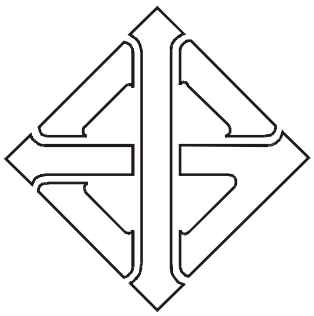

มาตรฐานผลิตภัณฑ์อุตสาหกรรม

THAI INDUSTRIAL STANDARD

มอก. 2059 – 2552

IEC 60876 – 1(2001 – 04)

สวิตช์ใยแก้วนำแสง

เล่ม 1 ข้อกำหนดรายการร่วม

FIBER OPTIC SPATIAL SWITCHES

PART 1: GENERIC SPECIFICATION

สำนักงานมาตรฐานผลิตภัณฑ์อุตสาหกรรม

กระทรวงอุตสาหกรรม

ICS 33.180.20 ISBN 978-616-231-247-2

มาตรฐานผลิตภัณฑ์อุตสาหกรรม

สวิตช์ใยแก้วนำแสง

เล่ม 1 ข้อกำหนดรายการร่วม

มอก. 2059–2552

สำนักงานมาตรฐานผลิตภัณฑ์อุตสาหกรรม
กระทรวงอุตสาหกรรม ถนนพระรามที่ 6 กรุงเทพฯ 10400
โทรศัพท์ 02 202 3300

ประกาศในราชกิจจานุเบกษา ฉบับประกาศและงานทั่วไป เล่ม 127 ตอนพิเศษ 70ง
วันที่ 4 มิถุนายน พุทธศักราช 2553

มาตรฐานผลิตภัณฑ์อุตสาหกรรมสวิตช์ใยแก้วนำแสง เล่ม 1 ข้อกำหนดรายการร่วม ได้ประกาศใช้ครั้งแรกโดยรับ IEC 876-1(1994) Fiber optic switches - Part 1: Generic specificationมาใช้ในระดับเหมือนกันทุกประการ (Identical) โดยใช้ IEC ฉบับภาษาอังกฤษเป็นหลัก โดยประกาศในราชกิจจานุเบกษา ฉบับประกาศทั่วไป เล่มที่119 ตอนพิเศษที่ 101ง วันที่ 15 ตุลาคม พุทธศักราช 2545

เนื่องจาก IEC ได้แก้ไขปรับปรุงมาตรฐาน IEC 876-1 (1994) เป็น IEC 60876-1 (2001-04) จึงได้ยกเลิกมาตรฐานเดิมและกำหนดมาตรฐานใหม่โดยรับ IEC 60876-1 (2001) Fiber optic spatial switches - Part 1: Generic specification มาใช้ในระดับเหมือนกันทุกประการโดยใช้มาตรฐาน IEC ฉบับภาษาอังกฤษเป็นหลัก

คณะกรรมการมาตรฐานผลิตภัณฑ์อุตสาหกรรมได้พิจารณามาตรฐานนี้แล้ว เห็นสมควรเสนอรัฐมนตรีประกาศตามมาตรา 15 แห่งพระราชบัญญัติมาตรฐานผลิตภัณฑ์อุตสาหกรรม พ.ศ. 2511

ประกาศกระทรวงอุตสาหกรรม

ฉบับที่ 4160 (พ.ศ. 2552)

ออกตามความในพระราชบัญญัติมาตรฐานผลิตภัณฑ์อุตสาหกรรม

พ.ศ. 2511

เรื่อง ยกเลิกและกำหนดมาตรฐานผลิตภัณฑ์อุตสาหกรรม

สวิตช์ใยแก้วนำแสง

เล่ม 1 ข้อกำหนดรายการร่วม

โดยที่เป็นการสมควรปรับปรุงมาตรฐานผลิตภัณฑ์อุตสาหกรรม สวิตช์ใยแก้วนำแสง เล่ม 1 ข้อกำหนดรายการร่วม มาตรฐานเลขที่ มอก.2059-2543

