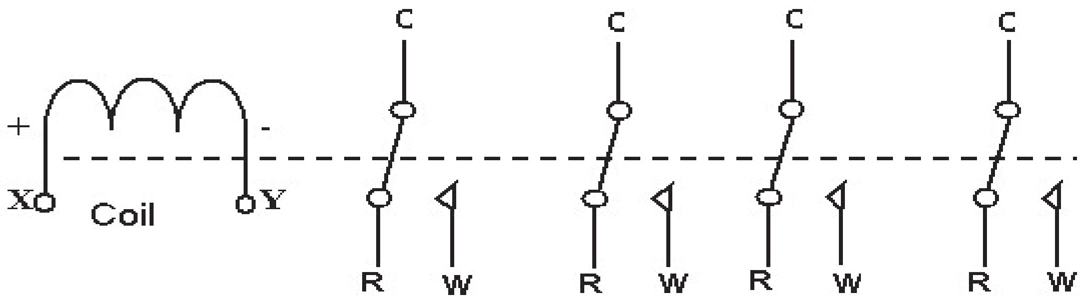


Figure 4 — 4RT relay

Microcontactor with three power contacts and one auxiliary contact (3T + 1RT)

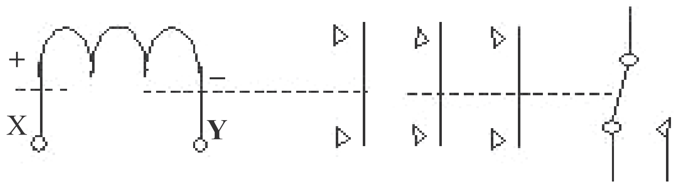


Figure 5 — 3T+1RT microcontactor

6.6.6.3 Inductance effects of relays

Relay and microcontactor coils are both resistive and inductive.

At each de-energization, and lacking precautions, the inductive component induces negative surge voltages that can reach several hundred volts (400 V to 1 500 V) during a few hundred microseconds (500 microseconds to 2 000 microseconds). This phenomenon can directly affect the computers if they do not have sufficient output protection or if their control units are poorly dimensioned.

There can be three types of consequences:

— premature degradation of control unit contacts due to electrical arcs.

— disturbance of computer operation.

— degradation of computer protections.

Each system designer is responsible for evaluating the level of severity of these consequences.

Specific relays with built-in limiters, called "suppressed" relays, have been developed to limit the transient surge voltage. Such “suppressed” relays must be clearly identified.

6.6.6.4 Coils operating voltage values

To operate, a coil shall be rated with a preferred voltage (e.g. 28 VDC).

For monostable electromechanical devices a minimum voltage shall be defined where all operation performances are guaranteed for an applied voltage at least equal to this value (e.g. 18 VDC).

Attention is brought to the fact that during operation, a decrease of voltage under this minimum value may lead to various situations **where performances cannot be guaranteed**:

— even if contacts stay in the work position (e.g. hold voltage = 7 VDC to 18 VDC);

— where the range of uncertainty with residual voltage whose effect would be to not cut power or to create unwanted switching (e.g. 1,5 VDC to 7 VDC);

— switching to the Rest position for a decreasing voltage under a drop-out value (e.g. 1,5 VDC).

6.6.7 Contactor

Reserved

6.7 Terminal junction systems

6.7.1 Definition and requirements

Terminal junction systems consists of modules, frames and end clamps. The modules can be stacked on the support frame and locked to the rail. These blocks of modules are used to form interconnections of electrical components and equipment in electrical or electronic systems.

For existing European Standards see Annex B.7.

6.7.2 Environmental

Terminal junctions shall not be located in areas of known moisture accumulation and must be adequately protected to minimize any hazardous effects due to moisture. They shall not be installed in areas where fluids can accumulate.

Terminal junctions shall be selected according to the environmental conditions in which they are to be located, taking into account the design of sealing, materials, plating, surface finish as well for terminal junction rails and end clamps.

6.7.3 Design

Terminal junctions shall be lightweight, modular junction blocks, which shall be either feedback or feed-through and shall be assembled into compact frames and supports to form various arrangements of interconnections according to the designers need. Each module shall accept a number of contacts, which are inserted and removed with tools.

6.7.3.1 Modules

Modules are built in two different configurations:

— the internal contact of the module consists of a socket and the external contact crimped on the wire consists of a pin.

— the internal contact of the module consists of a pin and the external contact crimped on the wire consists of a socket.

The internal contacts are connected inside the module to a bus bar that will build up a contact arrangement. Signal or power is distributed with the bus bar as well as interconnections for inline junctions are built up. Also a combination of bus bars and interconnections may be integrated in one module.

The modules accommodate standardised contact sizes, which shall mate with the external contacts and cables sizes named in the product standard of the terminal junction.

Sealed and non-sealed modules are available. On a sealed module a grommet is on the top of the interface, which seals the module, when cabled contacts or sealing plugs are assembled. The grommet shall be bonded or moulded onto the module housing.

Each external contact is locked inside the module by a retaining clip, which is an integral part of the module assembly. The retaining clip locks the contact into position until it is disengaged by the extracting tool. Crimp-type contacts shall be used for all connections.

On the module housing there shall be a provision for identification labels. With the help of the label the module can be identified in the terminal block.

6.7.3.2 Feedback modules

A feedback module has one interface containing contact cavities for wired contacts and are generally used for interconnecting and bussing. It acts like a terminal strip. The cable entry and exit are on one side.

6.7.3.3 Feed-through modules

A feed-through module has two interfaces, one of which is on the opposite side of the other. Both interfaces contain contact cavities for wired contacts. The contact arrangement is mirror image of the opposite interface.

Feedthrough modules are generally used for interconnecting and bussing, where the wiring must be guided through a panel or bulkhead.

6.7.3.4 Contact arrangement

The contact arrangements as well the external contact sizes are specified in the relevant product standard. The arrangement is indicated on the connection interface of the module.

6.7.3.5 Material and plating

Shunt and internal contacts of the module shall be copper alloy and gold plated.

6.7.3.6 Grommet sealing

Sealed modules are equipped with a flexible grommet, which seals the contact cavities of the modules. The grommet is on the top of the interface. The sealing is only guaranteed when the cable sizes specified in the product specification are installed. If the wire outer diameter differs, the sealing effectiveness is not guaranteed. Unused cavities shall be fitted with sealing plugs, unless otherwise specified by the design authority.

6.7.4 Mounting frames

Terminal junction mounting frames which are used to carry individual modules are designed as aluminium rails or composite frames.

Rails are mounted onto the structure and the modules are engaged in the rail.

6.7.5 Other types of modules

Other module types may be necessary for different applications. There are various arrangements, each offering a different connection possibility, for example:

a) distribution modules shall be used when two or more contact sizes are needed per module. If used for power distribution, the relevant Design Authority shall be consulted;

b) grounding modules shall provide multiple grounds made at a common point. These are feedback modules grounded to the structure;

c) grounding junctions shall provide a simple method of terminating a cable to ground. Cables with crimp contacts shall be inserted into the grounding junction or which is mounted on a metallic rail.

d) component modules shall provide a method of terminating cables to printed circuit boards, flexible printed board and flat cable;

e) in-line junctions shall be used to join two cables. They shall be similar to an in-line splice, but the contacts are removable using the insertion and extraction tools. They may also contain electronic components, such as diodes, resistors, filters, etc.;

f) multi junctions shall join three or more cables. They shall be similar to two or three in-line junctions which may bussed together or provide independent through connections;

g) stud junction modules could be used for power distribution. Cabled terminal lugs are mounted by a screw on the stud for distributing power.

6.8 Terminal Lugs Selection

6.8.1 Definition and requirements

Terminal lugs shall allow the correct connection of the various cable conductor types to various terminal studs configuration including ground studs.

Terminal lugs complying with the requirements of standards mentioned in B.8 of Annex B shall be selected. All other terminal lugs shall be in accordance with requirements defined by the Design Authority.

6.8.2 Selection criterias

The material and plating of all terminal lugs shall be compatible with that of the wire to be used, a possible adjacent terminal lug and of the stud. Aluminium terminal lugs shall be used only with aluminium wires. Terminal lugs used for aluminium wires shall be of a blind barrel type and particular care shall be taken to ensure that the rear sealing is achieved.

Terminal lugs shall be selected with a tongue hole diameter in accordance with the diameter of the associated stud. The size of the stud fixing the terminal lugs to the structure shall be in accordance with the associated wire size.

Gauge 26 and smaller shall not be used with terminal lugs.

When terminal lugs are specified for flight critical systems, only the ring tongue terminal type shall be used in aerospace application.

The size of stud fixing may also be selected to prevent circuit cross connection.

6.8.3 Inspection

For user control tests for terminal lugs see 9.8.4.

6.9 Splices Selection

6.9.1 Functions of Splices

Splices are used for the following functions listed below. See 9.9 for details of types of splice.

a) to lengthen a cable (whether permanent or quickly detachable);

b) to change the cross-sectional area of a conductor;

c) to make a permanent junction. In such applications, splices shall be limited to having only two wires crimped on each side, unless otherwise authorised by the Design Authority;

d) to repair a damaged wire as authorised by the Design Authority (subject o restrictions listed in 9.9.11). Such splices shall be recorded and where possible, be replaced by a complete cable at the earliest opportunity.

6.9.2 Definition and requirements

a) Splices installed in areas where there is a high risk of the presence of moisture, shall be sealed and moisture proof and meet the requirements of EN 3373-001, SAE AS 81824/1 or MIL-STD 202 Method 106G or as specified by the Design Authority.

b) for use in SWAMP areas splices shall meet the requirements of EN 3373-001 or SAE AS 81824/1.

c) Pre-insulated splices installed without the application of heat shall meet the requirements of MIL-STD-202 Method 106G.

d) Post-insulated splices shall conform to the requirements of the Design Authority.

e) All complete splices shall be insulated with a material which is compatible with the cable used and the installation environment.

f) When thermal shrink technics are used, the process temperature shall be compatible with associated components.

6.9.3 Installation constraints

Splices shall not be used in the following cables, unless specifically approved the Design Authority.

a) High voltage cables (greater than 600 V r.m.s.);

b) Fire resistant and fire proof cables;

c) Cables within a fire zone;

d) Thermo-couple cables;

e) Screened cables and cables in critical circuits, such as fly-by-wire, as declared by the aircraft manufacturer and enlisted in the aircraft manual;

f) Cables or harness installations which may be subjected to flexing, e.g. Cable crossing hinges, doors or access panels.

6.9.4 General notes on splices

a) The material and plating of the splice should be compatible with that of the cable or the connection should be sealed (see Annex B);

b) Parallel splices, where all the conductors to be joined are laid side by side in the barrel and crimped with a single action, are no longer permitted on military aircraft. Moreover, their use on civil aircraft is not recommended;

c) Only approved tools shall be used in making the joint, unless otherwise specified in an approved process.

6.9.5 Screened cable splices

These splices are intended to make a permanent connection between two similar sizes of screened cable. They may be used on single or multi-core cables where continuity between screen and screen and between conductor and conductor is required, but shall be insulated from each and every other screen and conductor.

6.9.6 Quick disconnect splices

Quick disconnect splices designed for disconnection without the use of insertion/extraction tools shall not be used.

6.9.7 Closed end splices

This type of splice is intended for use when several cables are to be crimped together in one barrel. All the cables shall be inserted into the same side of the barrel.

The barrel may be pre-insulated or, if not, encapsulated with a heat shrinkable cap after crimping.

Heat shrinkable caps used for this purpose normally contain meltable materials which produce a fully sealed connection.

6.9.8 Splices for fibre optic cables

Splices for fibre optic cables may be used for the following functions:

a) to lengthen a cable;

b) to make a permanent junction;

c) to repair a damaged cable (subject to the restrictions listed in 6.9.3).

Splices for fibre optic cables shall not be used to change the cross-section area of an optical fibre path.

Two common methods of splicing are fusion and mechanical techniques.

In an aircraft environment, the use of fusion splicing equipment is not recommended in areas affected by, or close to fuel vapours because of the risk of ignition during the fusion splicing process. Mechanical techniques which may involve the use of adhesives are preferred.

A mechanical or fusion splice shall provide component parts to reinstate the mechanical strength of the fibre optic cable, including coatings, strength members and environmental protection.

6.9.9 Inspection

For user control tests for splices see 9.8.4.

6.10 Solder Sleeves Selection

6.10.1 Description

The solder sleeve termination consists of a heat shrinkable, non-melting, outer insulating sleeve containing a pre-form of solder together with flux (see 6.10.2). The outer sleeve may also contain meltable thermoplastic inserts for creating an environmental seal of the solder sleeve terminations after installation.

The outer sleeve shall be sufficiently transparent to ensure that the solder joint may be visually inspected during and after installation.

6.10.2 Solder and flux

The solder alloy used shall depend upon the operating temperature of the cable (conductor and insulation) upon which it is installed. The manufacturer's data sheets shall identify the solder alloy to be used (see 5.11).

The solder pre-form is pre-fluxed and no further flux is required except for special applications where reference shall be made to the manufacturer's data.

6.10.3 Solder Sleeve Selection

Solder sleeve devices provide:

a) means of terminating the screens of screened cables;

b) splicing single and multicore cable

c) splicing screens covering splices in cores of screened multicore cables and maintaining 360 screening over the length of the splice;

d) connecting cables or screens to special connectors or cable outlet accessories designed for this purpose.

6.10.4 Selection criteria

Solder sleeves shall conform to SAE AS 83519 or a specification approved by the Design Authority.

For installation in SWAMP areas only devices approved for this purpose shall be used.

6.11 Feedthrough Selection

6.11.1 General

Feedthroughs are used, when cables looms are guided through a bulkhead from pressurized to unpressurized zone of the A/C, or between different environmental zones etc. The component guarantees a stable pressure inside the concerned area with their sealing property. Also feedthroughs can be used as a fume or fluid retention seal. Standard connectors without strong sealing characteristics should not be used to cover this need. Feedthroughs are available in several variants:

— as a compound version, where the cable loom is potted with compound.

— as a split housing version, where the cable loom is sealed by a flexible tape.

— as a grommet version, where the individual cables are guided through a grommet with a fixed arrangement.

— as a bulkhead version for same pressure area.

6.11.2 Selection criterias

Feed throughs shall be selected regarding the cable size. Big sized cables as power and generator cables shall be guided through a feedthrough with grommet, which shall have a dedicated diameter for the cable. Cables with woven or irregular jacket shall be avoided, as sealing is difficult to achieve.

Selection of Feedthrough materials shall take into account the environment, fluids, vibration and temperature requirements.

If bundles are protected with a conductive protection, the housing of the feedthrough must be conductive.

6.11.3 Design

In general feed throughs are mounted with a bolted flange or circular flange with jam nut. If no seal is integrated in the flange which is in contact with the structure, sealing with compound shall be provided, if sealing is required.

For compound feedthrough a method of ensuring correct sealing of the cables shall be provided.

6.12 Clamps Selection

6.12.1 General

Type of clamp used shall be suitable for environmental conditions.

The temperature rating of the support shall be equal to the maximum ambient temperature of the zone, plus the temperature rise due to current flow in the cable bundle and shall also take into account the possible temperature rise caused by the malfunction of an adjacent system or component, such as a burst hot air duct.

Clamps and supports for cable ties could be fastened by means of screws, rivets or adhesives.

On harness without ad-hoc protection, when a metallic clamp is used a protective cushion shall be used.

6.12.2 Selection of “P” clamps

The type of “P” clamp used shall be either a plastic, aluminium alloy or corrosion resisting steel “P” type complete with a cushion. Materials shall be suitable for the installation environment.

"P" clamps shall be selected such that when fully tightened, the cables are gripped sufficiently to prevent chafing or abrasion, sagging and oscillatory movement.

6.12.3 Selection of “Ω” clips

An omega clip is a spring clip in which the throat is narrower than the body to allow the harness to be a push fit without any additional fastening. The design shall incorporate flared edges to avoid chafing on the harness bundle. The clip may be fixed with fasteners or be self-locking.

6.13 Protective parts Selection

6.13.1 General

Protective parts include conduits, braids, tapes, protective wraps, single or multi-layer sleeves which are used to provide either mechanical protection, electrical insulation, thermal and fire resistance, additional short circuit protection, shield against electro-magnetic interference or a combination of functions.

Such protective parts shall be suitable for the intended operational environment, must not be abrasive for the contained wires or cables and where possible, should allow visibility and replacement of the ageing wires during operational life of the aircraft.

They shall be compatible with concerned environmental conditions and materials requirements of 5.11.

Various types of protective parts are existing and their use will depend upon the expected application. For existing European Standards see B.13 of Annex B.

6.13.2 Selection criterias

When choosing the appropriate protection solutions, one should keep in mind the following potential issues:

— Operating environment:

Temperature range, fluids compatibility, vibration areas, SWAMP areas, altitude.

— Installation/Maintenance:

Ease of Installation, possibility to add or remove cables, maintainability, possibility to inspect all the lengths of the cable looms, compatibility with existing fastening solutions (T-raps, lacing cords, band-it, P-clips), compatibility with existing grounding solutions.

