SLOVENSKI STANDARD
SIST EN 4533-004:2018

01-marec-2018

Nadomešča:
SIST EN 4533-004:2009

Aeronavtika - Sistemi iz optičnih vlaken - Priročnik - 004. del: Popravila, vzdrževanje in nadzor

Aerospace series - Fibre optic systems - Handbook - Part 004: Repair, maintenance, cleaning and inspection

Luft- und Raumfahrt - Faseroptische Systemtechnik - Handbuch - Teil 004: Reparatur, Wartung und Inspektion

Série aérospatiale - Systèmes des fibres optiques - Manuel d'utilisation - Partie 004 : Réparation, maintenance, nettoyage et contrôle

Ta slovenski standard je istoveten z: EN 4533-004:2018

ICS:

33.180.01	Sistemi z optičnimi vlakni na splošno	Fibre optic systems in general
49.060	Letalska in vesoljska električna oprema in sistemi	Aerospace electric equipment and systems

SIST EN 4533-004:2018 en,fr,de

EUROPEAN STANDARD

NORME EUROPÉENNE

EUROPÄISCHE NORM

EN 4533-004

January 2018

ICS 49.060

Supersedes EN 4533-004:2006

English Version

Aerospace series - Fibre optic systems - Handbook - Part 004: Repair, maintenance, cleaning and inspection

Série aérospatiale - Systèmes des fibres optiques - Manuel d'utilisation - Partie 004 : Réparation, maintenance, nettoyage et contrôle

Luft- und Raumfahrt - Faseroptische Systemtechnik - Handbuch - Teil 004: Reparatur, Wartung und Inspektion

This European Standard was approved by CEN on 23 July 2017.

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.

CEN members are the national standards bodies of Austria, Belgium, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, Former Yugoslav Republic of Macedonia, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Romania, Serbia, Slovakia, Slovenia, Spain, Sweden, Switzerland, Turkey and United Kingdom.

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

CEN-CENELEC Management Centre: Avenue Marnix 17, B-1000 Brussels

Ref. No. EN 4533-004:2018 E

Contents

Page

European foreword

This document (EN 4533-004:2018) 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 July 2018 and conflicting national standards shall be withdrawn at the latest by July 2018.

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

This document supersedes EN 4533-004:2006.

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, Former Yugoslav Republic of Macedonia, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Romania, Serbia, Slovakia, Slovenia, Spain, Sweden, Switzerland, Turkey and the United Kingdom.

Introduction

a) The Handbook

This handbook aims to provide general guidance for experts and non-experts alike in the area of designing, installing, and supporting fibre-optic systems on aircraft. Where appropriate more detailed sources of information are referenced throughout the text.

It is arranged in 4 parts, which reflect key aspects of an optical harness life cycle, namely:

Part 001: Termination methods and tools

Part 002: Test and measurement

Part 003: Looming and installation practices

Part 004: Repair, maintenance, cleaning and inspection

b) Background

It is widely accepted in the aerospace industry that photonic technology significant advantages over conventional electrical hardware. These include massive signal bandwidth capacity, electrical safety, and immunity of passive fibre-optic components to the problems associated with electromagnetic interference (EMI). Significant weight savings can also be realized in comparison to electrical harnesses which may require heavy screening. To date, the EMI issue has been the critical driver for airborne fibre-optic communications systems because of the growing use of non-metallic aerostructures. However, future avionic requirements are driving bandwidth specifications from 10’s of Mbits/s into the multi-Gbits/s regime in some cases, i.e. beyond the limits of electrical interconnect technology. The properties of photonic technology can potentially be exploited to advantage in many avionic applications, such as video/sensor multiplexing, flight control signalling, electronic warfare, and entertainment systems, as well as sensor for monitoring aerostructure.

The basic optical interconnect fabric or `optical harness’ is the key enabler for the successful introduction of optical technology onto commercial and military aircraft. Compared to the mature telecommunications applications, an aircraft fibre-optic system needs to operate in a hostile environment (e.g. temperature extremes, humidity, vibration, and contamination) and accommodate additional physical restrictions imposed by the airframe (e.g. harness attachments, tight bend radii requirements, and bulkhead connections). Until recently, optical harnessing technology and associated practices were insufficiently developed to be applied without large safety margins. In addition, the international standards did not adequately cover many aspects of the life cycle. The lack of accepted standards thus lead to airframe specific hardware and support. These factors collectively carried a significant cost penalty (procurement and through-life costs), that often made an optical harness less competitive than an electrical equivalent. This situation is changing with the adoption of more standardized (telecoms type) fibre types in aerospace cables and the availability of more ruggedized COTS components. These improved developments have been possible due to significant research collaboration between component and equipment manufacturers as well as the end use airframers.

1 Scope

The handbook gives guidelines related to 'Fault analysis and repair' as well as 'maintenance and inspection of fibre optic links. The first deals with what to do when something goes wrong – how to go from a fault notification to locating the fault, and finally, repairing it. The second covers the recommended procedures for upkeep and maintaining harness health over the lifetime of its installation.