อาศัยอำนาจตามความในมาตรา 15 แห่งพระราชบัญญัติมาตรฐานผลิตภัณฑ์อุตสาหกรรม พ.ศ. 2511 รัฐมนตรีว่าการกระทรวงอุตสาหกรรมออกประกาศยกเลิกประกาศกระทรวงอุตสาหกรรม ฉบับที่ 3068 (พ.ศ.2545) ออกตามความในพระราชบัญญัติมาตรฐานผลิตภัณฑ์อุตสาหกรรม พ.ศ.2511 เรื่อง กำหนดมาตรฐานผลิตภัณฑ์อุตสาหกรรม สวิตช์ใยแก้วนำแสง เล่ม 1 ข้อกำหนดรายการร่วม ลงวันที่ 29 พฤษภาคม พ.ศ.2545 และออกประกาศกำหนดมาตรฐานผลิตภัณฑ์อุตสาหกรรม สวิตช์ใยแก้วนำแสง เล่ม 1 ข้อกำหนดรายการร่วม มาตรฐานเลขที่ มอก.2059-2552 ขึ้นใหม่ ดังมีรายการละเอียดต่อท้ายประกาศนี้

ทั้งนี้ให้มีผลตั้งแต่วันถัดจากวันที่ประกาศในราชกิจจานุเบกษา เป็นต้นไป

ประกาศ ณ วันที่ 29 ธันวาคม พ.ศ. 2552

ชาญชัย ชัยรุ่งเรือง

รัฐมนตรีว่าการกระทรวงอุตสาหกรรม

มาตรฐานผลิตภัณฑ์อุตสาหกรรม
สวิตช์ใยแก้วนำแสง
เล่ม 1 ข้อกำหนดรายการร่วม

มาตรฐานผลิตภัณฑ์อุตสาหกรรมนี้กำหนดขึ้นโดยรับ IEC 60876-1 (2001) Fiber optic spatial switches - Part 1: Generic specification มาใช้ในระดับเหมือนกันทุกประการ (identical) โดยใช้ IEC ฉบับภาษาอังกฤษเป็นหลัก

มาตรฐานผลิตภัณฑ์อุตสาหกรรม IEC 60876 ใช้กับสวิตช์ใยแก้วนำแสง ที่มีลักษณะทั่วไปดังนี้

- สวิตช์ใยแก้วนำแสงที่ไม่มีส่วนประกอบอิเล็กทรอนิกส์แสงหรือตัวแปลงอื่น ๆ
- ช่องทางออกของสวิตช์ใยแก้วนำแสงซึ่งมีหนึ่งหรือมากกว่าหนึ่งช่องทางสำหรับการส่งผ่านของกำลังแสง รวมทั้งอาจจะมีสเตตจำนวนสองหรือมากกว่าที่กำลังแสงจะถูกส่งผ่านหรือปิดกั้นระหว่างช่องทางออกเหล่านี้
- ช่องทางออกที่เป็นใยแก้วนำแสงหรือขั้วต่อใยแก้วนำแสง

มาตรฐานผลิตภัณฑ์อุตสาหกรรมนี้กำหนดลักษณะที่ต้องการที่เป็นเอกภาพ สำหรับ

- ข้อกำหนดสำหรับสวิตช์ใยแก้วนำแสง
- ขั้นตอนการตรวจประเมินคุณภาพ

รายละเอียดให้เป็นไปตาม IEC 60876-1 (2001)

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CONTENTS

INTERNATIONAL ELECTROTECHNICAL COMMISSION

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FIBRE OPTIC SPATIAL SWITCHES –