— Geometry of the sleeve/Geometry of the wire harness:

Conformance to the geometry of the wire harness, flexibility, possibility to accommodate branches, possibility to rigidify the wire harnesses.

— Functionality:

Mechanical separation, protection against abrasion, ingress protection against fluids, sealing, thermal isolation, fire protection, short circuit resistance, electrical separation, EMI and RFI protection.

6.14 Identification parts Selection

6.14.1 General

Figure Identification parts include sleeves,labels and tags which are used to provide identification for interconnection system.

Such identification parts shall be suitable for the intended operational environment, must not be aggressive for the contained wires and should allow as much as possible visibility and replacement of the ageing wires during operational life of the aircraft.

Various types of protective parts are existing and their use will depend upon the expected application. For existing European Standards see B.13 of Annex B.

6.14.2 Selection criterias

When choosing the appropriate identification solutions, one should keep in mind the following potential issues:

— operating environment in the concern area;

— installation/Maintenance (ease of installation);

— lisibility other time.

6.15 Installation Components Selection

6.15.1 Selection of Cable Ties

In general five methods are used to tie looms and bundles:

1) Plastic cable ties
2) Metallic cable clamp with caution
3) Lacing tapes
4) adhesive tapes
5) lacing sheaths

The selection and use of cable ties shall be made in accordance with the instructions of the relevant Design Authority and shall include guidance on spacing between ties for the various aircraft environments/areas. Guidance on tie spacing is given in 9.17.3.

Where the type of cable tie is not specified by the Design Authority, the installer shall select the most suitable cable tie using the following parameters:

a) environmental conditions. e.g. temperature, vibration, SWAMP, etc.
b) loom or bundle diameter.
c) if failure of the tie would result in the tie falling into moving mechanical parts.
d) if failure of the tie would permit the movement of wiring against parts which would result in chafing or fouling of moving mechanical parts.
e) indentation of plastic cable ties shall not be aggressive for cable insulation inside the bundle.

Cable ties shall not be used:

a) Within conduits or sleeving;
b) On looms or harnesses within bundles, where head of cable ties cannot be placed facing away from the bundle.

6.15.1.1 Plastic Cable Ties

Cable ties shall be selected from EN 4056 or otherwise as specified by the Design Authority (see B.9 of Annex B).

Various grades of plastic cable ties exist and should be selected depending on application. Those having the highest flammability rating are preferred. Where exposure to ultra-violet light may exist the relevant grade should be used.

Cable ties with internal metallic locking serrations, which are liable to damage cables, shall be forbidden except see 5.13.2.3.

Care shall be taken for use:

a) In high vibration areas;
b) On looms containing coaxial or fibre optic cables unless approved by and to the conditions specified by the relevant Design Authority;
c) In Severe Wind and Moisture Problem (SWAMP) areas;
d) Within fuel tanks.

NOTE Some cable ties may require particular storage conditions.

6.15.1.2 Metallic cable ties

Various grades of metallic cable ties exist and should be selected depending on application. The two main types are:

a) Tie with buckle that uses mechanical fold of tie as the locking mechanism

b) Tie with head containing mechanical locking mechanism

Care shall be taken to ensure that:

a) Ties are not allowed in direct contact with insulation.

b) Where ties are used for bonding screens, the tensile load setting is clearly stated.

c) Where ties are used on harnesses, the tensile load setting is clearly stated to ensure that the harness loom is not crushed.

d) Any sharp edges are covered or protected.

e) Galvanic compatibility with any other metallic components.

6.15.1.3 Lacing tapes

Lacing tapes shall comply with ENXXXX (draft in preparation) or MIL Specs MIL-T-43435B and shall be installed using an adequate knot.

Care shall be taken to ensure that materials, including the finish, of lacing tapes and cable insulations are compatible.

6.15.1.4 Adhesive tapes

Various grades of adhesive tapes exist and should be selected depending on the application.

6.15.1.5 Lacing sheath

Various grades of lacing sheaths exist and should be selected depending on the application.

6.15.2 Tapes

Tapes shall be of a type approved for the application.

A supportive tape (for example PTFE impregnated glass tape or silicone rubber) shall be used as a filler under cable clamps and tie post connector backfittings, if an insulating cushion is not provided.

Tapes, which absorb moisture, or which have volatile plasticisers that could produce chemical reactions with the cables, shall not be used.

6.15.3 Raceways and cable tray

These are structural elements designed to provide support and protection for the electrical wiring installation in aircraft.

6.15.3.1 Cable Tray

A simple metallic or non-metallic tray usually flat and with perforations, that will allow electrical harnesses to be secured to it by means of cable ties etc. The tray provides support and segregation for the wiring from adjacent structure, equipment and wiring. Generally it does not provide protection against HIRF emissions or EMC requirements.

6.15.3.2 Raceway

Normally a multi-channel coated, metallic construction that encloses cable bundles on three sides and provides segregation between different cable routes and protection against mechanical damage, HIRF emissions and meets EMC requirements. This removes the necessity for conduits within the raceway. Channels should not be filled to more than 80 % of their capacity.

6.15.4 Harpoons

Some particular installation supports, such as raceways, may require the use of harpoons to maintain the cable loom. These shall conform to a recognised standard.

Care shall be taken to ensure that materials used and shapes of harpoons and cable insulations are compatible and shall also take into account environmental conditions such as temperature, vibration, SWAMP, etc.

Harpoons are used in conjunction with the fairlead and retainer described below and consist of a serrated shaft with self-retaining arrow- head. The head of the harpoon tie is inserted into holes in each channel of the raceway with the cable bundle passing to each side of the shaft, The fairlead is then slid over the shaft followed by the retainer which has a tongue that engages with the shaft serrations to provide a locking mechanism similar to a cable tie. Specialised tools are available for inserting and removing harpoon ties without damaging the raceway, electrical cables or adjacent structures. Excess shaft shall be cut off flush with the cable retainer using a cable tie installation tool that will also correctly tension the cable retainer/fairlead.

6.15.5 Fairlead

A fairlead is a rectangular device that has an 'H' cross-section and conforms to a recognised standard. It fills the width of the raceway channel and has a slot that allows it to be fitted over the shaft of the harpoon tie. It bears down on the cable bundle and is held in place by the cable retainer. The grooves in the side that form the 'H' section allow extra cables to be run in without dismantling the installation.

6.15.6 Cable Retainer

A cable retainer is a rectangular device conforming to a recognised standard. It fills the width of the raceway channel and has a slot to allow it to be fitted over the shaft of the harpoon tie. The slot contains a tongue that engages with the serrations on the harpoon tie to form a lock. The retainer is fitted above the fairlead and provides the method for holding the fairlead in place with the correct pressure being applied to hold the cable bundle securely within the raceway channel.

6.16 Junction Boxes

Junction boxes may be used to provide special protection for wire and cables junctions.

6.16.1 Construction

Junction boxes may be made of metal or non-metallic material, metalized or not.

Metallic boxes or conductive non metallic boxes:

- When necessary, shall have their interiors coated with an insulating material to minimize the possibility of grounding faults.
- Shall be fabricated with a sufficient wall thickness to provide stiffness and rigidity, to adequately support multiple attachments without flexing or deforming under service conditions, and to provide proper support and alignment for hinged or removable covers.

Except for vapour tight boxes, drainage holes shall be provided, allowing drainage of the boxes during service conditions.

6.16.2 Inside wiring

Wiring inside junction boxes shall be adequately supported at convenient intervals to meet the following requirements:

- provide neat and orderly arrangement of wiring,
- provide ease of inspection and maintenance,
- provide relief of strain on terminals,
- minimize possibility of faults,
- prevent vibration from damaging wiring or terminals.

6.16.3 Identification

Junction boxes shall be externally identified to facilitate correlation of the box with the wiring diagrams.

7 EWIS Components Identification

7.1 Applicable Rulemaking

25.1711 Component Identification; EWIS

7.2 General

To ensure that systems remain safe and operate as intended throughout the service life of the aircraft it is necessary that their components are properly labelled, or otherwise identified, so as to facilitate determination of the function of the allied system, together with any associated separation requirements and operating limitations. Clear labelling of EWIS allows installers, inspectors, and maintainers to readily identify that the correct system components are installed as designed, and allows modifiers to add systems with due regard to the existing protection and separation requirements.

Specific system identification principles are part of the general identification principles.

There are at least four types of EWIS and OFIS component identification, which are accomplished at different stages.

They are:

a) Component manufacturer part number,
b) Airframe manufacturer component function identification number,
c) Airframe manufacturer routing identification and modification,
d) Identification of user EWIS and OFIS modification or repair (operator's identification coding).

Methods of identification for each type can be different and are described in the following Subclauses.

7.3 Component Manufacturer Marking – Part Number

7.3.1 Component manufacturer identification

EWIS and OFIS components should be identified by their manufacturer in accordance with ISO 2574 or similar specifications. This identification comprises product part number, manufacturer identification, and, when possible or specifically required batch identification or year of manufacture.

This helps ensure:

- Identification and traceability of the component,
- Verification of compliance with the aircraft certification basis,
- Accuracy in manufacture, maintenance, quality control, storage and delivery,
- Verification of the use of approved/qualified sourcing,
- Monitoring of the aircraft configuration during the aircraft life.

EWIS and OFIS components concerned by above shall at least include: wires, connectors, terminal blocks, bus bars, circuit breakers, clamps.

7.3.2 Alternate manufacturer identification

It is also common practice to use the five-digit/letter C.A.G.E. code, particularly for wires. Alternatively, for small components whose size may make it difficult to use other forms of clear identification, a logo may be used.

7.3.3 Identification intervals

Wires and cables should be identified at intervals of not more than 380 mm (15 inches). This interval is different than the interval used by airframe manufacturers to prevent the possibility of two identifications overlapping over the entire length of the run, which could render both identifications illegible.

7.3.4 Types of wire manufacturer markings

Wire manufacturer markings should generally be green colour to differentiate them from the black marking typically used by the aircraft manufacturer, but other contrasting colours are also acceptable. The preferred marking process used is "ink transfer" or "ink jet" type, with post curing to increase resistance to mechanical or chemical wear. Hot stamp marking method has the potential to damage wire insulation and its use is discouraged.

The component technical specification should include methods used for identification and legibility during the design life of the component.

7.4 Airframer Component Function Marking – Function Identification Number

7.4.1 Airframe manufacturer identification

Identification of components by the airframe manufacturer helps ensure:

- Identification and inspection of cable runs
- Accuracy of manufacture, maintenance, quality control, storage and delivery
- Verification of the system to which the component belongs
- Identification of components related to systems required for safe flight, landing, or egress or have the potential to impact the flight crew's ability to cope with adverse operating conditions. functions identification should be provided in accordance with the following:

Identification of EWIS and OFIS components should clearly correspond to aircraft wiring manuals.

Functions of EWIS and OFIS components used on aircraft must be identified through adequate means, such as markings, labels, tags, placards, etc.

EWIS and OFIS Components concerned by such request shall at least include: wires, connectors, terminal blocks, bus bars, circuit breakers, electrical conduits, feed-through, pressure seals, splices.

In addition to the type identification imprinted by the original wire manufacturer, aircraft wire should also contain a unique circuit identification coding that is accomplished at time of harness assembly. This allows existing installed wire to be identified as to its performance capabilities when considering replacement. Inadvertent use of lower performance and unsuitable replacement wire can thus be avoided.

7.4.2 Identification intervals

Wires and cables should be identified at intervals of preferably not more than 460 mm (18 inches) and should not obscure the identification markings of the EWIS and OFIS component manufacturer or airframe manufacturer component identification number. This identification interval is different than the interval used by wire manufacturers to prevent the possibility of two identifications overlapping over the entire length of the run, which could render both identifications illegible.

Also, exceptions can be made for short runs of wires or cables or when the majority of the wire or cable is installed in a manner that facilitates easy reading of the identification markings.

Coaxial, non printable cables or transmission cables, generally susceptible to crush, are identified at both equipment ends, at least.

7.4.3 Types of airframe manufacturer markings

Means used for this identification should be appropriate for the component type. The identification process used should not cause degradation of the characteristics of any wire cables or other EWIS and OFIS components in the harness. During the design life the marking should be visible and the colour should contrast with the wire insulation or sleeve or support material.

Hot stamp printing is not recommended and its use shall be approved by the concerned authority. Alternative identification methods to mark directly on the wire are: "Laser Printing" preferably, "Dot Matrix" or "Ink Jet Printing" when there is no strong need for chemical or mechanical resistance of the ink. If such methods are not available the use of special sleeves to carry identification marks is possible.

In some cases it may not be practicable to mark an EWIS or OFIS component directly because of component size or identification requirements. In this case other methods of identification such as label or sleeve should be used.

7.5 Identification of EWIS and OFIS Bundles – Airframer Identification – Routing

7.5.1 Routing identification

Electrical drawings should describe wire routings through the entire aircraft (for example: incompatibility between routes, minimum distance between routes, absolute ban of combining bundles) and be available in the maintenance documentation as required by the regulation. This information ensures that modification designers and maintenance personnel are aware of the defined physical segregation of the different routes of the aircraft model they are working on. Coding for identification of routes or bundles used on aircraft should be displayed by adequate means such as labels, tags, placards, coloured ties, bar-codes.

This type of component identification helps ensure:

- Identification and inspection of bundles.
- Accuracy of manufacture, maintenance, quality control, storage and delivery.
- Determination of the type of route, or route function, (feeder power, radio etc.).
- Clear identification of systems that require physical segregation (i.e. to detect the possible mix of different routes/bundles, the misrouting of a system in an area, etc.).
- Identification of routes taken by systems that are required for safe flight, landing, egress, or have the potential to impact the ability of the flight crew to cope with adverse operating conditions.

7.5.2 Types of routing identification

Means used for such identification should be appropriate for the component type. During the design life the marking should be visible and the colour should contrast with the wire insulation or sleeve or support material.

The characteristics of all wire cables in each harness shall not be downgraded by the routing identification process used.

When necessary, ensure that all routes or bundles are identified properly at sufficient intervals for installation and maintenance visibility.

7.5.3 Visible identification of critical design configuration limitations

Rule 25.981(b) of the regulation states *that "... visible means to identify critical features of the design must be placed in areas of the aircraft where maintenance, actions, repairs, or alterations may apt to violate the critical design configuration limitations."*

The design approval holder should define a method of ensuring that this essential information will:

— be communicated by statements in appropriate manuals, such as wiring diagram manuals, and

— be evident to those who may perform and approve such repairs and alterations.

An example of a critical design configuration control limitation that would result in a requirement for visible identification means would be a requirement to maintain wire separation between FQIS (fuel quantity indication system) wiring and other electrical circuits that could introduce unsafe levels of energy into the FQIS wires. Acceptable means of providing visible identification means for this limitation would include colour-coding of the wiring or, for retrofit, placement of identification tabs at specific intervals along the wiring.

7.6 Identification of Equipments

Reserved

7.7 Identification of user EWIS and OFIS modification or repair – Operators identification coding

Repairs or modifications to EWIS or OFIS should follow the identification guidance given in the above Subclauses for aircraft manufacturers.

This helps ensure that the original aircraft manufacturer’s identification scheme is not compromise by future modifications or repairs and is maintained throughout the service life of the aircraft.

8 Separation and principles to apply

8.1 Applicable Rulemaking

25.1707 System Separation; EWIS

8.2 General requirements

8.2.1 General

On initial installation, ease of mounting, maintenance, dismantling and replacement of cabling shall be given priority consideration.

Cabling shall be manufactured and installed so as to fulfil the following requirements:

— accessibility for inspection and maintenance;

— minimum electromagnetic interference and coupling between systems;

— separation of systems, if common mode failure affect redundant system;

— prevent or minimize the risk of damage from:

1) chafing, scraping or abrasion;

2) use as manual support or for holding personal equipment;

3) use by personnel moving inside the aircraft;

4) stowage or movement of cargo;

5) battery electrolytes and fumes;

6) flying stones, ice, mud and burst tyres in the wheel wells;

7) combat or warfare;

8) loose or moving parts;

9) moisture and fluids;

10) localised high temperatures;

11) frequent coupling and decoupling of connectors.

Adequate protection should be provided to protect “live” items against hazardous contacts.

8.2.2 Segregation of functions

The purpose of segregation of functions is to give maximum protection against damage and interference to electrical circuits. It is recommended that wirings be segregated into independent bundles taking into account the nature of the transmitted signals e.g.: power supplies, data bus and radio frequency transmissions, control signals, monitoring signals, emergency and normal signals, etc. Those bundles can be close together or separated according to electrical architecture requirements.

Common failures modes between DC and AC voltages should be avoided.

8.3 EWIS and OFIS Separation principles

8.3.1 General

The continuing safe operation of an aircraft depends on the safe transfer of electrical energy by the EWIS and optical signals by the OFIS. If an EWIS and OFIS failure occurs, its separation from other EWIS or OFIS and from other systems and structures plays an important role in ensuring that hazardous effects of the failure are mitigated to an acceptable level.

25.1707 rule requires applicants to design EWIS and OFIS with appropriate separation to minimize the possibility of hazardous conditions that may be caused by an EWIS or OFIS interfering with an other EWIS or OFIS, other aircraft systems, or structure.

