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INTERNATIONAL STANDARD

NORME INTERNATIONALE

colour inside

Fibre optic sensors –
Part 1: Generic specification

Capteurs à fibres optiques –
Partie 1: Spécification générique

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FIBRE OPTIC SENSORS –

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FOREWORD

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International Standard IEC 61757-1 has been prepared by subcommittee 86C: Fibre optic systems and active devices, of IEC technical committee 86: Fibre optics.

This second edition cancels and replaces the first edition published in 1998 and constitutes a technical revision.

This edition includes a substantial technical update of all clauses, definitions, and cited references with respect to the previous edition.

The text of this standard is based on the following documents:

FDIS	Report on voting
86C/1059/FDIS	86C/1066/RVD

Full information on the voting for the approval of this standard can be found in the report on voting indicated in the above table.

This publication has been drafted in accordance with the ISO/IEC Directives, Part 2.

A list of all the parts in the IEC 61757 series, published under the general title *Fibre optic sensors*, can be found on the IEC website.

The committee has decided that the contents of this publication will remain unchanged until the stability date indicated on the IEC web site under "http://webstore.iec.ch" in the data related to the specific publication. At this date, the publication will be

- reconfirmed,
- withdrawn,
- replaced by a revised edition, or
- amended.

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FIBRE OPTIC SENSORS –

Part 1: Generic specification

1 Scope

This part of IEC 61757 is a generic specification covering optical fibres, components and sub-assemblies as they pertain specifically to fibre optic sensing applications. It has been designed to be used as a common working and discussion tool by the vendor of components and subassemblies intended to be integrated in fibre optic sensors, as well as by designers, manufacturers and users of fibre optic sensors independent of any application or installation.

The objective of this generic specification is to define, classify and provide the framework for specifying fibre optic sensors, and their specific components and subassemblies. The requirements of this standard apply to all related sectional, family, and detail specifications. Sectional specifications will contain requirements specific to sensors for particular quantities subject to measurement. Within each sectional specification, family and detail specifications contain requirements for a particular style or variant of a fibre optic sensor of that sectional specification.

A fibre optic sensor contains an optical or optically powered sensing element in which the information is created by reaction of light to a measurand. The sensing element can be the fibre itself or an optically powered element inserted along the optical path. In a fibre optic sensor, one or more light parameters are directly or indirectly modified by the measurand somewhere in the optical path, contrary to an optical data link where the information is merely transmitted from the transmitter to the receiver.

Generic tests or measurement methods are defined for specified attributes. Where possible, these definitions are by reference to an IEC standard – otherwise the test or measurement method is outlined in the relevant sectional, family and/or detail specification.

Annex A gives examples of fibre optic sensors to better illustrate the classification scheme. The examples given are illustrative only and are not limitative, nor do they constitute a recommendation or endorsement of a particular transduction principle.

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.

IEC 60050, *International Electrotechnical Vocabulary*

IEC 60060-1, *High-voltage test techniques – Part 1: General definitions and test requirements*

IEC 60068-1 *Environmental testing – Part 1: General and guidance*

IEC 60068-2-1, *Environmental testing – Part 2-1: Tests – Test A: Cold*

IEC 60068-2-2, *Environmental testing – Part 2-2: Tests – Test B: Dry heat*

IEC 60068-2-5, *Environmental testing – Part 2-5: Tests – Test Sa: Simulated solar radiation at ground level and guidance for solar radiation testing*

IEC 60068-2-6, *Environmental testing – Part 2-6: Tests – Test Fc: Vibration (sinusoidal)*

IEC 60068-2-10, *Environmental testing – Part 2-10: Tests – Test J and guidance: Mould growth*

IEC 60068-2-11, *Basic environmental testing procedures – Part 2-11: Tests – Test Ka: Salt mist*

IEC 60068-2-13, *Basic environmental testing procedures – Part 2-13: Tests – Test M: Low air pressure*

IEC 60068-2-14, *Environmental testing – Part 2-14: Tests – Test N: Change of temperature*

IEC 60068-2-27, *Environmental testing – Part 2-27: Tests – Test Ea and guidance: Shock*

IEC 60068-2-30, *Environmental testing - Part 2-30: Tests - Test Db: Damp heat, cyclic (12 h + 12 h cycle)*

IEC 60068-2-42, *Environmental testing – Part 2-42: Tests – Test Kc: Sulphur dioxide test for contacts and connections*

IEC 60068-2-43, *Environmental testing – Part 2-43: Tests – Test Kd: Hydrogen sulphide test for contacts and connections*

IEC 60068-2-78, *Environmental testing – Part 2-78: Tests – Cab: Damp heat, steady state*

IEC 60079-28, *Explosive atmospheres – Part 28: Protection of equipment and transmission systems using optical radiation*