Part 1: Generic specification

FOREWORD

1) The IEC (International Electrotechnical Commission) is a worldwide organization for standardization comprising all national electrotechnical committees (IEC National Committees). The object of the IEC is to promote international co-operation on all questions concerning standardization in the electrical and electronic fields. To this end and in addition to other activities, the IEC publishes International Standards. Their preparation is entrusted to technical committees; any IEC National Committee interested in the subject dealt with may participate in this preparatory work. International, governmental and non-governmental organizations liaising with the IEC also participate in this preparation. The IEC collaborates closely with the International Organization for Standardization (ISO) in accordance with conditions determined by agreement between the two organizations.
2) The formal decisions or agreements of the IEC on technical matters express, as nearly as possible, an international consensus of opinion on the relevant subjects since each technical committee has representation from all interested National Committees.
3) The documents produced have the form of recommendations for international use and are published in the form of standards, technical specifications, technical reports or guides and they are accepted by the National Committees in that sense.
4) In order to promote international unification, IEC National Committees undertake to apply IEC International Standards transparently to the maximum extent possible in their national and regional standards. Any divergence between the IEC Standard and the corresponding national or regional standard shall be clearly indicated in the latter.
5) The IEC provides no marking procedure to indicate its approval and cannot be rendered responsible for any equipment declared to be in conformity with one of its standards.
6) Attention is drawn to the possibility that some of the elements of this International Standard may be the subject of patent rights. The IEC shall not be held responsible for identifying any or all such patent rights.

International Standard IEC 60876-1 has been prepared by subcommittee 86B: Fibre optic interconnecting devices and passive components, of IEC technical committee 86: Fibre optics.

This third edition cancels and replaces the second edition, published in 1994, and constitutes a technical revision.

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

FDIS	Report on voting
86B/1466/FDIS	86B/1534/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 3.

The QC number that appears on the front cover of this publication is the specification number in the IEC Quality Assessment System for Electronic Components (IECQ).

The committee has decided that the contents of this publication will remain unchanged until 2008. At this date, the publication will be

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

INTRODUCTION

This part of IEC 60876 is divided into three clauses.

Clause 1, "General", contains the scope, the normative references and the definitions which pertain to this generic specification.

Clause 2, "Requirements", contains all of the requirements to be met by switches covered by this standard. These include requirements for classification, the IEC specification system, documentation, materials, workmanship, quality, performance, identification, and packaging.

Clause 3, "Quality assessment procedures", contains all of the procedures to be followed for proper quality assessment of products as covered by this standard.

FIBRE OPTIC SPATIAL SWITCHES –

Part 1: Generic specification

1 General

1.1 Scope

This part of IEC 60876 applies to fibre optic switches possessing all of the following general features:

– they are passive in that they contain no optoelectronic or other transducing elements;
– they have one or more ports for the transmission of optical power and two or more states in which power may be routed or blocked between these ports;
– the ports are optical fibres or optical fibre connectors.

This standard establishes uniform requirements for:

– fibre optic switch requirements;
– quality assessment procedures.

1.2 Normative references

The following normative documents contain provisions which, through reference in this text, constitute provisions of this part of IEC 60876. For dated references, subsequent amendments to, or revisions of, any of these publications do not apply. However, parties to agreements based on this part of IEC 60876 are encouraged to investigate the possibility of applying the most recent editions of the normative documents indicated below. For undated references, the latest edition of the normative document referred to applies. Members of IEC and ISO maintain registers of currently valid International Standards.

IEC 60027 (all parts), *Letter symbols to be used in electrical technology*

IEC 60050(731), *International Electrotechnical Vocabulary (IEV) – Chapter 731: Optical fibre communication*

IEC 60410, *Sampling plans and procedures for inspection by attributes*

IEC 60617 (all parts), *Graphical symbols for diagrams*

IEC 60695-2-2, *Fire hazard testing – Part 2: Test methods – Section 2: Needle-flame test*

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

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

IEC 61930, *Fibre optic graphical symbology*

IEC QC 001001:1998, *IEC Quality Assessment System for Electronic Components (IECQ) – Basic Rules*

IEC QC 001002 (all parts), *IEC Quality Assessment System for Electronic Components (IECQ) – Rules of Procedure*

IEC Guide 102, *Electronic components – Specification structures for quality assessment (Qualification approval and capability approval)*

ISO 129, *Technical drawings – Dimensioning – General principles, definitions, methods of execution and special indications*

ISO 286-1, *ISO system of limits and fits – Part 1: Bases of tolerances, deviations and fits*

ISO 1101, *Geometrical Product Specifications (GPS) – Geometrical tolerancing – Tolerances of form, orientation, location and run-out* [1)]

ISO 8601:1988, *Data elements and interchange formats – Information interchange – Representation of dates and times*

1.3 Definitions

For the purpose of this part of IEC 60876, the definitions given in IEC 60050(731) apply, together with the following definitions.