8.3.2 Separation by physical distances versus separation by barrier

Adequate physical separation shall be achieved by separation distance or by a barrier that provides protection equivalent to that separation distance. The following should be considered when designing and installing an EWIS or an OFIS:

a) In most cases, physical distance is the preferred method of achieving the required separation. This is because barriers themselves can be the cause of EWIS and OFIS component damage (e.g., chafing inside of conduits) and can lead to maintenance errors such as barriers removed during maintenance and inadvertently left off. They can also interfere with visual inspections of the EWIS and OFIS.

b) If a barrier is used to achieve the required separation, 25.1707 rule requires that it provide at least the same level of protection that would be achieved with physical distance. That means that when deciding on the choice of the barrier, factors such as dielectric strength, maximum and minimum operating temperatures, chemical resistivity, and mechanical strength should be taken into account.

c) In addition to the considerations given in Subclause (b) above, when wire bundle sleeving is used to provide separation, applicants should consider that the sleeving itself is susceptible to the same type of damage as wire insulation. The appropriate type of sleeving must be selected for each specific application and design consideration must be given to ensuring that the sleeving is not subjected to damage that would reduce the separation it provides

NOTE To appreciate the efficiency of a barrier, test EN 6059-502 could be applied.

8.3.3 Determination of separation

Determining the necessary amount of physical separation distance is essential. But because each system design and aircraft model can be unique, and because manufacturers have differing design standards and installation techniques, 25.1707 rule does not mandate specific separations distances. Instead it requires that the chosen separation be adequate so that an EWIS or OFIS component failure will not create a hazardous condition.

The following factors should be considered when determining the separation distance:

a) The electrical characteristics, amount of power, and severity of failure condition of the system functions performed by the signals in the EWIS and OFIS and adjacent EWIS and OFIS.

b) Installation design features, including the number, type, and location of support devices along the wire path.

c) The maximum amount of slack wire resulting from wire bundle build tolerances and the variability of wire bundle manufacturing.

d) Probable variations in the installation of the wiring and adjacent wiring, including position of wire support devices and amount of possible wire slack.

e) The intended operating environment, including amount of deflection or possible relative movement and the effect of failure of a wire support or other separation means.

f) Maintenance practices as defined by the aircraft manufacturer’s standard wiring practices manual and the instructions for continuing airworthiness required by 25.1529 rule and 25.1729 rule.

g) The maximum temperature generated by adjacent wire/wire bundles during normal and fault conditions.

h) Possible EMI, HIRF, or induced lightning effects.

Some areas of an aircraft may have localized areas where maintaining the minimum physical separation distance is not feasible. This is especially true in smaller aircrafts. In those cases, other means of ensuring equivalent minimum physical separation may be acceptable, if testing or analysis demonstrates that safe operation of the aircraft is not jeopardized. The applicant should substantiate to the Authorities that the means to achieve the required separation provides the necessary level of protection for wire related failures. Electro-magnetic interference (EMI) protection must also be verified.

Wires not protected from wiring faults by a circuit-protective device, such as thermal circuit breakers, arc fault protection devices, ground fault interrupters, other proven protection devices, or combination of such device as needed, whose failure can cause a hazard to the aircraft, should be routed separately from all other wiring.

8.3.4 Separation from personnel and cargo

EWIS and OFIS in general and wiring in particular should be installed so that the structure affords protection against its use as a handhold and damage from cargo. Wires and wire bundles should be routed or otherwise protected to minimize the potential for maintenance personnel to step, walk, or climb on them. Where the structure does not afford adequate protection, other protection means should be used, or a suitable mechanical guard should be provided. The wire bundles should be routed along heavier structural members whenever possible. Sharp edges must be protected by grommets to prevent chafing. Wires should not be routed between aircraft skin and fuel lines. Avoid running wires along the bottom of the fuselage, over the landing gear, in areas of the leading edge of the wing where fuel spillage is anticipated, or adjacent to flammable fluid lines or tanks. EWIS and OFIS components in the passenger cabin should be protected from possible damage by passengers. Wiring routed to, and on, seats, should be protected so passenger luggage, feet, or other possible contact by the passenger does not damage the wire. Separation distances (or equivalent barriers) should be determined considering the factors listed above.

8.3.5 Electromagnetic interference (EMI)

EWIS and wiring of sensitive circuits that may be affected by EMI must be routed away from other wiring interference, or provided with sufficient shielding to avoid system malfunctions under operating conditions. EMI between susceptible wiring and wiring which is a source of EMI increases in proportion to the length of parallel runs and decreases with greater separation. EMI should be limited to negligible levels in wiring related to systems necessary for continued safe flight, landing and egress. Function of systems should not be affected by the EMI generated by the adjacent wire. Separation distances (or equivalent barriers) should be determined considering the factors listed in 8.3.1 to 8.3.3 above.

8.3.6 Separation from flammable fluids

An arcing fault between an EWIS and OFIS in general and electrical wire in particular and flammable fluid line may puncture the line and result in a fire. Every effort must be made to avoid this hazard by physical separation of the EWIS and OFIS from lines and equipment containing oxygen, fuel, hydraulic fluid, and other flammable fluids. Separation distances (or equivalent barriers) should be determined considering the factors listed in 8.3.1 above. EWIS and OFIS should be routed and installed with a maximum achievable separation as determined considering the factors listed in 8.3.1 to 8.3.3 above whenever possible. Further, other means of protection (e.g. drip shield) must be provided to prevent potential leaking fluids on EWIS and OFIS.

8.3.7 Separation from water waste

Leakage from these systems can cause damage to EWIS and OFIS components and adversely affect their integrity. Every effort should be made to design and install EWIS and OFIS so that leaking fluid does not contact the wiring or electrical connectors. Wiring and other EWIS and OFIS components should be routed with a maximum achievable separation as determined in 8.3.1 to 8.3.3 above. Further, EWIS and OFIS should be designed and installed so that some means of protection from potential leaking fluids is provided (e.g., drip shields).

8.3.8 Separation from flight controls

In order to prevent chafing jamming or other types of interference that may lead to loss of control of the aircraft EWIS and OFIS in general and wiring in particular must be physically separated. Clamping of wires routed near moveable flight controls should be attached and should be spaced so that failure of a single attachment point can not result in interference with flight controls cables, components or other moveable flight control surfaces or moveable equipments. Separation distances (or equivalent barriers) should be determined considering the factors listed in 8.3.1 to 8.3.3 above.

8.3.9 Separation from high temperature equipment

EWIS and OFIS in general and wiring in particular must be routed away from high-temperature equipment and lines to prevent deterioration of the EWIS and OFIS and wire insulation. Wires must be rated so that the conductor temperature remains within the wire specification maximum when the ambient temperature, and heat rise, related to current carrying capacity are taken into account. The residual heating effects caused by environmental operating condition, exposure to sunlight, or proximate artificial light sources where radiant heat is a factor should also be taken into account.

Wires routed in fire zones for fire detection, fire extinguishing, fuel shutoff, and fly-by-wire flight control systems that must operate during and after a fire, must be selected from types that are qualified to provide circuit integrity after exposure to fire for a specified period. Separation distances (or equivalent barriers) should be determined considering the factors listed in 8.3.1 to 8.3.3 above.

8.3.10 Redundant system separation

Separation and electrical isolation shall be provided to maintain the independence of all redundant systems and equipment so that safety functions required for flight, landing, and egress are maintained.

EWIS and OFIS of redundant aircraft systems should be routed in separate bundles and through separate connectors to prevent a single fault from disabling multiple redundant systems. Segregation of functional similar, EWIS and OFIS components is necessary to prevent the degradation of their ability to perform their required functions.

Power feeders from separate power sources should be routed in separate bundles from each other and from other aircraft wiring, in order to prevent a single fault from disabling more than one power source. The ground wires from aircraft independent power sources should be grounded individually to the airframe at separate points so that a single ground failure will not disable multiple power sources. Wiring that is part of electro-explosive subsystems, such as cartridge-actuated fire extinguishers, and emergency jettison devices, should be routed in shielded and jacketed twisted-pair cables, shielded without discontinuities, and kept separate from other wiring at connectors. Separation distances (or equivalent barriers) should be determined considering the factors listed in 8.3.1 to 8.3.3 above.

8.4 Electrical requirements

8.4.1 Voltage drop

For electrical power distribution circuits, the total impedance of supply and return paths shall be such that the voltage at the load equipment terminals is within the limits of EN 2282.

8.4.2 Coaxial and Bus cables attenuation

For coaxial and bus cables interconnections, the attenuation associated with the path from the transmitter to receiver shall be within the limits defined in the system specification.

8.4.3 Ground electrical return

8.4.3.1 General

Separate electrical ground points shall be provided for a.c. and d.c. loads and also for signal grounds.

Common failures modes between DC and AC voltages should be avoided.

The location and design of ground electrical return points shall ensure that any overheating does not cause a failure of primary structure.

8.4.3.2 Metallic aircraft

On traditional metallic aircraft, the vehicle structure may serve as the ground electrical return circuit unless system considerations require separate ground electrical return cabling. Therefore, the electrical power source ground terminals shall be connected to the primary structure of the vehicle. For all electrical equipment, the method of making the connection to ground shall ensure that the maximum resistance values defined in EN 3371 are not exceeded and that all necessary precautions are taken to prevent corrosion.

8.4.3.3 Composite aircraft

See 5.13.6.4.

8.4.4 Electromagnetic Compatibility (EMC)

All electrical cabling shall be designed and installed to minimize any mutual electromagnetic interference in accordance with ISO 7137. Suitable methods that may be used to achieve this requirement are:

— to define the EMC category of each cable, then route each category separately;

— to provide EMC barriers between susceptible and emitive cables.

See also 8.13.4.

8.4.5 Grounding of screened cables

Unless otherwise specified by the detail installation specification for the equipment involved, screened cables shall have the screens adequately grounded. Where flying leads are used to connect screens to ground, these shall be of minimum length and shall not be lengthened during repair operations, in order that EMC performance is not degraded. For further information see EN 3371.

8.4.6 Compass deviation

Cabling and ground return paths shall be installed so as not to cause a compass deviation exceeding that permitted by ISO 7137. Each cable carrying direct current in the proximity of compasses shall have a corresponding ground cable twisted with it, to neutralize the magnetic field.

8.4.7 Corona effect prevention

8.4.7.1 General information

In order to prevent ionization, also referred to as Corona effect, or partial discharges between the outside of an unshielded wire covering and grounded structural elements over which the wire passes, or between the insulation and a screen, the wire covering should have adequate “equivalent insulation thickness” for the conditions of operation. “Wire covering” means any combination of extruded to taped insulations and insulating jackets.

Ionization causing chemical and mechanical deterioration of the coverings, is a source of radio frequency interference, and produces by-products which can corrode adjacent metallic components.

This phenomenon can also be found inside connectors or others electrical components (switching devices,)

For AC operating voltages not exceeding 240 volts rms, any given thickness of low-free insulation is adequate to support this voltage at any pressure or temperature; thickness is dictated by mechanical requirements. For higher AC voltages the “equivalent insulation thickness” can be calculated using the PASCHEN laws.

For DC, electrical cables can be used without ionization to a maximum voltage of 340 volts independent of the usual practical range of wire covering thicknesses. Under certain conditions (notably at high ambient temperatures and/or high altitude) some wire types may not be free from Corona effect at rated voltage.

The following abbreviations can be found:

- PDIV: Partial Discharge Inception Voltage.
- PDEV: Partial Discharge Extinction Voltage.

PDIV is the lowest voltage at which continuous partial discharges occur as the applied voltage is increased.

PDEV is the highest voltage at which partial discharges no longer occur as the applied voltage is decreased from the inception voltage described before.

More precise information on the partial discharge phenomenon can be found in ASTM D 1868 or in EN 60270.

8.4.7.2 Partial discharges consequences

For electrical components, the presence of partial discharges effects at operating voltage may result in a significant reduction of service life.

Some insulation materials are more susceptible to such discharge damage than others.

Evidence of partial discharges during operation signifies for example:

- the wire insulation thickness is insufficient for the applied voltage,
- distance between contact cavities in connector is insufficient for the applied voltage,
- the quality of the insulation is inadequate possibly due to excessive size of internal cavities or voids,
- an overstress is present, resulting in a local reduction of the wire insulation properties,
- a leakage way is present, resulting in a local reduction of the connector insulation properties.

Significant parameters may influence PDIV and PDEV such as pressure, temperature, humidity, previous electrification, rate of the voltage increase. Attention shall be given to installation conditions, for example excessive bending or surface wrinkling of insulation shall be avoided.

Up to few tens of kHz frequency can be considered as non-significant parameter.

8.4.7.3 Minimum distance between live items

With the arrival of new electrical network, also used in non pressurized areas, using higher voltages, Table 1 proposes minimum distance between live items, for an altitude of approx. 15 000 m (50 000 ft):

Table 1

Voltage V		Air space	Insulated material tracking distance
DC	AC	mm	mm
0 to 175	0 to 125	1,6	3,2
175 to 260	125 to 185	3	5
260 to 500	185 to 350	4,9	8
500 to 700	350 to 500	5,2	10
700 to 840	500 to 600	6,5	11,2
840 to 1 050	600 to 750	8	13
1 050 to 1 260	750 to 900	10	15,8

8.4.8 High voltage a.c. and d.c. network

Increase of voltage onboard vehicles is linked to the increase of electrical power necessary for all systems. These voltages are generally associated to high currents. So, particular cares shall be taken for the installation of such network in order to avoid risks of electrical shocks.

In order to ensure voltage segregation and, in case of short circuits, to avoid cross coupling and to limit collateral damage effects, high voltage a.c. routings shall be separated from other routings.

These high voltage routings shall be clearly identified.

8.5 Ignition

8.5.1 Magneto type

Flexible metallic conduit of a type specifically approved for this application by the Design Authority shall be used over magneto circuit cables. Magneto ground cables (except the induction vibrator output cable) shall not run through conduit or junction boxes containing other cables.

8.5.2 Ignition High Energy/High Voltage (HE/HV)

Flexible metallic covering with a single braided metallic screen shall be used over HE/HV cable assemblies. They shall not run parallel with engine harness cables closer than 100 mm or cross them within 10 mm. Any crossing of other cables shall be as near to 90° as possible.

8.6 Mechanical requirements

8.6.1 Cable handling

Cables shall be handled, marked and installed, using lane and system segregation, in such manner to minimize risks of damage with further possibilities of electrical arcing faults between cables and/or electrical ground with associated consequences.

8.6.2 Cable on engines

For direct attachment to engine mounted accessories, copper cables smaller than size 006 (20 AWG) are non preferred. If the Design Authority permits the use of size 004 (22 AWG) or 002 (24 AWG), then only high strength copper alloy conductors shall be used. These cables shall be adequately grouped, spot tied and supported with strain relief devices provided at all terminations.

8.7 Environmental requirements

8.7.1 Ambient temperature of installed harnesses

The maximum ambient temperature to which the cable harness and associated components will be subjected, plus the temperature rise due to current shall not cause the maximum components operating temperature to be exceeded.

The maximum operating temperature quoted in the cable specification shall not be exceeded, after taking into consideration all possible combinations of electrical loading, ambient temperature and the heating effects of the cable bundle (for example, see EN 2084, EN 2235 and EN 2853).

8.7.2 Cable in undercarriage bays

Cable bundles in undercarriage bays which are liable to damage from tyre burst, flying stones, ice, etc. shall be protected by conduits or other mechanical devices. Drain holes shall be positioned at all trap points of conduit systems unless they are fully sealed.

8.7.3 SWAMP Areas

Severe Wind and Moisture Problems areas are areas considered directly exposed to extended weather conditions, such as for example pylons, wheel wells, H/C-upper-deck, wing folds and areas near wing flaps.

In these areas suitable component types shall be chosen or particular protection shall be ensured. Particular attention shall be paid to risks of fluids accumulation.

8.8 Fuel tanks requirements

8.8.1 Rational

Two main risks are identified in fuel and fuel vapour areas:

— exceeding the maximum allowable surface temperature of the fuel tank due to thermal energy resulting from a current injection or an electrical arc,

— Ignition of flammable fuel vapours mixtures due to an electrical arcs (short circuit).

So, harnesses installation shall be designed:

— to preclude damage or heating of the fuel tank boundary,

— to minimize sparking in fuel vapour area.

8.8.2 Cables inside fuel tanks

Cables which are essential to the operation of the fuel system may be routed inside fuel tanks only if there is no alternative. Cables used in circuits capable of generating energy levels greater than 0,02 mJ shall be encased in a grounded metal conduit having a fluorocarbon liner. Cables which come in contact with fuel shall have an insulation which is compatible with the fuel and fuel vapour. Clamps and hardware used to attach cable inside fuel tanks shall also be compatible with fuel and fuel vapour. Tying cord, lacing tape, string, cable ties or other items which could become loose and clog fuel filters shall be prohibited inside fuel tanks. Unless specifically qualified, the use of fibre optic cables inside fuel tank is discouraged for maintenance purpose due to possible hazardous vapours and sensitivity of some fibre materials to fuel.