2 Normative references

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

EN 4533-001, *Aerospace series — Fibre optic systems — Handbook — Part 001: Termination methods and tools*

EN 4533-002, *Aerospace series — Fibre optic systems — Handbook — Part 002: Test and measurement*

EN 4533-003, *Aerospace series — Fibre optic systems — Handbook — Part 003: Looming and installation practices*

EN 2591-601, *Aerospace series — Elements of electrical and optical connection — Test methods — Part 601: Optical elements — Insertion loss*

EN 3733 (all parts), *Aerospace series — Connector, optical, circular, single channel, coupled by self-locking ring, operating temperature up to 150 °C continuous*

EN 4531-101, *Aerospace series — Connectors, optical, circular, single and multipin, coupled by threaded ring — Flush contacts — Part 101: Optical contact for EN 4641-100 cable – 55 °C to 125 °C — Product standard*

EN 4639-101, *Aerospace series — Connectors, optical, rectangular, modular, multicontact, 1,25 diameter ferrule, with removable alignment sleeve holder — Part 101 : Optical contact for cable EN 4641-100 — Operating temperatures between – 65 °C and 125 °C — Product standard*

EN 4645 (all parts), *Aerospace series — Connectors, optical, circular, single and multipin, coupled by threaded ring, self-locking 1,25 mm diameter ferrule with removable alignment sleeve holder*

IEC 60825-1, *Safety of laser products — Part 1: Equipment classification, requirements and user's guide*

IEC 61300-3-35, *Fibre optic interconnecting devices and passive components — Basic test and measurement procedures — Part 3-35: Examinations and measurements — Visual inspection of fibre optic connectors and fibre-stub transceivers*

ARINC 805, *Harsh environment fibre optic connectors/testing*

SAE-AS5675, *Characterization and requirements for new aerospace fibre optic cable assemblies — Jumpers, end face geometry, link loss measurement, and inspection*

3 Fault analysis

3.1 Fault notification

A fault notification will arise from one or more of three sources; scheduled maintenance, Built-In-Test (BIT), or failure of equipment.

Ideally, scheduled maintenance should highlight all latent faults i.e. those which initially have no effect on the system performance but may lead to a problem sometime later during aircraft operation. It should also highlight faults of the gradual degradation type i.e. those which gradually deteriorate the system performance but have yet to cause a failure and any other faults that slipped through the BIT net.

BIT is the ability of the aircraft's systems to diagnose themselves. It should identify all faults that occur in the time between scheduled maintenance and, with the exception of sudden catastrophic faults, before a failure occurs. It should also be able to provide some help in locating the fault.

Failure is the worst case and should only be the result of a fault occurring which cannot be prepared for.

3.2 Symptoms

This is where differences between fibre optic and electrical installations become apparent. The most common symptom in a fibre optic link is complete or partial loss of optical power. This occurs when light breaks its confinement from the fibre core and can be the result of damage to the fibre or interconnect. It can also be the result of contamination of the fibre optic terminus end face, excessive pressure, crushing or severe bending on the fibre optic cable. Depending on the magnitude of the loss, the result may be a fault that is above or below the link threshold – a fault below the link threshold is a failure. Severe damage, such as an optical fibre break may induce a complete loss of optical power.

Intermittent optical signals are possible and may be the result of fibre movement e.g. vibration or bending of a fibre. An increase in optical power is also possible although this is more likely to be due to stability of the light source rather than the link itself.

Gradual degradation of optical power is an important symptom to be able to detect as it could indicate the onset of a failure. Increasing contamination or proliferation of damage to the fibre optic terminus end face could be responsible. Outside of the harness it could be due to degradation of an optical source.

Back reflection is a phenomenon that occurs at any interface with different refractive index, e.g. glass/air. Back reflection is of particular concern where active devices utilise laser-based systems where reflected light can affect the transmitting capabilities of the optical source. This can result in degradation of the transmitted signal and potentially damage the optical source.

Latent fault symptoms i.e. those which have no effect on the optical power of the system but could be the first stage of a fault that does. These are most likely to be noticed during inspection and include poor routing, incorrect retention methods leading to exertion of excessive pressure on the fibre optic cable and poor stress relief on interconnects.

3.3 Potential faults

3.3.1 Fibre

Fibre breaks can occur in the cable where the fibre enters a connector and inside the connector ferrules. A broken fibre would lead to total loss of optical power or, if an optical path was maintained across the break, a reduction in power which could oscillate under vibration. Fibre breaks are most likely to occur during installation or other maintenance work when the fibre is placed under excessive stress. Latent faults such as damage to the structure of a backshell may lead to a break where the fibre is at its most vulnerable – entering the connector ferrules.

Other fibre faults are cracks which may develop under environmental stress and micro-bending which is where the fibre is bent into ‘ripples’ of millimetre bend radii within the cable. This effect has been seen in telecommunication cables when exposed to cold temperatures which cause the cable jacketing to contract. Damage and contamination of the fibre end face are listed as connector faults.

Another possible fibre fault can also occur, which is due to localized stress (for instance unappropriated cable-tie mounting, low bend radius, fibre crush) applied to the fibre that may induce unwanted optical attenuation.