IEC 60529, *Degrees of protection provided by enclosures (IP Code)*

IEC 60695-11-5, *Fire hazard testing – Part 11-5: Test flames – Needle-flame test method – Apparatus, confirmatory test arrangement and guidance*

IEC 60793-1-1, *Optical fibres – Part 1-1: Measurement methods and test procedures – General and guidance*

IEC 60793-1-54, *Optical fibres – Part 1-54: Measurement methods and test procedures - Gamma irradiation*

IEC 60793-2, *Optical fibres – Part 2: Product specifications – General*

IEC 60794-1-1, *Optical fibre cables – Part 1: Generic specification – General*

IEC 60794-1-2, *Optical fibre cables – Part 1-2: Generic specification – Basic optical cable test procedures*

IEC 60825-1, *Safety of laser products – Part 1: Equipment classification and requirements*

IEC 60874-1, *Fibre optic interconnecting devices and passive components – Connectors for optical fibres and cables – Part 1: Generic specification*

IEC 61000-4-2, *Electromagnetic compatibility (EMC) – Part 4-2: Testing and measurement techniques – Electrostatic discharge immunity test*

IEC 61000-4-3, *Electromagnetic compatibility (EMC) – Part 4-3: Testing and measurement techniques – Radiated, radio-frequency, electromagnetic field immunity test*

IEC 61000-4-4, *Electromagnetic compatibility (EMC) – Part 4-4: Testing and measurement techniques – Electrical fast transient/burst immunity test*

IEC 61000-4-5, *Electromagnetic compatibility (EMC) – Part 4-5: Testing and measurement techniques – Surge immunity test*

IEC 61300 (all parts), *Fibre optic interconnecting devices and passive components – Basic test and measurement procedures*

IEC 61300-2-18, *Fibre optic interconnecting devices and passive components – Basic test and measurement procedures – Part 2-18: Tests – Dry heat – High temperature endurance*

IEC 61300-2-22, *Fibre optic interconnecting devices and passive components – Basic test and measurement procedures – Part 2-22: Tests – Change of temperature*

IEC 61300-2-34, *Fibre optic interconnecting devices and passive components – Basic test and measurement procedures – Part 2-34: Tests – Resistance to solvents and contaminating fluids of interconnecting components and closures*

IEC 61300-2-46, *Fibre optic interconnecting devices and passive components – Basic test and measurement procedures – Part 2-46: Tests – Damp heat, cyclic*

IEC 61300-3-35, *Fibre optic interconnecting devices and passive components –Basic test and measurement procedures – Part 3-35: Examinations and measurements – Fibre optic connector endface visual and automated inspection*

IEC 61753 (all parts), *Fibre optic interconnecting devices and passive components performance standard*

IEC/TR 61931, *Fibre optic – Terminology*

IEC/TR 62222, *Fire performance of communication cables installed in buildings*

IEC/TR 62283, *Optical fibres – Guidance for nuclear radiation tests*

IEC/TR 62362, *Selection of optical fibre cable specifications relative to mechanical, ingress, climatic or electromagnetic characteristics – Guidance*

IEC/TR 62627-01, *Fibre optic interconnecting devices and passive components – Part 01: Fibre optic connector cleaning methods*

ISO/IEC Guide 98-3, *Uncertainty of measurement – Part 3: Guide to the expression of uncertainty in measurement (GUM:1995)*

ISO/IEC Guide 99, *International vocabulary of metrology — Basic and general concepts and associated terms (VIM)*

3 Terms and definitions

For the purpose of this International Standard, the definitions of IEC 60050 (IEV), IEC/TR 61931, ISO/IEC Guide 99 (VIM), and the following apply:

3.1
accuracy
quality which characterizes the ability of a measuring instrument [of a fibre optic sensor] to provide an indicated value close to a true value of the measurand

Note 1 to entry: This term is used in the "true value" approach. This is a value that would be obtained by a perfect measurement.

Note 2 to entry: Accuracy is all the better when the indicated value is closer to the corresponding true value.

[SOURCE: IEC 60050-311:2001, 311-06-08, modified]

3.2
analogue signal interface
signal interface which provides analogue output signals in a form directly usable for control or measurement purposes, and which is generally electrical

Note 1 to entry: Output schemes should preferably comply with existing interface standards such as those existing for electrical analogue signals. Output schemes can be, for example, 4-20 mA, 0-20 mA, 0-5V, etc. A fibre optic sensor with a photodetector or other square-law detector, or with integrated signal processing electronics is a representative application example.

3.3
characteristic curve / calibration curve
expression of the relation between indication and corresponding measured quantity value

[SOURCE: ISO/IEC Guide 99]

Note 1 to entry: A characteristic curve / calibration curve expresses a one-to-one relation that does not supply a complete measurement result as it bears no information about the measurement uncertainty.