8.8.3 Wiring segregation

The design and routing of the fuel tank harnesses, used to connect the fuel system components, shall be configured to ensure segregation to protect against the effects of signals cross coupling and short circuits.

The in-tank harnesses shall be physically separated and secured from all other electrical harnesses from the tanks back to their dedicated calculators.

To ensure the reliability of fuel wiring segregation during all the aircraft life, specific identification rules shall be applied.

8.8.4 Harness installation

Outside tank boundary or in fuel vapour areas, the failure of one attachment point shall be considered in order that contact with an adjacent fuel tank boundary or structure (including pipes, equipments…) in a fuel vapour area would not accur.

Outside tank boundary or in fuel vapour areas, the installation shall be designed to ensure that a cut wire/cable can never come in contact with the fuel tank boundary or structure (including pipes, equipments…) in a fuel vapour area.

After the loss of an attachment point or the cut of a wire or cable, there shall be a minimum clearance between the fuel tank wall and the electrical wire/cables. If such clearance cannot be ensured, there shall be a sufficient external protection between the tank wall and the wiring.

Electrostatic protection: see EN 3371.

8.8.5 Cable routing through fuel tanks

The routing of cables through fuel tanks shall be avoided where possible.

If cables, which are not part of the fuel system circuits, shall be routed through fuel tanks, they shall be routed through a dry access cable channel or duct, so as to preclude contact of the cable insulation with the fuel. The cable channel or duct shall be of a size to facilitate the removal and repair of the cables without the removal of the fuel tank and shall have a fluorocarbon liner which will provide electrical insulation. In any case possible short circuit effect shall be considered.

8.9 Fire zone

When the harnesses are located in or passing through a fire zone:

— if the function is not required to operate during fire conditions, fire proof or fire resistant components are not required.

— if one or more functions are required to operate during fire conditions, fire proof or fire resistant components shall be used.

— when components are passing through a firewall the components shall not compromise the firewall resistance.

8.10 Attachment requirements

Cabling shall be supported and protected to meet the following requirements:

a) to prevent chafing or abrasion and guarantee a physical separation of at least 05 mm between any cable and structure or other system. Where physical supports are not possible, grommets or protection strips shall be securely fastened to all adjacent metallic edges;

b) to secure cabling where routed through bulkheads and structural members;

c) to ensure cabling is properly grouped in junction boxes, panels and secure cable bundles;

d) to prevent mechanical strain or work hardening that would tend to break conductors or connections. Cables which are required to move shall be installed so that the harness or bundle will axially twist with movement rather than bend;

e) to prevent arcing or overheated cabling from causing damage to mechanical control cables, associated moving equipment and pipes carrying inflammable fluids;

f) to prevent cabling from hindering maintenance functions, e.g., inspection and modifications;

g) to prevent physical interference between cabling and other equipment;

h) to provide support for cabling so as to prevent excessive movement in areas of high vibration;

i) to dress cabling at connectors and terminating devices in the direction of the run, without deformation of grommet seals.

But:

a) Continuous lacing shall not be used, except in panels and junction boxes where this practice is optional.

b) The use of insulating sleeving for the protection of wiring shall be kept to a minimum. In case of use drainings shall be included to eliminate the possibility of entrapment of liquids.

8.11 Optical cable requirements

8.11.1 Installation

Optical cables can be installed alongside electrical bundles, using the same route categories as defined in 8.13.4.1. Particular caution shall be given to ensure that route temperature is compatible with service temperature of the optical cable used.

Processes used to fix the optical cable on a bundle, such as tying, shall be specifically qualified (see EN 3745-517) in order to ensure that no degradation will affect transmission characteristics.

During installation and maintenance activities, at connection point, attention shall be brought to the protection and cleanliness of extremities.

8.11.2 Attenuation

For fibre optic interconnections, the attenuation associated with the path from the transmitter to receiver, including all intermediate connections, shall be within the limits defined in the system specification.

8.12 Size requirements

Particular attention shall be given to the mechanical strength and installation handling of wire sizes smaller than size 004 (22 AWG). See also 6.3.3.1.1.

According to areas, small bundles longer than 150 mm with very few wires of small sizes shall be adequately supported or protected, by a conduit for example.

As a design objective, the maximum diameter of a complete bundle shall not exceed 50 mm.

In the same bundle, use of wires and cables of very different sizes shall be discouraged.

8.13 Electrical and Optical installation

8.13.1 Zone categories

Because associated constraints could be differents, aircrafts can be divided in specific zones.

Main zones are:

- Pressurized zones
- Hot zones
- Vibration zones
- Hydraulic zones
- Fuel and fuel vapour zones
- SWAMP zones
- Severe environmental zones
- Fire zones
- Hazardous zones
- EMH/EMI sensitive zones
- Cargo zones
- Etc.

8.13.2 General rules

Inside each zone installation rules and practices to apply shall be homogeneous, but attention is brought on the fact that bundles might go through different zones.

Choice of components to use inside bundles shall take into account maximum constraints which can be encountered. For example: fire resistant cable in fire zone, sealed connector in SWAMP areas, etc.

8.13.2 Protection against specific hazards

In addition to general requirements for separation the EWIS installation shall take into account specific hazards such as:

Bird strike, wheels explosion, cross engine debris…

8.13.3 Separation between route categories

8.13.3.1 Route categories

For safety reasons and possible electro-magnetic interference, wires and cables related to all systems shall be installed in physically separated routes.

Numbers and categories of routes are defined according to:

- nature of wires and cables,
- type of voltages,
- type of signals,
- electrical architecture needs,
- segregation of functions, as mentioned in 8.2.2.

Typical examples are:

- Generation routes,
- Power distribution routes in 28 Vdc, 115 Vac, 230 Vac, 220 Vac/50 Hz,
- Signals routes, sensitive to interferences or not,
- Audio and video routes,
- Coaxial, high frequency and leaky line routes,
- Fuel system routes,
- Commercial routes.

8.13.3.2 Route separation

When necessary, route separation shall be maintained throughout the vehicule inclusive of production break joints, connections and wiring.

When such separation is imperative and cannot be ensured by physical wiring separation, approved electrical and EMI protective elements shall be added on one harness.

Distances to be maintained between all the various route categories shall be defined according to the specific needs.

8.13.4 Panels and boxes

When necessary, wiring inside panels, boxes, racks shall be installed in such way that distance between the various routes shall ensure the required separation.

8.13.5 Cabin related harnesses

It is generally allowed for the commercial operators to perform regular cabin reconfigurations or improvement of commercial applications dedicated to passengers. This results in possible modifications to the existing electrical wiring installation.

As such modifications may have impact on basic installation or segregation configurations, the cabin related electrical harnesses shall be segregated from the flight related ones, including connectors.

In order to facilitate recognition, cabin related harnesses shall be specifically identified.

9 Installation and manufacturing principles

9.1 Applicable Rulemaking

According to 5.1.

9.2 Security against high voltage

Energised side of components shall not be accessible by human being while powered. This becomes particularly important with the arrival of new networks, such as 230 Vac, 270 Vdc, for which letal risks are increased.

Particular identification shall be used to highlight possible risks of exposure.

9.3 General principles of cables routing

9.3.1 Arrangement of cables

Cables shall be arranged in looms and harnesses and bundles for ease of installation and maintenance.

Care shall be taken when designing harness bundles with mixed cable sizes to prevent undue stress on the small sizes.

Individual looms and harnesses shall be initially spot tied. When such looms and harnesses are bundled together for installation purposes, lacing cord spot ties need not be removed unless under a clipping point but mechanically applied spot ties shall be removed in all cases.

When flexibility is needed, cables assembled into bundles shall be in a neat lay with a slight twist on the whole bundle.

Crossed cables within a bundle shall be avoided wherever possible.

9.3.2 Inspection and maintenance

As a design objective, in open cabling, looms, bundles or harnesses should be installed to permit inspection and replacement of cables without the removal of the whole.

9.3.3 Dead endings

All unconnected cables shall be dead ended, i.e. insulated in an approved manner. Dead ended cables shall be readily accessible, preferably within 150 mm of connectors and feed-through bushings.

9.3.4 Drip loop and slack in cabling

Where cabling is dressed downward to a connector, terminal block, panel or junction box a drip loop shall be provided in the cabling to prevent fluids or condensate running into the devices. Cabling terminated by potted connectors is exempt from this requirement, as is cabling through pressure bungs. In addition to slack provided for drip loops, slack shall also be provided in the following situations:

a) When electrical cabling is terminated in a connector (excluding RF connectors) a minimum of 50 mm of slack shall be provided to allow for replacement of a complete connector. This slack shall be between the connector and the second cabling support clamp. The 50 mm slack requirement means that, with the connector unmated and the first cable support clamp loosened, the cabling shall permit the front face of the connector to extend 50 mm beyond the point normally required to properly mate with the connector.

b) For fibre optic cabling the minimum of 50 mm may not be sufficient for replacement of a complete connector. The minimum for a particular fibre optic connector type shall be defined by the Design Authority;

c) At each end of a cable terminated by a lug, slack shall be provided equal to twice the length of the lug barrel for cable sizes below 340 (2 AWG) (copper) and size 220 (4 AWG) (aluminium). For cable sizes 340 (2 AWG) and larger (copper) and sizes 220 (4 AWG) and larger (aluminium), the minimum length of slack shall be equal to the length of the crimp barrel. The slack shall be in the vicinity of the terminal lug to allow replacement of the lug, by maintenance personnel, with a minimum disturbance to other cabling;

d) Sufficient to prevent strain on cables, junctions and supports;

e) Sufficient to permit free movement of anti-vibration mounted equipment and racks;

f) Sufficient to permit cabling which would hinder maintenance, to be moved clear without damage or strain.

NOTE The above requirements for slack shall be met on every production aircraft as well as on experimental models.

9.4 Arrangement and installation of power routes

9.4.1 Feeder route

Feeder routes associated with independent power sources or power sources connected in combination shall be installed to ensure adequate physical separation and electrical isolation so that a fault in any one airplane power source EWIS will not adversely affect any other independent power sources.

The separation between these routes shall be positively obtained by means of attachment points locations, separators or special knots using lacing tapes or plastic ties.

The three phase cables of a power feeder should be kept together in the same bundle and easily identifiable.

When several cables exist per phase, a specific separator should be used. The separator could be used between attachment points and in the curve for small bend radius to maintain sufficient clearance between phases.

Positive separation shall be obtained with structure. Electrical insulation between the feeders and structure shall be obtained using insulated devices for attachment. The attachment parts shall be designed and selected to withstand the harsh environments crossed by the routes.

9.4.2 Power route

Positive separation shall be obtained with structure. Electrical insulation between the power cables and structure shall be obtained using insulated devices for attachment. The attachment parts shall be designed and selected to withstand the environments crossed by the routes.

9.4.3 Power supply of equipments

When dual power supply is required for equipment, segregation of lines shall be insure along from source to equipment interface connectors.

9.5 Minimum bending radius requirements

9.5.1 General

Information given below are there as guidelines for electrical installation purpose. These guidelines are necessary when digital mock-ups do not give to designers the same physical information that physical mock-ups were providing.

The intent is to give a bend radius value that is able to maintain an acceptable level of stress on the cable construction and to maintain its original characteristics.

Technical information given by wire and cable standards or by cable manufacturers on their own products shall be considered.

Bending behaviour of wire and cable is dependant on the conductor construction, the insulation or jacket material, the type of screen and associated manufacturing process, but is also dependant on the quality of the installation and associated assembly process.

It shall also be noted that torsion may increase the stress on the insulation at the bending level.

Depending on the type of insulation, a visible means to appreciate possible stresses is to examine the external surface of the wire or cable for possible wrinkles or cracks. Small wrinkles appearing inside the specified bend radius could be acceptable particularly for thin wall insulation construction.

It is also recalled that excessive bending or surface wrinkling due to bending can affect insulation corona resistance when necessary, see 8.4.7.

9.5.2 Method

Except otherwise specified by the manufacturer or the product standard or by specific user validation, the minimum bend radius shall be x times the maximum external diameter.

9.5.3 Bend radius for a standard Wire or Cable used alone

Recommended minimum bend radius for a standard cable used alone shall be as defined in the following Table 2.

Table 2

Cable description		Static installation	Dynamic installation or high vibration area
Wires (single)	Flexible	× 3	× 5
	Small size	× 6	× 12
	Medium size	× 8	× 16
	Large size	× 11	× 22
Cables (assembly or screened jacketed)	Flexible	× 3	× 5
	Small size	× 6	× 12
	Medium size	× 8	× 16
	Large size	× 11	× 22

a) With the following definitions:

Flexible: – particular conductor with high number of strands, or
– flexible insulation or construction (for example: material with high elongation such as PTFE)

Small size: – insulation for size 26 to size 10, or
– simple assembly or single screen construction

Medium size: – insulation from size 8 to size 4
– special multi-core assembly construction
– special screen construction

Large size: – insulation from size 3 to size 0 000
– specific dense construction

b) Guideline for validation:

The validation is given by mandrel diameters used for tests EN 3475-401, EN 3475-403, EN 3475-405, EN 3475-406, EN 3475-410 and EN 3475-512.

9.5.4 Bend radius for a transmission cable used alone

Recommended minimum bend radius for a transmission cable used alone shall be as defined in the following Table 3.

Table 3

Cable description		Static installation	Dynamic installation or high vibration [a] area
Bus cables	Flexible	× 5	× 10
	Standard	× 6	× 12
	Semi-rigid	× 8	× 16
Coaxial	Flexible	× 5	× 10
	Standard	× 7	× 14
	Semi-rigid	× 10	× 20
	Rigid	× 20	× 40
Optical cable	*Standard*	× 10	× 20

[a] For High vibration area, it is recommended to manage the loop resulting of the cable bend radius.
For instance: reduce the pitch between each fitting clamp.
The use of more adequate clamps, without any possible bundle movement, stays necessary.

a) With the following definitions:

Flexible: – flexible insulation or construction.

Standard: – single screen construction,
– extruded jacket.

Semi-rigid: – single strand conductor,
– special screen construction,
– polyimide jacket.

Rigid: – specific dense construction (example: screen tube).

b) Guideline for validation:

For Bus or Coaxial cables information may be found in EN 3375 or EN 4604.

Electrical performances shall be kept with the bend radius defined.

The validation is given by mandrel diameters used for tests EN 3475-401, EN 3475-403, EN 3475-405, EN 3475-406, EN 3475-415 and EN 3475-416 if requested.

9.5.5 Bend radius for optical fibre cables

For optical fibre cable there are two minimum bend radii that shall be observed, short term and long term.

The minimum short term bend radius is the smallest radius that the cable shall be subjected to during loom or bundle arrangement and during subsequent installation and maintenance.

The long term bend radius, or the installed bend radius, is the smallest radius that the cable shall be subjected to once it is installed. Bends shall be smooth and as generous as possible and, if necessary, bend radius restrictors shall be considered as a means of achieving the minimum stated limit (see EN 3745).

The short and long term bend radii are defined in the product standard relating to the optical fibre cables.

9.5.6 Bend radius for bundles or harnesses

Bundles or harnesses may contain various types and sizes of cable, and so particular care shall be given according to their construction.

As general rule, in static installation the minimum bend radius shall be of:

- Six times the bundle diameter with verification that the obtained value is greater than the value of the biggest cable inside the bundle calculated as mentioned in 9.5.3 or 9.5.4. In case of discrepancy the biggest value shall be retained.
- or 10 times the bundle diameter if the bundle contains at least one coaxial cable or fibre optic.
- For dynamic installations, which are never simple to install, the best determination will be given by a practical test representing the most realistic case.

- In first approximation the minimum bend radius shall be of:
- 12 times the bundle diameter with the same verifications than above,
- or 20 times the bundle diameter if the bundle contains at least one coaxial cable or fibre optic.

9.5.7 Bend radius for bundles or harnesses in hinge area

There shall be no contact of the harness with any items during the open/close operations at hinge level.

All relative movement of bundle and clamps is forbidden. According to bundle behaviour the use of two clamps could be necessary.

Where the hinge bundle movement cannot be secured a mechanical protection shall be installed between the two clamps.

It shall also be preferred to use bundle working in torsion rather than in flexion.

The harness can be twisted and preformed in order to facilitate the movement of the bundle in hinge area. The minimum bend radius of the bundle shall be respected in the worst position of the bundle during the movement (see 9.5.6). There shall be also no stress on connection items during the move/remove operations of the equipment.

9.5.8 Service loop for equipment removing (“blind” mounting)

For un-rackable equipment remove, an over length including equipment length shall be applied on the bundle connected to this equipment in order to allow an external disconnection.

There shall be no stress on connection items during the move/remove operations of the equipment.

There shall be no direct contact of the harness with any items when installed.

All relative movement of bundle and clamps is forbidden.

Where the bundle movement cannot be secured a mechanical protection shall be installed to avoid mechanical chafing.

To guarantee a good “blind” mounting: over-length shall be pre-formed and managed in an open or close stowage area.

9.6 Cables preparation

9.6.1 Marking

The procedures used to control the marking of cables for identification purposes, shall ensure that the durability of the marking and the integrity of the cable after marking, meet the requirements of EN 3475 (for cable manufacturer) and EN 3838 (for user).

