EESTI STANDARD EVS-EN 4533-001:2020

Aerospace series - Fibre optic systems - Handbook - Part 001: Termination methods and tools

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European foreword

This document (EN 4533-001:2020) 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 document 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 document shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by August 2020, and conflicting national standards shall be withdrawn at the latest by August 2020.

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 4533-001:2006.

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Introduction

a) The Handbook

The purpose of EN 4533 is to provide information on the use of fibre optic components on aerospace platforms. The documents also include best practice methods for the through-life support of the installations. Where appropriate more detailed sources of information are referenced throughout the text.

The handbook is arranged into 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 offers 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 aero structures. However, future avionics 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, vibrations, 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 leads 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 users air framers.

1 Scope

1.1 General

Part 001 of EN 4533 examines the termination of optical fibre cables used in aerospace applications. Termination is the act of installing an optical terminus onto the end of a buffered fibre or fibre optic cable. It encompasses several sequential procedures or practices. Although termini will have specific termination procedures, many share common elements and these are discussed in this document. Termination is required to form an optical link between any two network or system components or to join fibre optic links together.

The fibre optic terminus features a precision ferrule with a tight tolerance central bore hole to accommodate the optical fibre (suitably bonded in place and highly polished). Accurate alignment with another (mating) terminus will be provided within the interconnect (or connector) alignment mechanism. As well as single fibre ferrules, it is noted that multi-fibre ferrules exist (e.g. the MT ferrule) and these will also be discussed in this part of the handbook.

Another technology used to connect 2 fibres is the expanded beam. 2 ball lenses are used to expand, collimate and then refocus the light from and to fibres. Contacts are not mated together. It helps reducing the wear between 2 contacts and allows more mating cycles. This technology is less sensitive to misalignments and dust. Losses are remaining more stable than butt joint contact even if the nominal loss is higher.

NOTE Current terminology in the aerospace fibre optics community refers to an optical terminus or termini. The term optical contact may be seen in some documents and has a similar meaning. However, the term contact is now generally reserved for electrical interconnection pins. The optical terminus (or termini) is housed within an interconnect (connector is an equivalent term). Interconnects can be single-way or multi-way. The interconnect or connector will generally house the alignment mechanism for the optical termini (usually a precision split-C sleeve made of ceramic or metal). The reader should be aware of these different terms.

An optical link can be classified as a length of fibre optic cable terminated at both ends with fibre optic termini. The optical link provides the transmission line between any two components via the optical termini which are typically housed within an interconnecting device (typically a connector) with tight tolerancing within the alignment mechanisms to ensure a low loss light transmission.

Part 001 will explain the need for high integrity terminations, provide an insight into component selection issues and suggests best practice when terminating fibres into termini for high integrity applications. A detailed review of the termination process can be found in section 4 of this part and is organised in line with the sequence of a typical termination procedure.

The vast number of cable constructions and connectors available make defining a single termination instruction that is applicable to all combinations very difficult. Therefore, this handbook concentrates on the common features of most termination practices and defining best practice for current to near future applications of fibre optics on aircraft. This has limited the studies within this part to currently available ‘avionic’ silica fibre cables and adhesive filled butt-coupled type connectors. Many of the principles described however would still be applicable for other termination techniques. Other types of termination are considered further in the repair part of this handbook.

It is noted that the adhesive based pot-and-polish process is applicable to the majority of single-way fibre optic interconnects connectors and termini for multi-way interconnects and connectors. They share this commonality.

1.2 Need to high integrity terminations

In order to implement a fibre optic based system on an aircraft it is vital to ensure that all the constituent elements of the system will continue to operate, to specification, over the life of the system. An important aspect of this requirement is the need for reliable interconnection components. Interconnects are a key component in any fibre optic system or network. Digital communications links, sensor systems, entertainment systems etc. all require interconnects both at equipment interfaces and for linking cables and harness sections together over the airframe.

Interconnects need to be robust to mating and demating operations, environmental changes and also the effects of contamination. They need to be amenable to inspection and cleaning for through life support.

The choice of technology used in optical links and connections is mainly dependant of the environment. In service performance is a pillar in the component selection. Cable to connector interface needs to be assessed to prove the effectiveness of the solution.

High integrity terminations are required to ensure reliable, low loss light transmission through the interconnection. High integrity terminations are produced by observing best practice and using the correct materials, tools and procedures with appropriate controls.

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.

All interconnection technologies are taken in account in the context of the EN 4533-001.

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

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

EN 4533-004, *Aerospace series — Fibre optic systems — Handbook — Repair, maintenance, cleaning and inspection*

3 Component Selection

3.1 Elements

It is important to recognise that a fibre optic termination, while appearing straightforward, is in fact a complex interaction of the constituent elements such as: fibre, ferrule, fibre coatings, connector design, cable strength member anchorage method, adhesive type and cure regime (where used), material properties and so on. Each of these elements will have an impact on the termination, in terms of reliability, integrity and process complexity.

The following sections discuss the key elements to the termination.