3.4
communication interface
digital interface of a fibre optic sensor which provides digital output signals in a form directly usable for control or measurement purposes, or which enables digital communication with other digital divices (e.g. personal computer)

Note 1 to entry: It is usually designed to a specific standard (e.g. Universal Serial Interface Bus USB, RS-232) and used for transmitting control and measurement data.

3.5
distributed fibre optic sensor
fibre optic sensor which provides a spatially resolved measurement of a measurand over an extended region by means of a continuous sensing element

3.6
drift
change in the metrological characteristics of a measuring instrument [and /or fibre optic sensor], generally slow, continuous, not necessarily in the same direction and not related to a change in the measurand

3.7
durability
ability of a fibre optic sensor to perform a required function under defined conditions of use and maintenance, until a limiting state is reached

Note 1 to entry: A limiting state of an item may be characterized by the end of the useful life, unsuitability for any economic or technological reasons or other relevant factors.

3.8
extrinsic fibre optic sensor
fibre optic sensor in which the characteristics of the light are affected externally to the optical fibre(s) by the measurand

3.9
fibre optic sensor
part of a measuring instrument, or measuring chain, which is directly affected by the measurand and which generates a change in the optical characteristics of an optical fibre related to the value of the measurand. The optical fibre itself acts as the sensing element or it includes an optical or optically powered sensing element and may include one or more of the following (see Figures 1, 2, and 3):

– optical fibre lead;
– signal conditioning.

3.10
gauge length / measurement basis
length of the parallel portion of the measured object over which the fibre optic sensor gathers information

[SOURCE: COST Guideline for Use of Fibre Optic Sensors]

Note 1 to entry: For example, if the sensor is only anchored at two fixed points L cm apart, then the gauge length is L. On the other hand, if a sensor of length l is continuously-fixed in or to a measured object of length L, then the actual gauge length depends on the method of attachment to the measured object and is a function of the mechanical properties of both the sensor and its surrounding; it is generally longer than l but shorter than L.

Note 2 to entry: If a user wants to achieve a pre-determined gauge length, he must be very careful in selecting the procedure by which the sensor is anchored/attached/embedded. In case of continuously-fixed sensors, the fixing length must exceed the defined gauge length by a few tens of fibre diameter to avoid shear-lag problems at the edges. In the specific case of fracture or cracks within the gauge length of the sample, the final gauge length must be calculated then from the gauge length at fracture by subtracting from the latter the elastic portion of the elongation.

3.11
influence quantity
quantity that, in a direct measurement, does not affect the quantity that is actually measured, but affects the relation between the indication and the measurement result

[SOURCE: ISO/IEC Guide 99]

3.12
integrating fibre optic sensor
fibre optic sensor which provides a measurement result of a measurand over an extended region by means of a continuous sensing element of a defined length. The measurand is not spatially resolved but is integrated or summed over the length of the sensing element.

3.13
intrinsic fibre optic sensor
fibre optic sensor whose sensing element consists of one or more optical fibre(s) in which one or more characteristics like intensity, phase, polarization, spectrum, wavelength or transit time of light depend on the measurand

Note 1 to entry: There are a lot of fibre optic sensors where the sensing principle is based on a change in coating characteristics only (e.g. chemical or RH sensors) or on an interaction between core and cladding (e.g. bending sensor). They can be defined as indirect intrinsic fibre optic sensors. Direct intrinsic fibre optic sensors are defined by a direct change of the fibre core characteristics (e.g. Brillouin, Raman or Rayleigh scattering based sensors).

3.14
instrumental measurement uncertainty
component of measurement uncertainty arising from a measuring instrument or measuring system in use

Note 1 to entry: Instrumental measurement uncertainty is obtained through calibration of a measuring instrument or measuring system, except for a primary measurement standard for which other means are used.

Note 2 to entry: Instrumental uncertainty is used in a Type B evaluation of measurement uncertainty according to ISO/IEC Guide 98-3, *Uncertainty of measurement – Part 3: Guide to the expression of uncertainty in measurement (GUM:1995)*.

3.15
limiting operating condition / limiting values for operation
extreme operating condition that a measuring instrument or measuring system or a sensing element [or a fibre optic sensor] is required to withstand without damage, and without degradation of specified metrological properties, when it is subsequently operated under its rated operating conditions

[SOURCE: ISO/IEC Guide 99]

Note 1 to entry: Limiting conditions for storage, transport or operation can differ.

Note 2 to entry: Limiting conditions can include limiting values of a quantity being measured and of any influence quantity.

Note 3 to entry: The limiting values can depend on the duration of their application.

3.16
measurement precision
closeness of agreement between indications or measured quantity values obtained by replicate measurements on the same or similar objects under specified conditions

[SOURCE: ISO/IEC Guide 99]

Note 1 to entry: Measurement precision is usually expressed numerically by measures of imprecision, such as standard deviation, variance, or coefficient of variation under the specified conditions of measurement.