9.6.2 Cutting to length

The cutting tool shall in no case modify the initial characteristics of the cable.

Suitable tools reserved for this purpose such as cable cutting pliers with rounded and profiled jaws shall be used.

The cut shall be clean, without burrs and perpendicular to the axis of the cable, the geometrical distortion of the diameter must be kept to a minimum in order not to penalize the further stripping and crimping operations.

For aluminium conductor cables, specific care should be taken to comply with this particular technology (oxidation of aluminium surface).

9.6.3 Stripping

The stripping of cables and the tools used for stripping shall be in accordance with EN 2812. The stripping of fibre optic cables and the tools used for their stripping shall be in accordance with EN 3745.

The stripped extremity should not be damaged or polluted between stripping and crimping operations.

9.7 Supports

9.7.1 Cabling support

The spacing of supports shall be such as to ensure that the requirements of 8.10 are met, and shall not exceed the maximum distance between adjacent frames 700 mm. This distance shall be reduced according to specific environmental condition, such as vibration for example.

In addition, where cabling is routed through cutouts in any aircraft structure, clamps, “P” clamps or fairleads shall be installed as necessary to provide mechanical and abrasion protection. Cabling contained in troughs, ducts or conduits is exempt from this requirement. Clamps and “P” clamps for harnesses or looms, which are not circular, shall be shaped to fit the contour of the harness or looms. The primary support of cabling shall not be attached to adjacent cabling.

The harness shall be supported at intervals to prevent it from chaffing with any other surface.

Each fixing point shall be designed so that a minimum clearance of 0,5 mm between bundle and other part is obtained.

Bundle sagging, in clamp intervals, shall preserve a clearance of 5 mm min. between bundle and other parts.

A protection on the part or appropriate tubing on the harness could be used where the previous installation is not possible.

9.7.2 Support at connectors

Cables terminating in connectors shall be supported to dress the cabling in the direction of the run. This may be accomplished by adaptors, clamps, potting and cable guides.

Where no strain relief backshell is fitted, a primary support shall be positioned adjacent to the connector within the dimension shown in Table 4 below:

Table 4

Connector type	**Distance** max. mm
Fixed receptacle	150
Plug - Manufacturing break	150
Plug - Equipment	250
Rack mounting	300

9.7.3 Cable supports

Cable supports shall not restrict the cabling in such manner as to interfere with operation of shock mounts.

9.7.4 Installation of “P” clamps

The harness or loom shall be supported at intervals to prevent it resting on sharp edges or coming into contact with any other surfaces. The distance between “P” clamps shall not exceed 600 mm.

Care shall be taken not to overtighten and cause damage to the cable insulation. Should a suitable size of “P” clamp not be available, the harness/loom shall be wrapped with sufficient suitable tape as described in 7.2.

To avoid entrapment of cables, where possible the mounting point of the “P” clamp shall always be above the harness/loom. “P” clamps having integral wedges shall be preferred. If no such “P” clamps are available, at least one wrap of a suitable tape as in 7.2 shall be used.

9.7.5 Adhesive clamps

Certain designs use adhesive means to fasten bundle supports to the aircraft structure. Service history shows that these can work loose during aircraft operation, either as a result of improper design or inadequate surface preparation. You should pay particular attention to the selection and methods used for affixing this type of wire bundle support.

9.7.6 Installation of Omega clips

Harness branches that are fastened using omega clips shall be of a regular shape in order to ensure adequate grip around the harness. Additional components, such as fillers, may need to be added to the harness in cases where the constituent cables result in an irregular shape.

Omega clips shall not be used where there is a sharp change of direction in the harness route, such that there is a risk of the harness chafing on the edge of the clip or of the harness pulling out of the throat of the clip.

Where omega clips are used, the harness shall be fixed and located such that under maximum ‘g’ loads, the resultant force is not acting through the open throat of the clip.

Where omega clips are used, the harness shall be able to be fitted and removed from the clip without interfering with surrounding scenery.

9.8 Connectors and accessories

9.8.1 Installation

9.8.1.1 Mounting details

As a general rule, mating and unmating of one connector shall be possible without removing the adjacent connectors.

For circular connectors, sufficient space shall be provided between connectors to allow mating and unmating without the use of tools and for external zones, where possible, that space shall allow for handling with gloves.

For rectangular connectors, according to the locking system, sufficient space shall be provided to allow mating and unmating without risk of damage to the cabling or adjacent connectors.

Connectors shall, wherever possible, be mounted so that the axis of the mated pair is horizontal. Where this is not possible, other means shall be employed to ensure that fluids do not collect in the back of the connector. This shall be achieved by the use of drip loops, which are formed from the extra length of cable intended for remaking terminations.

For horizontally mounted connectors the master keyway shall be in the 12 o'clock position, and for vertically mounted connectors, in the the flight direction, otherwise master keyway shall be positioned externally to the equipment. Where angled backshells are used, the outlet position shall be defined on the relevant drawing, by the angle in relation to the master keyway.

Receptacles on pressurized structures shall be mounted with the flange on the high pressure side.

Where possible, connectors shall be installed such that the live side (supply) has socket contacts.

9.8.1.2 Sealing plugs and dummy contacts

Where necessary, dummy contacts shall be fitted to unused cavities to ensure interfacial sealing, unless otherwise authorized by Design Authority, and all unfilled cavities of connectors with environmental grommets and removable contacts shall be fitted with a sealing plug. Components assuming both functions can be used alone.

9.8.1.3 Severe environmental areas

Connectors in such areas and areas of high and sustained vibration shall be of the threaded coupling type, and preferably of the self-locking type, otherwise they shall be wire locked using stainless steel locking wire.

9.8.1.4 Adjacent locations

As a general rule, the use of adjacent connectors with identical polarization shall be avoided. Should this not be possible, the cable harnesses shall be routed, supported and controlled such that a cross connection shall not occur. Total reliance shall not be placed on identification methods.

9.8.1.5 Cable sealing

Before installing a cable into a connector, reference shall be made to the product standard for that connector, to ensure that the cable insulation diameter is compatible with the connector grommet seal. If the diameter is below the size authorized by the product standard, it shall be increased by sleeving as specified by the Design Authority.

9.8.2 Precautions to ensure correct connector mating

9.8.2.1 Connections installation/removal

Connections with terminals liable to be adversely affected by dust, foreign matter, hydraulic fluids, etc, which might cause short-circuits or sparks, shall be protected.

9.8.2.2 Precautions by connectors

Different type of connectors can be used to prevent incorrect connection.

Connectors positioned at a distance of less than 300 mm or 10 times connector diameter shall be of a different size, polarization or contact arrangement.

9.8.2.3 Precautions by routing

The length of cable can be sufficiently reduced to prevent any incorrect connection.

Routings arriving at identical connectors shall be such that permutations are impossible.

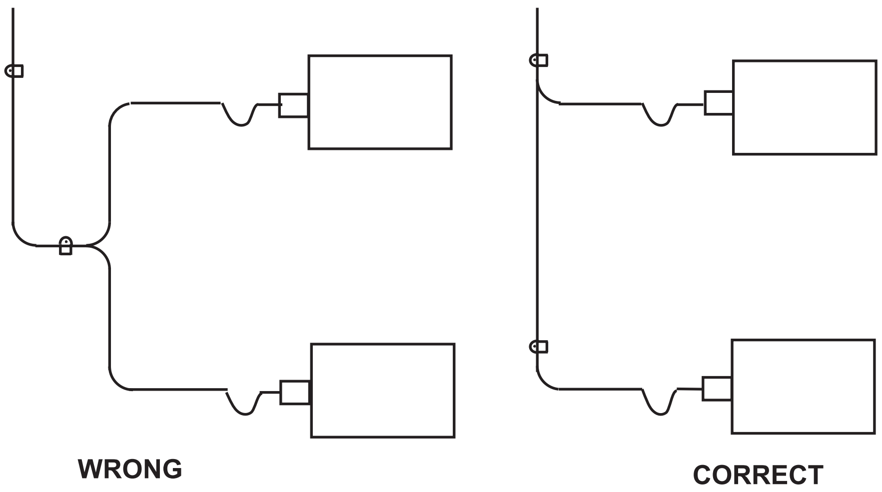


Figure 6

9.8.2.4 Precautions by chains

Applicable also for optical cables.

Not recommended solution.

If it is not possible to change the routing and the connector configuration to avoid a possible permutation of connectors, small chains or leads shall be provided.

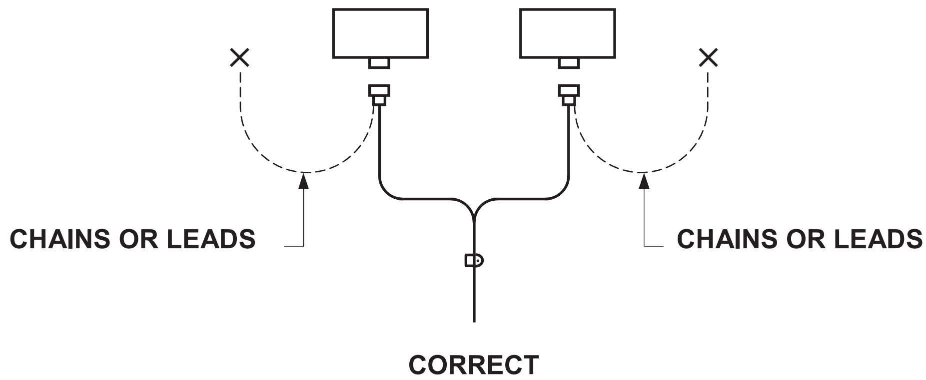


Figure 7

9.8.3 Terminals

9.8.3.1 Soldered terminations

When soldering is necessary, it shall be carried out in accordance with the instructions of the Design Authority, ensuring that the solder and flux used is correct for the conductor plating.

Normally no difficulties are experienced when soldering new conductors or terminations with tin, silver or nickel platings. Lead free solder is not to be used unless the application has been formally qualified.

After service, particularly where used at elevated temperatures, poor solderability may be experienced.

To produce a good soldered joint it may be necessary to carry out one of the following operations:

a) to cut back to a suitable clean section of conductor;

b) to chemically clean the contaminated section of conductor;

c) to replace the contaminated section of conductor as necessary.

Where activated fluxes are used, all residues shall be removed after soldering.

Controlled soldering operations may be carried out using solder sleeves, see 9.9.15, as authorized by the Design Authority.

Solder sleeve devices provide a means for:

— terminating screened cables;

— splicing single and multiple cores;

— splicing screens covering splices in cores of screened cables which maintain 360° screening over length of splice;

— connecting cables or screens to special connectors or connector backfittings designed for this purpose.

9.8.3.2 Crimped terminations

The crimped joints shall meet the performance requirements of EN 2242 and EN 3373 and shall mainly use crimping tools conforming to the requirements of MIL-DTL-22520, EN 4008 or equivalent. Crimping characteristics of contacts shall conform to appropriate product standard.

In no circumstances shall the conductor be doubled back to suit the internal diameter of the crimp barrel.

Unless specifically qualified the crimping of more than one conductor inside the same barrel is forbidden.

9.8.3.3 Fibre optic terminations

The method of terminating optical fibre cables consists of a number of stages. These stages include:

a) cable preparation;

b) crimping and adhesive bonding;

c) cleaving and polishing.

NOTE It is important that the cable and connector combinations shall be as defined in the termination instructions.

9.8.3.3.1 Cable preparation

To enable fibre optic cable to be terminated, the sheath, strength member and coatings shall be cut back and stripped to expose specified lengths of coatings and the fibre itself. Only tools approved by the Design Authority shall be used for this task.

The removal of coatings over the fibre may include chemical or thermal processes in order to achieve a satisfactory bond to the fibre during attachment of the terminal.

NOTE Exposed silica fibres are relatively frail and open to chemical attack, as well as ingress of moisture. Therefore, exposure time shall be kept to a minimum.

9.8.3.3.2 Crimping and adhesive bonding

Crimp tools used to secure part of an optical connector, shall conform to the requirements of EN 4008 (series).

Adhesive bonding of the optical connector to the fibre shall be undertaken with due consideration being given to the curing cycle of the adhesive and its effect on the integrity of the fibre, e.g. the curing temperatures shall not be in excess of 110 °C. Curing times shall be sufficiently long to ensure that the adhesive has fully cured.

9.8.3.3.3 Cleaving and polishing

Cleaving of excess fibre protruding from a bonded connector provides a good fibre end on which to begin polishing. Removal of excess fibre can be achieved using a diamond tipped scribing tool (sapphire or tungsten carbide may be substituted) to score the fibre at the required position, prior to applying an axial force to break the fibre.

Cleaving is also a requirement for splicing techniques of which a purpose designed tool is required to ensure that the fibre end faces are flat and thus produce a low insertion loss. This is because polishing is rarely used when assembling splices.

NOTE Fibre removed during the cleaning process shall be carefully disposed of to avoid injury.

Polishing connectorised fibre ends to achieve a low insertion loss requires that care is exercised throughout the process. Polishing tools and papers may become contaminated during the polishing process. Regular cleaning of polishing tools and regular replacement of polishing papers shall reduce the incidence of scratches on the end face of the fibre.

9.8.4 User control tests for terminals and splices

9.8.4.1 Routine inspection

All crimped terminations shall be visually inspected as defined in EN 2242 and EN 3373, whereas solder sleeves shall be inspected to ensure that:

a) the outer shrinkable sleeve is fully shrunk and there is no damage to the cable insulation (see note below);

b) meltable inserts for sealing, where present, have melted and flowed;

c) the cables or components are correctly installed in the solder sleeve and no strands protrude;

d) the solder inserts have melted completely and have wetted the conductors being joined. Where the solder sleeve has a temperature indicator, it has changed in accordance with the manufacturer's instructions.

NOTE Some discolouration of the outer sleeve is permissible provided that the underlying solder is visible for inspection purposes. Some slight discolouration of the cable sheath may occur close to the solder sleeve, this is not normally detrimental.

9.8.4.2 Inspection and testing of fibre optic terminations

All fibre optic terminations shall be visually inspected to ensure that:

a) the end face of the fibre is clean and free from scratches, cracks and chips;

b) the end face of the fibre is not grown out or sunken;

c) the termination is straight and free from dents and excess adhesive;

d) the fibre is securely bonded in the termination.

Fully terminated cables shall be insertion loss tested. The permitted value of loss shall be defined by the Design Authority. Insertion loss test methods are given in EN 2591-222.

NOTE Under no circumstances shall anyone look into the end of a powered fibre. The only exception to this rule is when a white light source is used during the visual inspection of the end face of an optical fibre.

9.8.5 Fibre optic connectors

Fibre optic terminations shall be protected from dust and contamination.

Connectors with fibre optic contacts shall be sealed or check locked after coupling to avoid any uncontrolled de-coupling and coupling.

After each de-coupling any connector with fibre optic contacts shall have the contact surface of the fibre optic contact inspected and cleaned. (See note in 9.8.3.3).

All connectors with fibre optic contacts shall be provided with a dust cap when disconnected, and shall be labelled in such a way that the connector can be readily identified as a fibre optic connector.

9.9 Splices

9.9.1 In-line splices

When a splice is used to permanently lengthen a cable, the conductors of the existing cable and the extension piece shall have a similar Cross-Sectional Area (C.S.A.).

9.9.2 Step-down splices

This type of splice is used when a conductor of large cross section is desirable to minimize volt drop over a length of cable, but is unsuitable for end terminations. Thus, in this application, the conductors to be joined may have widely differing cross sections, i.e. a difference not normally accommodated by one barrel size.

9.9.3 Insulated splices

All complete splices shall be insulated with a material which is compatible with the cable used and the installation environment. There are three types of splices which may be used, each with a different method of providing the insulation requirement:

a) pre-insulated, which is crimped without the disturbance of insulation;

b) post-insulated, using a special shaped push-on sleeve;

c) post-insulated, using heat shrinkable tubing.

9.9.4 Low air density splices

Where splices are used in areas of rapid pressure changes or excessive moisture, they shall be environmentally sealed, to prevent ingress of moisture. Such splices shall meet the requirements for low air pressure defined in EN 3373, or SAE AS 81824/1.

9.9.5 Location of splices

When necessary splices can not be located under “P” clips, cable ties or Backshell saddle.

In any one particular cable, the spacing between splices shall not be less than 500 mm and no more than two splices shall be used in three metres of cable, except in the case of repairs where additional lengths of cable shall be inserted.

Splices shall, wherever possible, be so positioned that they can be visually inspected after installation.

Splices shall not be located on bends such that the natural form of the loom is impaired.

Splices which are not environmentally sealed shall be installed so as to minimize the possibility of fluid ingress.

Where a number of splices are required in any one cable bundle, they shall be staggered by one splice length along the length of the cable bundle.

9.9.6 Support of splices

Where splices are positioned in single loomed cables the maximum unsupported length of cable shall not exceed 500 mm.

Splices in loomed cables shall be supported by the loom, e.g. by strapping within 50 mm of the end of each splice unless the splice is of a design to provide inherent strain relief, e.g. by a heat shrinkable sheath.

