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Space systems — Fiber optic components — Design and verification requirements

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Foreword

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This document was prepared by Technical Committee ISO/TC 20, *Aircraft and space vehicles*, Subcommittee SC 14, *Space systems and operations*.

Introduction

Fibre optic sub-systems are finding increasingly wide utilizations in space systems. In these fibre optic sub-systems, fibre optic components are the significant elements. Hence, the reliability of fibre optic components is essential to the system lifetime, performance and safety. For space applications in particular, the environmental adaptability of fibre optic components can be a critical factor in the mission schedule and success.

This document is a directive document for fibre optic components, which are sorted as a specific category used in space systems. In this document, the design and verification requirements for fibre optic components focus on the space environmental adaptability and reliability, the pertinent procedures and concerns are described in order to provide safe and reliable hardware and operation.

NOTE Each manufacturer could suggest to the customer that tailoring is possible for any part of the standard that seems difficult to apply because of a manufacturing process that is being used.

Space systems — Fiber optic components — Design and verification requirements

1 Scope

This document specifies requirements for the design and verification of fibre optic components used in space fibre optic sub-systems. In this document, the requirements are established to assure the reliability and environmental adaptability of fibre optic components in space environmental conditions. These are in a range of applications such as ground systems, unmanned applications and manned systems. This document suggests a set of requirements to be applied to the selection of space fibre optic components.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements 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.

ISO 14302, *Space systems — Electromagnetic compatibility requirements*

ISO 14621-1, *Space systems — Electrical, electronic, and electromagnetic (EEE) parts — Parts management*

ISO 14621-2, *Space systems — Electrical, electronic, and electromagnetic (EEE) parts — Control program requirements*

3 Terms, definitions, abbreviated terms and symbols

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

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

— IEC Electropedia: available at http://www.electropedia.org/

— ISO Online browsing platform: available at https://www.iso.org/obp

3.1 Terms and definitions

3.1.1
optical fibre
filament shaped optical waveguide made of dielectric materials

[SOURCE: IEC 60050]

3.1.2
optical fibre cable
assembly comprising one or more optical fibres or fibre bundles inside a common covering designed to protect them against mechanical stresses and other environmental influences while retaining the transmission quality of the fibres

[SOURCE: IEC 60050]

3.1.3
optical fibre pigtail
short length of optical fibre, usually permanently attached to a component and intended to facilitate jointing between that component and another optical fibre or component

Note 1 to entry: "Launching fibre" is synonymous with optical fibre pigtail only when the latter is connected to an optical source.

[SOURCE: IEC 60050]

3.1.4
fibre optic component
components that are based on optical fibre properties or components that are coupled with optical fibres that cannot be disassembled, including passive fibre optic components and active fibre optic components

3.1.5
passive fibre optic component
fibre optic components that could realize certain photoelectric functions with no need for external energy, including fibre optic connectors, optical fibre couplers, wavelength division multiplexers, fibre optic attenuators, fibre optic filters, fibre optic isolators, circulators, polarization controllers, fibre delay lines and fibre optic gratings

3.1.6
active fibre optic component
fibre optic components that require a source of energy for their operation to realize the function of electro-optical/optical-electro conversion, including semiconductor sources (LD, LED, DFB, QW, SQW, VCSEL), semiconductor detectors (PD, PIN, APD), fibre lasers, optical amplifiers, wavelength transducers, optical modulators and optical switches

3.1.7
space fibre optic sub-system
assembly of interconnected basic fibre optic subsystems

Note 1 to entry: The assembly is specified at defined interfaces within the fibre optic system.

[SOURCE: IEC 61281-1:1999, modified]

3.1.8
coupling efficiency
efficiency of optical power transfer between an optical component and its fibre pigtail

3.1.9
fibre alignment dislocation
misalignment between the fibre tip and optic chip (or crystal) facet

3.2 Abbreviated terms

AFOC active fibre optic component

AIT assembly, integration, test

APD avalanche photodiode

COTS commercial off-the-shelf

DFB distributed feedback

DLAT destructive lot acceptance test

DPA destructive physical analysis

EEE electrical, electronic, and electromagnetic

ESD electrostatic discharge

FBG fibre Bragg grating

FMEA failure mode and effect analysis

FOC fibre optic component

LAT lot acceptance test

LD laser diode

LED light emitting diode

MRL manufacturing readiness level

MTTF mean time to failure

NA numerical aperture

PD photodiode

PDL polarization dependent loss

PFOC passive fibre optic component

PID process identified document

QW quantum well

RHA radiation hardness assurance

SQW single quantum well

TEC thermal-electric cooler

TRL technology readiness level

VCSEL vertical cavity surface emitting laser

WDM wavelength division multiplexing

3.3 Symbols

V volt

MΩ mega ohm

°C degree Celsius

Hz hertz

m/s^2 gravitational acceleration

ms millisecond

µm micrometre

N	newton
cm^3	cubic centimetre
Pa	pascal

4 General requirements

4.1 Design criterion

— Design and verification of FOC shall meet related requirements in ISO 14621-1, ISO 14621-2 and ISO 14302.

— Mature technologies and operating principles, COTS are preferred (TRL 6 (refer to ISO 16290) shall be demonstrated for any selected technology and associated COTS).

— The design shall satisfy the requirements of environmental adaptability and reliability.

— The design parameters could be optimized by validated software simulations and corrected by process tests.

— New materials and technologies shall be fully proven before application, verified materials and technologies for space environment are preferred, TRL 6 (refer to ISO 16290) will be demonstrated for technology and associated COTS.