3.3.2 Cable

Physical damage to the cable can come from abrasion or clamping/crush damage. The cable also has a long and short-term minimum bend radius. If these are not adhered to, there is risk of damage to the fibre.

3.3.3 Connector

The connector and the area around the connector is perhaps the most susceptible to faults. De-mating can lead to the most common problem; contamination. De-mating is discouraged as far as possible but it is unavoidable in some circumstances.

Contamination can range from mild, where a wipe clean with a lint-free cloth will suffice, to severe, where the connection mechanism is affected. Contamination may lead to permanent damage of the fibre end face. Fluid contamination presents some unique problems.

There are also issues of fibre grow in/out (when the adhesion between fibre and ferrule fails) and fibre misalignment.

Connectors also have the potential to be carrying latent faults such as over-tightening of the connection mechanism and inadequate strain relief.

3.3.4 Backshell

Apart from physical damage to the backshell there is also potential for fibres to be crushed, bent or strangled if the routing within the backshell is not correct.

3.3.5 Conduit

Breaking, kinking or crushing of conduit could have an effect on the optical fibre but experience with electrical harnesses suggests that damage to a conduit is likely to be a latent fault which is found during scheduled maintenance before it affects harness performance.

3.3.6 Pigtailed components

A break or crack of a pigtailed fibre from a component would give rise to a total or partial optical power loss symptom.

3.3.7 Splices

Splice faults that could have a direct effect on the optical signal include fibre separation. Additionally, mechanical splices may be degraded by contamination, fluids ingress, migration of index matching means. Latent faults are similar to those for connectors; inadequate strain relief and support.

3.3.8 Others

The faults listed above are limited in scope to the harness. Faults at the hardware interface level e.g. transceivers and controlling electronics would result in a selection of the symptoms detailed in 3.2. Potential faults are summarised in Table 1.

Table 1 — Possible symptoms for optical component failure

	Complete loss of optical power	***Drop in optical power or intermittent loss of power or gradual degradation***	***Increase in back reflection***	***Decrease in optical power***	***Latent fault symptom***
Fibre	*Fibre break*	*Fibre break* *Fibre crack* *Micro-bending*	*Fibre break* *Fibre crack*	*Fibre localized stress*	—
Cable	—	*Tight Bend* *Cable Crushed*	—	—	*Cable abrasion* *Cable crushing* *Cable split*
Terminus	*Severe contamination* *Fibre grow in/out* *Fibre break inside of terminus*		*Fibre grow in/out* *Fibre misalignment*	—	*Inadequate strain relief*
Connector	*Contamination*	*Contamination* *Fluid ingress*	—	*Fluid ingress (index matching)*	*Inadequate strain relief*
Backshell	—	*Fibres crushed/bent/strangled*	—	—	*Physical damage*
Conduit	—	*Conduit kink or crush*	—	—	*Conduit break, kink or crush*
Coupler	*Pigtail break* *Mixer rod crack*	*Pigtail break/Crack* *Mixer rod crack*	*Pigtail break*	—	—
Splice	*Fibre grow in/out* *Packaging failure*	*Fibre grow in/out* *Packaging failure* *Fluid ingress*	*Poor end face preparation* *Poor end face alignment*	—	*Inadequate strain relief*
Other	*Transceiver fault*	*Transceiver fault*	—	*Transceiver fault*	—

3.4 Fault identification and location

3.4.1 General

Fault finding techniques and strategies will play a key role in restoring and maintaining the integrity of aircraft fibre-optic systems. Unless appropriate solutions are available the aircraft operator could incur significant down time, cost, and inconvenience whilst the fault is being located. The problem is exasperated by the fact that the fibre-optic networks in question could be relatively complex, incorporating fan-out connection paths (enabled by passive couplers or active switches, for example) and may be harnessed into relatively inaccessible areas of the airframe.

Criteria considered when assessing potential fault finding techniques included:

— effectiveness of the technique for likely fault scenarios,

— cost of equipment,

— skill level and time required to perform the technique,

— size, weight, power requirements, and robustness of equipment,

— safety issues.

The first factor that will influence the choice of fault location technique is the type of harness – inaccessible, embedded or open. Several of the techniques described below cannot be used on an embedded or inaccessible harness.

The first step of fault identification is to determine the failed part: cable, connector or system. The following fault location methods are presented from the simplest to the most complex.

3.4.2 Good practices during maintenance/Inspection

The following good practices are recommended to be included as part of any overall scheduled maintenance philosophy:

— Whenever test equipment requires de-mating of a connector the appropriate cleaning procedure should be followed to ensure no contamination is introduced.

— End protection must be used at all times. When de-mating is required the de-mated connectors should be protected. Dust caps should be kept clean. Disposable items are preferred.

— Correct fibre handling procedures should be followed to avoid damage. Minimum bend radii should be observed. Exposed fibre should be treated as sharps.

— Eye safety issues should be highlighted. Test equipment should all be eye safe and extra care needs to be taken if the system transceivers pose potential eye safety problems.

— Correct sources and filters should be used for all footprinting, including O.T.D.R’s. Failure to do so will invalidate data collected.