9.9.7 Post-insulation of splices

Uninsulated splices shall be insulated after installation, with materials suitable for the cable and the environment of the zone where the splice is installed. When shrink-on sleeves are used for post-insulation, the diameter of the cable shall, where necessary, be built up to provide an adequate insulation support.

9.9.8 Recording procedure for splices

Any splice used for a repair or modification not foreseen by the Design Authority shall be recorded in the aircraft technical log (or equivalent).

This shall note the following:

a) location;

b) cable identification and, where possible, circuit or other identification;

c) cable size and type;

d) manufacturer's name and part number and standard of the splice.

9.10 Solder sleeve termination

9.10.1 Installation

Solder sleeve terminations shall be heated with the appropriate tool. This will be a hot air blower, a heater using compressed air, or an infra-red heater, which has been specifically designed for the purpose. Such heating devices incorporate a special reflector designed to concentrate heat on the solder pre-form and minimize heating of adjoining insulating materials. When making repairs to existing cables, note shall be made of 9.8.3.1.

For use on fuelled aircraft where concentrations of fuel vapour may provide a safety hazard, only heating tools designed for use in hazardous areas shall be used, e.g. an infra-red heater with inert gas purging.

For screen termination and splicing in severe environmental areas, suitable solder sleeves shall be used (see SAE AS 83519).

Users shall ensure that they have obtained adequate instructions for correct installation and subsequent inspection.

9.10.2 Inspection

The outer sleeve shall be correctly positioned over the completed joint, the solder shall have melted and wetted the joint and, where present, melt able inserts shall have melted to make a seal. Some discolouration of the outer sleeve is allowable provided that it is possible to observe that correct heating of the solder insert has been achieved.

9.11 Terminal lugs

9.11.1 Installations

The design of terminal lug installations shall be such that:

a) when installed no mechanical stress shall be applied to the barrel of the terminal lug;

b) insulating materials shall not be held in compression;

c) screw threads shall not be used as the primary current carrying path;

d) the diameter of the contact surface on which terminal lugs are mounted shall not be less than the tongue width of the terminal lug end;

e) the finish of the terminal lug end and the contact surface shall be electrically compatible to avoid corrosion;

f) where terminal lugs are required to be bent, these shall be pre-formed by the terminal lug manufacturer. If this is not possible, terminal lugs may be bent in accordance with manufacturers specifications for cable sizes 001 to 050 (26 AWG to 10 AWG) during installation, provided it is done once only and through an angle not exceeding 30° or for 45° for AWG12 and smaller. Bending of aluminium lugs is not authorized. For larger cable sizes and greater angles of bend, the manufacturer shall be consulted;

g) to reduce the possibility of human error when assembling cables with ring terminal lug ends, different size stud holes, fanning strips or control of cable length from tie-down points shall be used rather than relying on code identification;

h) non-insulated terminal lugs shall only be used for terminations on structural parts (electrical grounds or bonding jumpers);

i) terminations on structural parts shall be designed in accordance with EN 3371;

j) structural attachment bolts and component fixing bolts or screws shall not be used as primary current path for grounding or earth return terminations.

k) When various terminal lugs must be used on the same stud, particular care must be brought to their electrochemical compatibility, to their shape and to their assembly position. Use of separators/spacers is permitted except for feeders cables. Use of washers between lugs is not permitted.

l) Some terminal lugs may require additional protective sleeve for electrical or mechanical purpose.

m) When used for bounding leads, practices shall comply with requirements of EN 3371.

9.11.2 Terminal lug on screw or stud fixing

All screw terminations shall be provided with some form of locking device. Screws with captive lock washer or stiffnuts are preferable to loose lock washers.

Not more than two terminal lugs or four in two different directions shall be attached to any one screw and in such cases the terminal lug shall be installed back to back, with only the tongues in contact.

If a lock washer is used between the head of the screw and the terminal lug, a plain washer shall not be fitted between the terminal lug and lock washer.

Lock washers with internal or external teeth or features that may damage the protective finish of the terminal log shall not be used.

Nuts for use on copper alloy studs shall be of tin-plated copper alloy. If self-locking nuts are used, only types with a plastic locking device shall be used and these shall be limited to 4 mm diameter maximum, shall be used only once, and shall not be used where heating is likely to occur.

9.11.3 Torque values

Care shall be taken to ensure that the torque loading of nuts on a studded terminal block is in accordance with the product standard.

9.12 Fixing

For attachment of electrical harnesses (protected, non protected or shielded), choice of attachment devices shall take into account environmental constraints linked to the concerned area. Particular care shall be necessary in vibration, SWAMP, fuel and hydraulic areas.

Type of attachment device shall be defined in the installation drawing, with associated rules for choice of size.

These attachment devices can be:

— Metallic clamp with associated protection if the bundle is not protected (by a conduit for example),

— Plastic clamp,

— V support bracket,

— Metallic ramp with associated protection if the bundle is not protected (by a conduit for example),

— Plastic ramp,

- Adhesive clamps (use limited by load per attachment point and environmental conditions),
- Omega clips.

See also 9.7.

9.13 Use of separators

In all cases the use of separators shall be specified in the installation drawings (location and type).

Use of separators shall be kept to a minimum.

Separators shall be strictly limited for segregation function (over length management is not acceptable) and used only when segregation distances between bundles cannot be ensured.

Separator technology / material shall be compliant with environmental constraints.

Where separators are installed the loss of separator shall be taken into account. The design should ensure a minimum clearance of 10 mm after the separator loss.

Where metallic separators are used, they shall be bonded.

9.14 Installation of non-coded equipment

Installation of simple components such as diode, resistance, inside bundles is discouraged.

In all cases the installation of such components shall be specified in the installation drawings (location and type).

The installation of these “in-line” electrical items shall be:

- apparent (visible) at the periphery of the bundle,
- staggered along a harness to avoid contact between them and excessive heat build-up,
- adequately attached on the harness to minimize relative movement,
- located in an accessible area and identified.

Unless a special device affords effective protection against the infiltration of liquids, the installation of these electrical items ‘in-line” with electrical wires shall not be allowed:

- in zones below toilets and galleys,
- in SWAMP areas,
- in hazardous areas.

9.15 Harness mixing

Unless necessary specific segregation rule, standard harnesses, tied separately, can be tied together.

In the common area lacing tape tying is a preferred solution in order to avoid possible damages of bundles at individual tying level. Tying shall take into account the global weight of the harnesses.

Such assembly shall not have a bigger diameter than in 9.16.

9.16 Bundle diameter

The diameter of cable bundles shall not exceed 50 mm.

The variation in the diameter of a tied bundle, composed of same number of cables, shall not be greater than 10 % of its nominal diameter.

For bundles leading to end fittings, connector, ground or connecting module, the volume of the bundle must be within the maximum volume of these end fittings (it is good practice to stagger shielding pick-ups to comply with this point).

9.17 Tying

9.17.1 Tools

Ties shall be applied only with calibrated and approved tension controlled tools, either hand operated or automatic.

9.17.2 Breakouts

Cable ties shall be positioned as close as is practicable on either side of a loom breakout point.

9.17.3 Cable tie positioning

Looms or harnesses in designated high vibration areas such as engines and pylons shall have cable tie spacings not greater than 50 mm.

Other high vibration areas such as wings, tailplane, undercarriage bays and other non-pressurized areas shall have a nominal cable tie spacing of 150 mm with a maximum of 200 mm.

In all other areas, cable tie spacing shall not be greater than 250 mm.

NOTE Additional cable ties shall be installed, when in doubt.

The finished loom shall be smooth and tight with no cable sag or ballooning between cable ties.

Cable ties that are not part of a clipping device shall be positioned to avoid clipping points.

Heads of cable ties shall be positioned to avoid damage to adjacent parts.

9.17.4 Transportation cable ties

Cable ties are often used to maintain the form of a loom or harness during transportation from manufacturing shop to aircraft. Transportation cable ties shall be clearly identifiable as such and they shall be removed on installing the loom or harness in the aircraft.

CAUTION — Care shall be exercised when removing the transportation cable ties, so as not to damage the cables or create foreign object debris.

9.17.5 Lacing

In general, continuous lacing tape or cord shall not be used, except in panels, junction boxes and engine bays where this practice is optional.

9.17.6 Route identification

Coloured plastic ties or lacing tapes or cords may be used to identify cable routes for the purposes of separation requirements.

9.18 Spare provision

At original design level, in order to facilitate evolution, modification or repair of the electrical installation, spare provisions can be provided for wires or cables, contacts on connectors, connector places and conduits.

All basic spares shall be specified in the installation drawings (location and type).

Following indications are given as guidelines and shall be appreciated on an aircraft by aircraft basis:

- Spare conduits can be installed in difficult access areas.
- A draw wire shall be installed inside each spare conduit.
- Spare wires or cables shall be identified at each end plus an end caps at each extremity to provide mechanical and electrical protection.
- For contacts, around 20 % of contact cavities can be available per connector.
- For connectors places, around 15 % of locations can be available on support plates.

9.19 Harness twisting

Harnesses may be twisted during the manufacturing process to cover specific needs in particular areas or zones.

Such twisting improves the harnesses behaviour for flexibility, resistance to severe bending or flexion, vibration, dynamic installation. This can be necessary for wings, at hinges level for doors, for overbraided bundles…

The twisting area shall be determined by attachment points. Installation marker shall be used to positively position the twisting area in the aircraft.

All necessary twists shall be specified in the manufacturing drawings (location and process).

9.20 Use of conduits

9.20.1 General

Conduits used for the mechanical or electrical protection of cables shall be kept to a minimum.

When conduit is used for wires routing, protection against wires chafing within the conduit shall be required in regards with a correct filling ratio.

The size of the conduit shall be determined in order to obtain the maximum permissible fill factor.

Conduits with open end fittings shall be rounded and smoothed without sharp edge.

Inside conduits wires and cables, except for particular electrical need, shall not be attached together, plastic ties, connecting items as connectors, wire splices, and identification sleeves shall not be present.

At each open end of the conduit, wires bundle must to be fixed on a structure bracket by adequate clamp to avoid relative motion between the wires bundle and the conduit.

In the same way, all conduit brackets will not accepted moving in translation between the conduit and the structure.

Conduit shall be fixed to withstand all conditions of vibration or constraint to which it maybe exposed in function of areas where it will be installed.

Flexible conduit shall be installed so that radial movement between fitting points will not impose excessive stress.

Conduit installations shall prevent ingress of liquids and foreign debris

To avoid all liquids entrapment, sealing or the use of drainage holes in bottom points of conduits shall be made.

9.20.2 Filling ratios

To be able to increase the quantity of cables routing inside conduits, these conduits shall only be partially filled. Filling ratios depend of associated technologies used, but following examples seem a good compromise:

- For conduits with length lower than 2 m.
- Filling rate shall not exceed 80 % of the conduit section at the aircraft delivery (20 % of the section spare available for the customer).
- For conduits with length greater than 2 m.
- Filling rate shall not exceed 60 % of the conduit section at the aircraft delivery (20 % of the section spare available for the customer).
- Metallic conduits shall be electrical bonded to the structure.

9.21 Use of Sleeves

Sleeves may be used for the following applications:

a) binding: when it is necessary to maintain cables together,

b) insulation: when it is necessary to add an insulation, for terminal lugs for example,

c) identification: as support of necessary markings, or to provide phase colour,

d) mechanical and thermal protection: when existing parts do no seem sufficient,

e) enlarging diameter: when necessary to improve sealing behaviour at grommet level for example.

Choice of sleeve technology shall be done in accordance with the use.

Care to use the correct size of sleeve shall consider shrink ratio.

9.22 Split conduits or sleeves

Split conduits or sleeves are use when easy installation and removal are expected.

Their aptitude to retain fluids shall be taken into account.

Materials used for these products shall meet requirements of 5.11.4.

Quality of the two edges of the split shall be such that there will be no risks of mechanical aggression for the inside bundles.

For conduits, the maximum admissible bundle diameter shall not move apart the two edges.

For sleeves an overlap is needed. A tracer line shall be included to indicate the minimum overlap, defining the maximum admissible bundle diameter for which the sleeve can operate.

Installation and removal of these electrical sleeves shall be as simple as possible. The help of a simple associated tool is permissible to move apart the two edges. When used, this tool shall not damage the sleeve, its edges and the content.

Formal closure can be obtained by use of ties.

9.23 Over screening

9.23.1 General

Screening of an electrical bundles or harnesses provides electromagnetic protection of the electric cables when necessary, in an area without natural faraday cage protection for example.

Over screening length and associated protection shall be defined in the drawings (location and type).

This can be achieved by use of various technologies which shall be compatible with concerned environmental conditions and materials requirements of 5.11.

The main technologies are:

- shielded conduits,
- direct overbraiding, with or without branches
- conductive sleeves, splitted or not
- raceways,
- wrapped conductive tapes.

For direct overbraiding, manufacturing parameters shall be precisely defined in order to ensure necessary performances such as Transfert impedance.

Overbraiding or conductive sleeves technologies are used for harnesses that means for the assembly of all the bundles constituent one harness. Due to the different lengths of each bundle belongs to the same harness, the notion of branch appears.

The branch diameter will be compliant with both screening efficiency (transfer impedance), manufacturing machine parameters and industrial process.

All angles of deviation shall be manufactured respecting minimum bundle bend radii.

Specific transitions and joiners can be used when changing of technology (over braided bundle to shielded conduit).

One bonding on each extremity minimum, achieved on metallic part, shall be applied in accordance with system requirements. Intermediate bonding could be applied every three metres.

9.23.2 Internal protection

Except for shielded conduits or raceways for which such protection is already provided, an internal protection between cables and braid shall be necessary, or the absence justified.

The selected solution shall enable the best trade-off to be achieved between bundle flexibility and cable protection.

For all protection by tape, where a single wrapping is used, best practice is to overlap by 51 % minimum.

The tape shall be held at each end inside the connector backshell.

Cable length shall take into account the two repairs on each end. It shall be possible to add splices or solder sleeves, where allowed, under the braid but only at the level of the pull back braid.

9.23.3 External protection

Except for raceways, not concerned, an external protection from external aggressions, placed directly on the metallic braid may be required, depending on the aircraft zone.

In SWAMP, fluids and moving parts areas and where chafing is possible, an external protection shall be required.

This protection may either be local or along the whole length of the harness.

An external protection on metallic bands is also required to prevent risks of accident when handling.

9.23.4 Exit attachment

The whole bundle shall be held at outlets to avoid movements or frictions. For that, the bundle can be maintained and protected by a protective sleeve inside the end fitting.

All the end-fitting items used including connector backshells shall be rounded and smoothed without sharp edge.

9.24 Tape

9.24.1 Cases of use

Specific tape can be used for:

- mechanical protection of cables inside overbraiding or conductive sleeves,
- packing, protection of cables on back shells,
- filling, protecting optical cables on bundle couplings,
- fixing of harness hinge (attachment point),
- to protect big or very small diameter bundle with a shape not circular,
- to insure an efficient maintain on clamp,
- on bundles without protection attached by clamp,
- on optical cables installed on V bracket and wiring ramp,
- on optical cables installed in/on harness,
- bundle punctual external protection, which shall not, required any holding (e.g. by clamp),
- convoluted conduit fixed on V support,
- shielded bundle external protection (e.g. harness extremities).

Remark: A tie attachment shall be added to secure the end of the tape, if non self-adhesive.

9.24.2 Type of tapes

Various types of tapes exist. Some of them are self-adhesive, some are more flexible.

They are mainly based on PTFE and Silicone materials.

Self-adhesive glass reinforced tape can be used for mechanical protection of electrical cable in all area from – 65 °C to 260 °C.

9.25 Protection between cables and metallic parts

Any contact between non protected electrical cables and non-insulated metal parts shall be prohibited in operational conditions.

For this purpose, brackets or fasteners shall be so designed as to make any contact impossible.

Where such contact cannot be avoided, the bundle shall have a protective sheath or the metal

surface shall be insulated by an adhesive structural protection or painted when the cable temperature remains lower than 150 °C.

When temperature is above 150 °C PEEK/PTFE coating is required.

Grommet protection shall be installed on the structure when cabling is routed through cutouts in any aircraft structure.

9.26 Panels and Boxes

If panels, boxes or equipment need to be electrically insulated for technical reasons, this shall be defined in the installation drawings with the recommended solution.

When panels, boxes or equipment are installed on support, the corresponding electro-chemical potential between materials in contact shall be taken into account to avoid any corrosion problems. Only metals having a difference of potential less than 300 mV shall be used for permanent contact, unless otherwise agreed by a material specialist or unless sealed connections.

9.27 Feedthrough installation

Each feedthrough shall whenever possible mounted from the pressurized area to the structure. All nuts and screws shall be tightened with the recommended torque given by the assembly instruction. In case, when the mounting screws are loose, the feedthrough will be pressed to the structure and seals the connection itself due to the over pressure.

Also backshells shall be used at least on one side of the feedthrough for cable retention. This prevents movement of the loom. The cable loom shall be guided straight out in order to avoid mechanical constaint on the backshell.