Note 2 to entry: The 'specified conditions' can be, for example, repeatability conditions of measurement, intermediate precision conditions of measurement or reproducibility conditions of measurement.

Note 3 to entry: Measurement precision is used to define measurement repeatability, intermediate measurement precision, and measurement reproducibility.

Note 4 to entry: Sometimes "measurement precision" is erroneously used to mean measurement accuracy.

3.17
measuring interval / measuring range
set of values of quantities of the same kind that can be measured by a given measuring instrument or measuring system [or fibre optic sensor] with specified instrumental uncertainty, under defined conditions

[SOURCE: ISO/IEC Guide 99]

3.18
multiple point fibre optic sensor
fibre optic sensor consisting of a number of single point sensors which enables a spatially resolved measurement of a measurand over an extended region at discrete locations

3.19
optical or optically powered sensing element
device which accepts information in the form of a physical quantity and converts it to information in the form of an optical quantity, according to a definite law

3.20
optical fibre
filament-shaped waveguide made of dielectric materials for guiding optical waves

[SOURCE: IEC 60050-151:2001, 151-12-35]

For the purpose of this International Standard, the general specifications for optical fibres of IEC 60793-2 apply.

Note 1 to entry: Fibre optic sensors based on planar or micro-structured waveguides, or photonic crystal fibres or multi-core fibres are under consideration and not yet part of this standard.

3.21
optical fibre lead(s)
optical fibre line(s) which connect the sensing element to the optical source and to the optical receiver

3.22
optical interface
arbitrary point at which the effect of the measurand on the sensing element is optically defined

Note 1 to enrty: The optical interface represents the raw optical signal for subsequent processing by the user. Typical attributes for this type of interface would be the wavelength, state of polarization, optical power, and so on. More detailed specifications would include fibre-optic connector style, optical fibre type, etc.

3.23
optical receiver
device which receives the light affected by the measurand and converts it into a quantity, generally electric, according to a predetermined law. It may contain one or more photo detectors, signal conditioners and communication interfaces

3.24
optical source
device which supplies the optical energy required to allow the interaction between the sensing element and the measurand. It contains, as a minimum, a luminous source and it may contain signal conditioning. When the optical energy is generated by the phenomenon sensed, no optical source is required

3.25
rated operating condition
operating condition that must be fulfilled during measurement in order that a measuring instrument or measuring system [or fibre optic sensor] perform as designed

[SOURCE: ISO/IEC Guide 99]

Note 1 to entry: Rated operating conditions generally specify intervals of values for a quantity being measured and for any influence quantity.

3.26
resolution
smallest change in a quantity being measured that causes a perceptible change in the corresponding indication

[SOURCE: ISO/IEC Guide 99]

Note 1 to entry: Resolution can depend on, for example, noise (internal or external) or friction. It may also depend on the value of a quantity being measured.

3.27
sensitivity
quotient of the change in an indication of a measuring system [or a fibre optic sensor] and the corresponding change in a value of a quantity being measured

[SOURCE: ISO/IEC Guide 99]

Note 1 to entry: Sensitivity of a measuring system can depend on the value of the quantity being measured.

Note 2 to entry: The change considered in a value of a quantity being measured must be large compared with the resolution.

3.28
signal interface
arbitrary point at which the effect of the measurand is present in a form directly usable for control or measurement purposes. The optical interface(s) and the signal interface(s) can in some cases coincide

3.29
single point fibre optic sensor
fibre optice sensor consisting of one discrete sensing element which generates a signal related to the value of the measurand

3.30
spatial resolution
measure of the ability of a distributed fibre optic sensor to distinguish spatial indications of the measurand

Note 1 to entry: Measurand resolution (e.g. temperature or strain), spatial resolution, distance range and acquisition time are inter-related. The signal processing has additional influence.

3.31
stability
ability of a measuring instrument [and /or fibre optic sensor] to keep its [metrological] performance characteristics within a specified range during a specified time interval, all other conditions being the same

[SOURCE: IEC 60050:2001, 311-06-12, modified]

3.32
step response time
duration between the instant when the measurand (or quantity supplied) is subjected to a specified abrupt change and the instant when the indication (or quantity supplied) reaches, and remains within specified limits of, its final steady-state value

Note 1 to entry: This definition is the one conventionally used for measuring instruments. Other definitions exist.

[SOURCE: IEC 60050-311:2001, 311-06-04]

3.33
variation due to an influence quantity / cross sensitivity
difference in indication for a given measured quantity value when an influence quantity assumes successively two different quantity values [e.g. while measuring a strain a temperature change may appear as a strain change.

[SOURCE: ISO/IEC Guide 99]

Figure 1 shows fibre optic sensor configuration with a passive sensing element and separate fibre leads for optical input and output.