— Apply derating design to FOC, the stress exerted on FOC during usage should be lower than the rated value in order to slow degradation, decrease failure rate and improve reliability of FOC.

— Balance the design of FOC by overall consideration of the function, reliability, risk, and economic efficiency.

4.2 Design input

— Specific requirements from customer, user and prime contractor.

— Requirements based on the space environment and system application, including mission profile in order to calculate a consistent MTTF according to dedicated methodology.

— Standards and criteria approved by customer and industry.

— New technology that helps to improve FOC performance in space environment.

— Safety requirements from space systems.

— Safety regarding health regulations.

4.3 Design output

The following output files shall be documented during the design and verification processes, which are in accordance with the design flow chart shown in Figure 1:

— document for design plans and strategies;

— document for justification (e.g.: design report);

— document for manufacturing process (e.g.: technical document, data record);

— document for verification (e.g.: specifications, reliability report, application verification report);

— document for safety demonstration (e.g.: health, safeguard, operations, transportation, and storage);

— document for users (e.g.: operation guides and precautions).

4.4 Design flow

— The design flow chart is shown in Figure 1.

— Conduct failure mode and effect analysis (FMEA) during the design process (IEC 60812:2006) to identify weak links, safety issues and key items of the design, so as to improve the design iteratively.

— When the design is modified, in principle, verification tests shall be completely conducted again in accordance with the whole verification process. Conducting effect analysis only on the modified part with related verification items is allowable. The verification results shall be added to the original verification report and demonstrate that the modified part does not have unwanted transverse system effect.

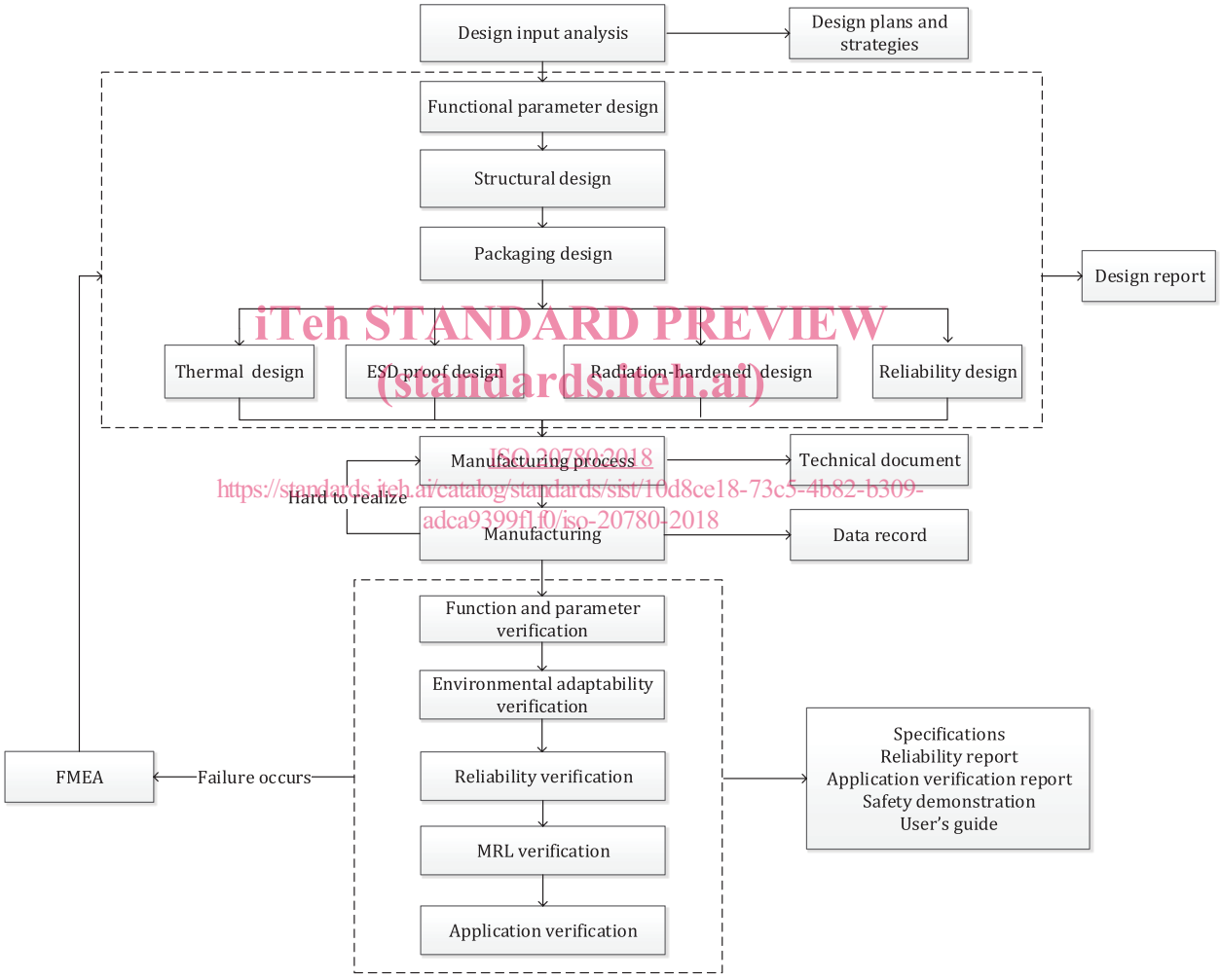

Figure 1 — Design flow chart for fibre optic components