On the airframe feed throughs should be installed on adapterplates. With the help of the plates it is possible to have a bigger hole in the bulkhead. This enables to install the complete loom with connectors through the hole. The plate covers the distance between feedthrough and bulkhead. The adapterplate shall be mounted from the same side as the feed through.

Spare wires can be installed at the compound feedthrough according to the aircraft manufacturers design directive. This allows later during aircraft live the installation of provisions without replacing the complete loom. Also it is possible to install a spare conduit inside the feed through, which is closed with end caps at both ends. This allows later a installation of a complete bundle. At the grommet and split housing feedthrough no spare wires are necessary. The split housing version can be disassembled and wires can be removed or added. At the grommet version empty cavities shall be closed with sealing plugs from the pressurized side of the aircraft.

If shielded looms are used for EMI or lighting protection, only conductive plated components shall be used. Also the grounding through the adapter plate to the structure must be guaranteed.

Cabling shall be handled, marked, stripped and installed so as not to distort the sealing grommet or components (connectors, bulkhead passages, etc.).

When the surface of the cable is not circular and smooth, precautions shall be taken to ensure a satisfactory seal through bulkheads and at terminating devices.

The cables shall be installed so that transverse loads will in no way destroy the integrity of the sealing features of the grommet.

9.28 Terminal junctions

9.28.1 Installation

The design of terminal junction installations shall ensure that:

a) the cables of a certain group of modules shall be tied together to the bundle to prevent tension on the cables. Furthermore with that grouping the amount of cable ties shall be reduced,

b) there is no tension of the cable at the module interface to guarantee the sealing of the grommet, if applicable,

c) a rupture or failure of the frame will not lead to a failure of the cable bundle,

d) not used cavities shall be closed with sealing plugs,

e) each module is identified with labels, which are clipped on the module housing,

f) only modules with grommet shall be used for aluminium cables,

g) only for the module specified cable sizes are used to ensure the sealing of the grommet. If the cable size is too small, it can be thickened up with a shrink sleeve,

h) end clamps shall locked in the A/C with lock wire, if requested,

i) no uncabled contacts shall be inserted in the cavities of the modules.

9.28.2 Installation area

Modules shall be mounted in that way that the centre axis of the cavity is facing horizontal or downwards. If this installation principle is not possible, other protections shall used to ensure that fluids do not collect on the grommet of the module. This can be achieved with the help of drip loops and drip protection above the terminal junctions. Unsealed modules shall be protected with drip loops and drip protection.

Terminal junctions shall not be installed in areas where moisture can accumulate as well the risk of damage by fluids, heat, vapour and mechanical stress must be minimized.

9.29 Locking of standard electrical and optical items

For connectors, locking technologies could be:

— bayonet coupling,

— threaded coupling,

— nut/screw system,

— push pull,

— rack and panel.

Correct positioning of mated parts shall be verified at least by visual inspection.

Free coupling ring, acoustic indicator, clutch mechanism could improve the verification.

In vibration area, connectors, backshells, shall be tightened and locked with:

— self locking device,
— locking compound with activator
— lock wire or safety cable

Torque line, with a fangible paint, should be applied after a torque tightening value has been applied and shall be positioned so that it is visible to facilitate inspection.

9.30 Bonding points – Lightning protection

Practices shall comply with requirements of EN 3371.

9.31 Grounding – Current return

Practices shall comply with requirements of EN 3371.

9.32 Potting

The potting compound selected shall be compatible with concerned environmental conditions and materials requirements of 5.11. It also shall be compatible with all other materials and components and shall not degrade their performance.

The manufacturer's instructions and relevant safety precautions shall be followed when mixing and using the compound.

The packaging shall be marked with a shelf life expiry date and shall not be used after such date, unless recertified.

When potting contains materials e.g. polytetrafluoroethylene (PTFE) or silicone, the surfaces may need etching or priming. Etchants or primers recommended by the manufacturer of the component parts shall be used.

Potting shall be carried out using a suitable mould where applicable, and care shall be taken to ensure that no air bubbles are trapped.

Before filling and while curing, the cables shall be supported and tied loosely together to ensure that the cable bundle is correctly located, and each cable is surrounded by compound.

When heat is used to accelerate curing, temperature shall be compatible with harness components.

Routine inspection shall only be carried out after the recommended curing time has elapsed.

10 Modification and repairs by STC applicants

(1) Preliminaries:

- Operators should repair and STC applicants should design wiring modification with respect to OAM wiring philosophy and instructionsor other equivalent standards acceptable to the administrator.

- Modifiers and maintainers of aeronautical products should use practices that reflect the certification criteria applicable to the original aircraft manufacturer (OAM). (Ref. ANM-01-04).

(2) In order to facilitate inspection/monitoring/replacement/repair/modification, eventually implementation, and finally approval:

(i) Repair data package should comprise: configuration, material and production process necessary to repair the wiring installation, including parts identification, location, installation and routing as appropriate, and the temporary or permanent nature of the repair, in accordance with OAM's standard practices instructions or equivalent.

(ii) Type design data package should comprise: configuration, material and production process necessary to produce each part in accordance with the certification basis of the product, any specification referenced by the required drawings, drawings that completely define location, installation and routing of all equipment etc., (Ref. FAA Policy Statement Number ANM-01-04, System Wiring policy for Certification of Part 25 Airplanes).

Modifications and repairs shall be identified in accordance with the approved OAM's identification process standard or recorded according to efficient and acceptable methods.

(3) All EWIS and OFIS components shall be identified.

(i) When replacing wiring or coaxial cables, identify them adequately at both equipment power source ends at least.

(ii) All wires, terminal blocks, and individual studs are clearly identified to correspond to aircraft wiring manuals.

(iii) Identification should be available all along the wire (preferably at not less than 460 mm maximum) at the defined pattern as defined by the OAM. Identification means at each wire extremity is only acceptable when the physical identification on the wire cable cannot be achieved at [OAM] defined pattern due to e.g. wire length restriction.

(4) Types of wire markings:

(i) The use of Hot Stamp printing of wire in aerospace applications is forbidden not recommended. Good Industry practices do not support the use of hot stamp printing. Suitable non-impact marking methods are readily available as an alternative. These methods include: UV laser printing, dot matrix printing, or ink jet printing when there is no strong need for chemical or mechanical resistance of the ink. If such methods are not available the use of sleeves to carry identification marks should be used instead of marking the wire insulation directly.

(ii) Means used for such identification should be appropriate for the component type. As long as it is installed on the aircraft the marking should be visible and the colour should contrast with the wire insulation or sleeve or support material, e.g. a temporary repair/identification mean using a non-hydraulic resistant material in an hydraulic bay could remain on the aircraft for some days, knowing that the material is not suitable on the long term.

(iii) The characteristics of all EWIS and OFIS components shall not be degraded by the identification process used.

(iv) Replace worn stencils and missing placards in the concerned area.

11 EWIS and OFIS Safety

11.1 Applicable Rulemaking

As a minimum, the installation of EWIS and OFIS components shall take into account EASA Certification requirements and in particular the constraining rule 25.1709 and its associated AC.

11.2 Recommendation

Works necessary to satisfy the rule 25.1709 and its associated AC shall be simplified, if the original design come from an electrical architecture which take strongly into account all requirements coming from Clause 8 of this standard.

Annex A
(informative)

EN 3197 detailed content

Annex B
(normative)

Main normative references and ASD-STAN Technical Reports per family of products

B.1 Quality and General standards

B.1.1 Quality

EN 9133, *Aerospace series — Quality management systems — Qualification Procedure for Aerospace Standard Parts*

B.1.2 Vocabulary

EN 45020, *Standardization and related activities — General vocabulary (ISO/IEC Guide 2:2004)*

IEC 60050-581, *International Electrotechnical Vocabulary — Part 581: Electromechanical components for electronic equipment*

ISO 8815, *Aircraft — Electrical cables and cable harnesses — Vocabulary*

TR 4684, *Aerospace series — Electrical, optical technology and components definitions* [5)]

B.1.3 Installation

EN 2282, *Aerospace series — Characteristics of aircraft electrical supplies*

EN 2283, *Aerospace series —Testing of aircraft wiring*

EN 3197, *Aerospace series — Design and installation of aircraft electrical and optical interconnection systems*

EN 3371, *Aerospace series — Electrical bonding — Technical specification*

EN 3830, *Aerospace series — Electrical load and power source analysis*

EN 3909, *Aerospace series — Test fluids and test methods for electric components and sub-assemblies*

B.1.4 General standards

EN 2424, *Aerospace series — Marking of aerospace products*

EN 2824, *Aerospace series — Burning behaviour of non metallic materials under the influence of radiating heat and flames — Determination of smoke density and gas components in the smoke of materials — Test equipment, apparatus and media*

5) In preparation at the date of publication of this standard.

EN 2825, *Aerospace series — Burning behaviour of non metallic materials under the influence of radiating heat and flames — Determination of smoke density*

EN 2826, *Aerospace series — Burning behaviour of non metallic materials under the influence of radiating heat and flames — Determination of gas components in the smoke*

TR 9535, *Aerospace series — Substance declaration*

TR 9536, *Aerospace series — Declarable Substance Recommended Practice*

B.2 Wires and cables

B.2.1 Test Methods

EN 3475-100 (all parts), *Aerospace series — Cables, electrical, aircraft use — Test methods — Part 100: General*

EN 3909, *Aerospace series — Test fluids and test methods for electric components and sub-assemblies*

B.2.2 Product Norms

B.2.2.1 Conductor Norms

EN 2083, *Aerospace series — Copper or copper alloy conductors for electrical cables — Product standard*

EN 4434, *Aerospace series — Copper or copper alloy lightweight conductors for electrical cables — Product standard (Normal and tight tolerances)*

EN 3719, *Aerospace series — Aluminium or aluminium alloy conductors for electrical cables — Product standard*

EN 4651, *Aerospace series — Copper-clad aluminium alloy conductors for electrical cables — Product standard*

B.2.2.2 135 °C Wires

EN 2084, *Aerospace series — Cables, electric, single-core, general purpose, with conductors in copper or copper alloy — Technical specification*

B.2.2.3 150 °C Wires and Cables

NO STANDARD AVAILABLE

B.2.2.4 180 °C Wires and Cables

EN 2084, *Aerospace series — Cables, electric, single-core, general purpose, with conductors in copper or copper alloy — Technical specification*

EN 4611-002 (all parts), *Aerospace series — Cables, electrical, for general purpose, single and multicore assembly — XLETFE Family — Part 002: General*

EN 2235, *Aerospace series — Single and multicore electrical cables, screened and jacketed*

EN 4612-002 (all parts), *Aerospace series — Cables electrical, for general purpose, single and multicore assembly — XLETFE Family — Jacketed or screened and jacketed — Part 002: General*

B.2.2.5 180 °C Wires and Cables with aluminium or CCAL conductors

EN 4681-001 (all parts), *Aerospace series — Cables, electric, general purpose, with conductors in aluminium or copper-clad aluminium — Part 001: Technical specification* 5)

EN 4682-001 (all parts), *Aerospace series — Cables, electric, screened and jacketed, general purpose, with conductors in aluminium or copper-clad aluminium — Part 001: Technical specification* 5)

B.2.2.6 200 °C Wires and Cables

EN 2084, *Aerospace series — Cables, electric, single-core, general purpose, with conductors in copper or copper alloy — Technical specification*

EN 2266-002 (all parts), *Aerospace series — Cables, electrical, for general purpose — Operating temperatures between − 55 °C and 200 °C — Part 002: General*

EN 2235, *Aerospace series — Single and multicore electrical cables, screened and jacketed*

EN 2713-002 (all parts), *Aerospace series — Cables, electrical, single and multicore for general purpose — Operating temperatures between − 55 °C and 200 °C — Part 002: Screened and jacketed — General*

B.2.2.7 260 °C Wires and Cables

EN 2084, *Aerospace series — Cables, electric, single-core, general purpose, with conductors in copper or copper alloy — Technical specification*

EN 2267-002 (all parts), *Aerospace series — Cables, electrical, for general purpose — Operating temperatures between − 55 °C and 260 °C — Part 002: General*

EN 2854-002 (all parts), *Aerospace series — Cables, electrical, for general purpose — Cross sections equal to and greater than 9 mm*^{2} *— Operating temperatures between − 55 °C and 260 °C — Part 002: General*

EN 2235, *Aerospace series — Single and multicore electrical cables, screened and jacketed*

EN 2714-002 (all parts), *Aerospace series — Cables, electrical, single and multicore for general purpose — Operating temperatures between − 55 °C and 260 °C — Part 002: Screened and jacketed — General*

B.2.2.8 Fireproof and Fire resistant Wires and Cables

EN 2234, *Aerospace series — Cable, electrical, fire resistant — Technical specification*

EN 2346-002 (all parts), *Aerospace series — Cable, electrical, fire resistant — Operating temperatures between − 65 °C and 260 °C — Part 002: General*

EN 4608-001 (all parts), *Aerospace series — Cable, electrical, fire resistant — Single and twisted multicore assembly, screened (braided) and jacketed — Operating temperatures between − 65 °C and 260 °C — Part 001: Technical specification*

EN 4608-002, *Aerospace series — Cable, electrical, for signal transmission — Part 002: General*

B.2.2.9 Coaxial Cables

EN 4604-001 (all parts), *Aerospace series — Cable, electrical, for signal transmission — Part 001: Technical specification*

B.2.2.10 Databus Cables

EN 3375-001 (all parts), *Aerospace series — Cable, electrical, for digital data transmission — Part 001: Technical specification*

B.2.2.11 Thermocouple Wires and Cables

EN 4049-001 (all parts), *Aerospace series — Thermocouple extension cable — Operating temperatures between – 65 °C to 260 °C — Part 001: Technical specification*

B.2.3 Implementation standards

EN 2853, *Aerospace series — Current ratings for electrical cables with conductor EN 2083*

EN 2812, *Aerospace series — Stripping of electrical cables*

EN 3838, *Aerospace series — Requirements and tests on user-applied markings on aircraft electrical cables*

EN 4650, *Aerospace series — Wire and cable marking process, UV Laser*

B.2.4 Particular documents

TR 4648, *Aerospace series — Cable, electrical — Re-qualification following changes in design, material or manufacturing process*

TR 6058, *Aerospace series — Cable code identification list*

B.3 Optical fibre cables, connectors and contacts

B.3.1 Optical fibre cables

B.3.1.1 Test Methods

EN 3745-100 (all parts), *Aerospace series — Fibres and cables, optical, aircraft use — Test methods — Part 100: General*

EN 3909, *Aerospace series — Test fluids for electric components and sub-assemblies*

B.3.1.2 Product Norms

B.3.1.3 280 µm diameter cladding

EN 4532, *Aerospace series — Cables, optical, single core 200 µm/280 µm fibre, 2,5 mm outer jacket — Technical specification*

B.3.1.4 125 µm diameter cladding

EN 4641-001 (all parts), *Aerospace series — Cables, optical, 125 µm diameter cladding — Part 001: Technical specification*

B.3.1.5 Implementation standards

EN 4533 (all parts), *Aerospace series — Fibre optic systems — Handbook*

B.3.1.6 Particular documents

TR 6058, *Aerospace series — Cable code identification list*

B.3.2 Optical connectors and contacts

B.3.2.1 Test Methods

EN 2591-100 (all parts), *Aerospace series — Elements of electrical and optical connection — Test methods — Part 100: General*

EN 3909, *Aerospace series — Test fluids for electric components and sub-assemblies*

B.3.2.2 Product Norms

B.3.2.2.1 Single channel connector

EN 3733-001 (all parts), *Aerospace series — Connector, optical , circular, single channel, coupled by self-locking ring, operating temperature up to 150 °C continuous — Part 001: Technical specification*

B.3.2.2.2 2,5 mm ferrule diameter – Flush contacts

EN 4531-001 (all parts), *Aerospace series — Connectors, optical, circular, single and multipin, coupled by threaded ring — Flush contacts — Part 001: Technical specification*

EN 4626-001 (all parts), *Aerospace series — Connectors, optical, rectangular, multicontact, rack and panel, Quadrax cavity, 2,5 mm diameter ferrule — Operating temperatures − 65 °C to 125 °C (cable dependent) — Flush contacts — Part 001: Technical specification*

B.3.2.2.3 1,25 mm ferrule diameter with removable sleeve holder

EN 4639-001 (all parts), *Aerospace series — Connectors, optical, rectangular, modular, multicontact, 1,25 diameter ferrule, with removable alignment sleeve holder — Part 001: Technical specification*

EN XXXX, *Single and multi channel 1,25 mm — Circular connector*

B.3.2.3 Particular documents

TR 4646-001, Termination and acceptance criteria for EN 4531

TR 4647-001, Termination and acceptance criteria for EN 4639

TR 6058, *Aerospace series — Cable code identification list*

B.4 Connectors and contacts

B.4.1 Test Methods

EN 2591-100 (all parts), *Aerospace series — Elements of electrical and optical connection — Test methods — Part 100: General*

EN 3909, *Aerospace series — Test fluids and test methods for electric components and sub-assemblies*

B.4.2 Product Norms

B.4.2.1 Circular types, threaded coupling:

B.4.2.1.1 Fire resistant or non fire resistant, operating temperature – 65 °C to 175 °C or 200 °C continuous, 260 °C peak. Aluminium or stainless steel shell material.

EN 2997-001 (all parts), *Aerospace series — Connectors, electrical, circular, coupled by threaded ring, fire-resistant or non fire-resistant, operating temperatures – 65 °C to 175 °C continuous, 200 °C continuous, 260 °C peak — Part 001: Technical specification*

B.4.2.1.2 Triple start threaded, scoop proof, fire resistant or non fire resistant, operating temperature – 65 °C to 175 °C or 200 °C continuous. Aluminium, stainless steel or composites shell materials.

EN 3645-001 (all parts), *Aerospace series — Connectors, electrical, circular, scoop-proof, triple start threaded coupling, operating temperature 175 °C or 200 °C continuous — Part 001: Technical specification*

B.4.2.1.3 Scoop proof, fire resistant or non fire resistant, operating temperature – 65 °C to 260 °C peak. Stainless steel shell material.

EN 4067-001 (all parts), *Aerospace series — Connectors, electrical, circular, scoop-proof, coupled by threaded ring, fire-resistant, operating temperature 260 °C peak — Part 001: Technical specification*

B.4.2.1.4 Single way, triaxial interface, operating temperature – 65 °C to 150 °C continuous. Copper alloy shell material.

EN 3716-001 (all parts), *Aerospace series — Connector, single-way, with triaxial interface, for transmission of digital data — Part 001: Technical specification*

B.4.2.2 Circular types, bayonet coupling:

B.4.2.2.1 Medium and high contact density, scoop proof, operating temperature – 65 °C to 175 °C or 200 °C continuous. Aluminium shell material.

EN 3372-001 (all parts), *Aerospace series — Connectors, electrical, circular, medium and high contact density, scoop-proof with bayonet coupling, operating temperatures – 65 °C to 175 °C or 200 °C continuous — Part 001: Technical specification*

B.4.2.2.2 Lightweight, operating temperature – 65 °C to 175 °C or 200 °C continuous. Aluminium shell material.

EN 3646-001 (all parts), *Aerospace series — Connectors, electrical, circular, bayonet coupling, operating temperature 175 °C or 200 °C continuous — Part 001: Technical specification*

B.4.2.3 Rectangular types

B.4.2.3.1 Two screw locking, operating temperature – 65 °C to 150 °C continuous. Aluminium shell material.

EN 3218-001 (all parts), *Aerospace series — Connectors, rectangular, with metallic shells and screw-locking — Part 001: Technical specification*

B.4.2.3.2 Two locking devices, operating temperature – 65 °C to 175 °C continuous. Plastic shell material.

EN 3545-001 (all parts), *Aerospace series — Connectors, electrical, rectangular, with sealed and non-sealed rear, plastic housing, locking device, operating temperatures – 55 °C to 175 °C — Part 001: Technical specification*

B.4.2.4 Rectangular types, rack and panel

B.4.2.4.1 Interchangeable insert type, multi insert cavities, low contact insertion force, operating temperature – 65 °C to 150 °C continuous. Aluminium shell material.

EN 3682-001 (all parts), *Aerospace series — Connectors, plug and receptacle, electrical, rectangular, interchangeable insert type, rack to panel, operating temperature 150 °C continuous — Part 001: Technical specification*

B.4.2.5 Rectangular types, modular

B.4.2.5.1 Multiple removable modules, centre locking screw, operating temperature – 55 °C to 175 °C continuous. Aluminium or composite shell material.

EN 4165-001 (all parts), *Aerospace series — Connectors, electrical, rectangular, modular — Operating temperature 175 °C continuous — Part 001: Technical specification — Product standard*

B.4.2.5.2 Multiple removable inserts, locking screw, operating temperature – 55 °C to 175 °C continuous. Aluminium or composite shell material.

EN 4644-001 (all parts), *Aerospace series — Connector, electrical and optical, rectangular, modular, rectangular inserts, operating temperature 175 °C continuous — Part 001: Technical specification*

B.4.2.6 Coaxial connectors

EN 4652-001 (all parts), *Aerospace series — Connectors, coaxial, radio frequency — Part 001: Technical specifications*

B.4.2.7 Contacts

EN 3155-001 (all parts), *Aerospace series — Electrical contacts used in elements of connection — Part 001: Technical specification*

B.4.2.8 Cable outlet accessories

EN 3660-001 (all parts), *Aerospace series — Cable outlet accessories for circular and rectangular electrical and optical connectors — Part 001: Technical specification*

B.4.2.9 Sealing sleeves

EN 4530-001 (all parts), *Aerospace series — Sealing sleeves used in elements of connection — Part 001: Technical specification*

B.4.2.10 Sealing plugs

EN 4529-001 (all parts), *Aerospace series — Elements of electrical and optical connection — Sealing plugs — Part 001: Technical specification*

B.4.3 Implementation standards

B.4.3.1 Crimping tools and associated accessories

EN 4008-001 (all parts), *Aerospace series — Elements of electrical and optical connection — Crimping tools and associated accessories — Part 001: Technical specification*

B.4.4 Particular documents

TR 4633, *Aerospace series — Connectors, electrical — Change in designe qualification*

TR 4680, *Aerospace series — Contacts, electrical, qualification for change of materials and process*

B.5 Protective devices

B.5.1 Test Methods

EN 3841-100 (all parts), *Aerospace series — Circuit breakers — Test methods — Part 100: General*

EN 3909, *Aerospace series — Test fluids and test methods for electric components and sub-assemblies*

EN 2350, *Aerospace series — Circuit breakers — Technical specification*

B.5.2 Product Norms

B.5.2.1 Circuit breaker single-pole without signal contact

EN 2495, *Aerospace series — Single-pole circuit breakers temperature compensated — rated currents up to 25A — Product standard*

EN 2794-001 (all parts), *Aerospace series — Circuit breakers, single-pole, temperature compensated, rated currents 20 A to 50 A — Part 001: Technical specification*

EN 3773-001 (all parts), *Aerospace series — Circuit breakers, single-pole, temperature compensated, rated currents 1 A to 25 A, switching capacity 65 In / 1 000 A max. — Part 001: Technical specification*

B.5.2.2 Circuit breaker three-pole without signal contact

EN 2592, *Aerospace series — Three-pole circuit breakers temperature compensated rated currents up to 25 A — Product standard*

EN 2665-001, *Aerospace series — Circuit breakers, three-pole, temperature compensated, rated currents 20 A to 50 A — Part 001: Technical specification*

EN 3774-001, *Aerospace series — Circuit breakers, three-pole, temperature compensated, rated currents 2 A to 25 A, switching capacity 65 In — Part 001: Technical specification*

B.5.2.3 Circuit breaker single-pole with signal contact

EN 2995-001 (all parts), *Aerospace series — Circuit breakers, single-pole, temperature compensated, rated current 1 A to 25 A — Part 001: Technical specification*

EN 3661-001 (all parts), *Aerospace series — Circuit breakers, single-pole, temperature compensated, rated current 20 A to 50 A — Part 001: Technical specification*

B.5.2.4 circuit breaker three-pole with signal contact

EN 2996-001 (all parts), *Aerospace series — Circuit breakers, three-pole, temperature compensated, rated current 1 A to 25 A — Part 001: Technical specification*

EN 3662-001 (all parts), *Aerospace series — Circuit breakers, three-pole, temperature compensated, rated current 20 A to 50 A — Part 001: Technical specification*

B.5.3 Implementation standards

EN 6113, *Aerospace series — Circuit breaker, connecting and attachment hardware*

TR 6083, *Aerospace series — Cut-outs for installation of electrical components*

B.6 Switching devices

B.6.1 Test Methods

NO STANDARD AVAILABLE

EN 3909, *Aerospace series — Test fluids and test methods for electric components and sub-assemblies*

B.6.2 Product Norms

B.6.3 Implementation standards

NO STANDARD AVAILABLE

B.7 Terminal junctions

B.7.1 Test Methods

EN 2591-100 (all parts), *Aerospace series — Elements of electrical and optical connection — Test methods — Part 100: General*

EN 3909, *Aerospace series — Test fluids and test methods for electric components and sub-assemblies*

B.7.2 Product Norms

B.7.2.1 Modular interconnection systems

EN 3708-001 (all parts), *Aerospace series — Modular interconnection systems — Terminal junction systems — Part 001: Technical specification*

B.7.3 Implementation standards

B.7.3.1 Crimping tools and associated accessories

EN 4008-001 (all parts), *Aerospace series — Elements of electrical and optical connection — Crimping tools and associated accessories — Part 001: Technical specification*

B.7.4 Particular documents

TR 4633, *Aerospace series — Connectors, electrical — Change in designe qualification*

B.8 Terminal lugs and in-line splice

B.8.1 Test Methods

EN 2591-100 (all parts), *Aerospace series — Elements of electrical and optical connection — Test methods — Part 100: General*

EN 3909, *Aerospace series — Test fluids and test methods for electric components and sub-assemblies*

B.8.2 Product Norms

B.8.2.1 For crimping on electric conductors

EN 3373-001 (all parts), *Aerospace series — Terminal lugs and in-line splices for crimping on electric conductors — Part 001: Technical specification*

B.8.2.2 Implementation standards

EN 2242, *Aerospace series — Control of tools used for crimping of electrical cables with conductors defined by EN 2083 and EN 2346*

B.9 Ties

B.9.1 Test Methods

EN 4057-100 (all parts), *Aerospace series — Cable ties for harnesses — Test methods — Part 100: General*

EN 3909, *Aerospace series — Test fluids and test methods for electric components and sub-assemblies*

B.9.2 Product Norms

B.9.2.1 Plastic cable ties

EN 4056-001 (all parts), *Aerospace series — Cable ties for harnesses — Part 001: Technical specification*

EN 50146, *Cables ties for electrical installations*

B.9.3 Implementation standards

MS 90387, *Tool, hand, adjustable for plastic and metal tiedown straps*

B.10 Solder sleeves

B.10.1 Test Methods

NO STANDARD AVAILABLE

B.10.2 Product Norms

NO STANDARD AVAILABLE

B.10.3 Implementation standards

NO STANDARD AVAILABLE

B.11 Bonding leads

B.11.1 Test Methods

EN 2591-100 (all parts), *Aerospace series — Elements of electrical and optical connection — Test methods — Part 100: General*

EN 3475-100 (all parts), *Aerospace series — Cables, electrical, aircraft use — Test methods — Part 100: General*

B.11.2 Product Norms

B.11.2.1 Bonding straps with terminal lugs crimped on both ends

EN 4199-001 (all parts), *Aerospace series — Bonding straps for aircraft — Part 001: Technical specification*

EN 3371, *Aerospace series — Electrical bonding — Technical specification*

B.12 Clamps

B.12.1 Test Methods

NO STANDARD AVAILABLE

EN 3909, *Aerospace series — Test fluids and test methods for electric components and sub-assemblies*

B.12.2 Product Norms

NO STANDARD AVAILABLE

B.12.3 Implementation standards

NO STANDARD AVAILABLE

B.13 Protective parts

B.13.1 Test Methods

EN 6059-100 (all parts), *Aerospace series — Electrical cables, installation — Protection sleeves — Test methods — Part 100: General*

EN 3909, *Aerospace series — Test fluids and test methods for electric components and sub-assemblies*

B.13.2 Product Norms

B.13.2.1 Protection sleeve in meta-aramid fibres

EN 6049-001 (all parts), *Aerospace series — Electrical cables, installation — Protection sleeve in meta-aramid fibres — Part 001: Technical specification*

B.13.2.2 Wrap around electrical sleeving

EN 4674-001 (all parts), *Aerospace series — Electrical cables, installation, wrap around electrical sleeving — Part 001: Technical specification* [5)]

B.13.3 Implementation standards

NO STANDARD AVAILABLE

B.14 Identification parts

B.14.1 Test Methods

EN 6059-100 (all parts), *Aerospace series — Electrical cables, installation — Protection sleeves — Test methods — Part 100: General*

EN 3909, *Aerospace series — Test fluids and test methods for electric components and sub-assemblies*

B.14.2 Product Norms

B.14.2.1 Protection sleeve in meta-aramid fibres

EN 6049-001 (all parts), *Aerospace series — Electrical cables, installation — Protection sleeve in meta-aramid fibres — Part 001: Technical specification*

B.14.2.2 Wrap around electrical sleeving

EN 4674-001 (all parts), *Aerospace series — Electrical cables, installation, wrap around electrical sleeving — Part 001: Technical specification* [5)]

B.14.3 Implementation standards

NO STANDARD AVAILABLE

B.15 Installation Components

B.15.1 Test Methods

NO STANDARD AVAILABLE

EN 3909, *Aerospace series — Test fluids and test methods for electric components and sub-assemblies*

B.15.2 Product Norms

NO STANDARD AVAILABLE

B.15.3 Implementation standards

NO STANDARD AVAILABLE

B.16 Lamps

B.16.1 Test Methods

EN 2756, *Aerospace series — Lamps, incandescent — Tests*

B.16.2 Product Norms

B.16.2.1 Lamps, incandescent

EN 2240-001 (all parts), *Aerospace series — Lamps, incandescent — Part 001: Technical specification*

B.16.2.2 Lamps, electroluminescent

EN 4453-001, *Aerospace series — Electroluminescent lamps — Part 001: Technical specification* [5)]

B.16.3 Implementation standards

NO STANDARD AVAILABLE

Annex C
(informative)

Differences of electrochemical potentials between some conductive materials (in mV)

See Table C.1.

Table C.1

ABCISSA

ORDINATE	Platinium	Gold/Carbon	Stainless steel	Titanium	AG - HG	Nickel	Copper alloy	Copper	Alu-bronze Brass 30 % ZN	Silicon	Brass 50 % ZN	Bronze	Tin	Lead	Light alloy NSA 3001	Steels	Aluminium A5	Cadmium	Chromium	Zinc	Manganese	Magnesium
Platinium	0	130	250	340	350	430	450	570	600	685	700	770	800	840	940	1 000	1 090	1 100	1 200	1 400	1 470	1 950
Gold/Carbon	130	0	110	210	220	300	320	440	470	535	570	640	670	710	810	870	960	970	1 070	1 270	1 340	1 620
Stainless steel	250	110	0	90	100	160	200	320	350	415	450	520	550	590	690	750	840	850	950	1 150	1 220	1 700
Titanium	340	210	90	0	10	90	110	230	260	325	360	430	460	500	600	680	750	760	860	1 060	1 150	1 610
Silver - Mercury	350	220	100	10	0	80	100	220	250	315	350	420	450	490	590	650	740	750	850	1 050	1 120	1 600
Nickel	430	300	180	90	80	0	20	140	170	235	270	340	370	410	510	570	650	670	770	970	1 040	1 520
Copper alloy	450	320	200	110	100	20	0	120	150	215	250	320	350	390	490	530	640	650	750	950	1 020	1 500
Copper	570	440	320	230	220	140	120	0	30	95	130	200	230	270	370	430	520	530	630	830	900	1 380
Alu-bronze Brass 30 % ZN	600	470	350	260	250	170	150	30	0	65	100	170	200	240	340	400	490	500	600	800	870	1 350
Silicon	665	535	415	325	315	235	215	95	65	0	35	105	135	175	275	335	425	435	353	735	805	1 285
Brass 50 % ZN	700	570	520	360	350	270	250	130	100	35	0	70	100	140	240	300	390	400	500	700	770	1 250
Bronze	770	640	550	430	420	340	320	200	170	105	70	0	30	70	170	230	320	330	435	630	700	1 180
Tin	800	670	590	460	450	370	350	230	200	135	100	30	0	40	140	200	290	300	400	600	670	1 150
Lead	840	710	680	500	490	410	390	270	240	175	140	70	40	0	100	160	250	260	300	560	630	1 110
Light alloy NSA 3001	940	810	690	600	590	510	490	370	340	275	240	170	140	100	0	60	150	160	260	460	530	1 010
Steels	1 000	870	750	660	650	570	550	430	400	335	300	230	200	160	60	0	90	150	200	400	470	950
Aluminium A5	1 090	960	840	750	740	650	640	520	490	425	390	320	290	250	150	90	0	100	110	310	380	860
Cadmium	1 100	970	850	760	750	670	650	530	500	435	400	330	300	260	160	150	100	0	100	300	370	850
Chromium	1 200	1 070	950	860	850	770	750	630	600	535	500	430	400	360	260	200	110	100	0	200	270	750
Zinc	1 400	1 270	1 150	1 050	1 050	970	950	830	800	735	700	630	600	560	460	400	310	300	200	0	70	550
Manganese	1 470	1 340	1 220	1 150	1 120	1 040	1 020	900	870	805	770	700	670	630	530	470	380	370	270	70	0	480
Magnesium	1 950	1 620	1 700	1 610	1 600	1 520	1 500	1 380	1 350	1 285	1 250	1 180	1 150	1 110	1 010	950	860	850	750	550	480	0

Below the line X ═══ X the metal of the ordinate is attacked

Above the line Y ═══ Y the metal of abscissa is attacked

Between these 2 lines, the contact is practically neutral Electrolysis: water with 2 % salt.

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