1.3.1
optical switch
passive component possessing one or more ports which selectively transmits, redirects or blocks optical power in an optical fibre transmission line

1.3.2
port
optical fibre or optical fibre connector attached to a passive component for the entry and/or exit of optical power

1.3.3
switch state
particular optical configuration of a switch, whereby optical power is transmitted or blocked between specific ports in a predetermined manner

1.3.4
actuation mechanism
physical means (mechanical, electrical, acoustic, optical, etc.) by which a switch is designed to change between states

1.3.5
actuation energy
input energy required to place a switch in a specific state

[1)] To be published.

1.3.6
transfer matrix
optical properties of a fibre optic switch can be defined in a $n \times n$ matrix of coefficients (n is the number of ports)

NOTE The T matrix represents the on-state paths (worst-case transmission) and the T° matrix represents the off-state paths (worst-case isolation).

1.3.7
transfer coefficient
element t_{ij} or $t°_{ij}$ of the transfer matrix

NOTE Each coefficient t_{ij} is the worst-case (minimum) fraction of power transferred from port i to port j for any state with path ij switched on. Each coefficient $t°_{ij}$ is the worst-case (maximum) fraction of power transferred from port i to port j for any state with path ij switched off.

1.3.8
logarithmic transfer matrix
in general, the logarithmic transfer matrix is as follows:

$$a_{ij} = -10 \log t_{ij}$$

where

a_{ij} is the optical power reduction in decibels out of port j with unit power into port i, i.e.

t_{ij} is the transfer matrix coefficient.

Similarly, for the off state, $a°_{ij} = 10 \log t°_{ij}$

1.3.9
attenuation
element a_{ij} (where i ≠ j) of the logarithmic transfer matrix. It is the reduction in optical power between an input and output port of a passive component expressed in decibels and is defined as follows:

$$a_{ij} = -10 \log (P_j/P_i)$$

where

P_i is the optical power launched into the input port, and

P_j is the optical power received from the output port. The insertion loss values depend on the state of the switch

1.3.10
return loss – reflection loss
element a_{ij} (where i = j) of the logarithmic transfer matrix. It is the fraction of input power that is returned from the input port of a passive component and is defined as follows:

$$RL_i = -10 \log (PR_i/P_i)$$

where

P_i is the optical power launched into the input port, and

P_j the optical power received back from the same port.

The return loss values depend on the state of the switch

1.3.11
operating wavelength
nominal wavelength ρ at which a passive component is designed to operate with the specified performance

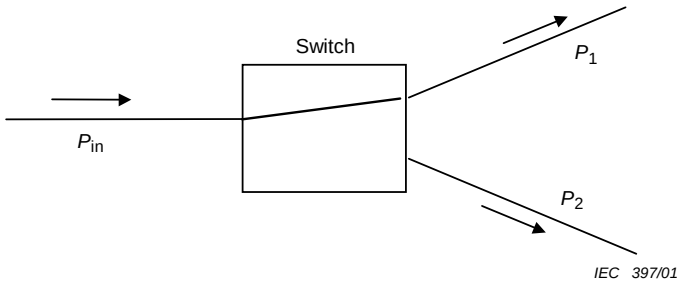
1.3.12
operating wavelength range (bandpass)
specified range of wavelengths from ρ_{min} to ρ_{max} around a nominal operating wavelength ρ within which a passive component is designed to operate with the specified performance

1.3.13
conducting ports
two ports between which the attenuation is nominally zero for a passive component

1.3.14
isolated ports
two ports between which the attenuation is nominally infinite for a passive component

1.3.15
crosstalk
ratio of the optical power that goes out from a given output port to an optical power that goes out from another output port, nominally isolated from the previous one, when all other ports are terminated

EXAMPLE: Typical 1 ข2 switch



When the switch is connected to port 1, crosstalk is defined as follows:

$$FC_{12} \quad 10 \log \frac{P_2}{P_1}$$

where

P_1 is the optical power that goes out from the output port 1, and

P_2 is the optical power that goes out from the output port 2 (nominally isolated from port 1).

When the switch is connected to port 2, crosstalk is defined as follows:

$$FC_{21} \quad 10 \log \frac{P_1}{P_2}$$

where

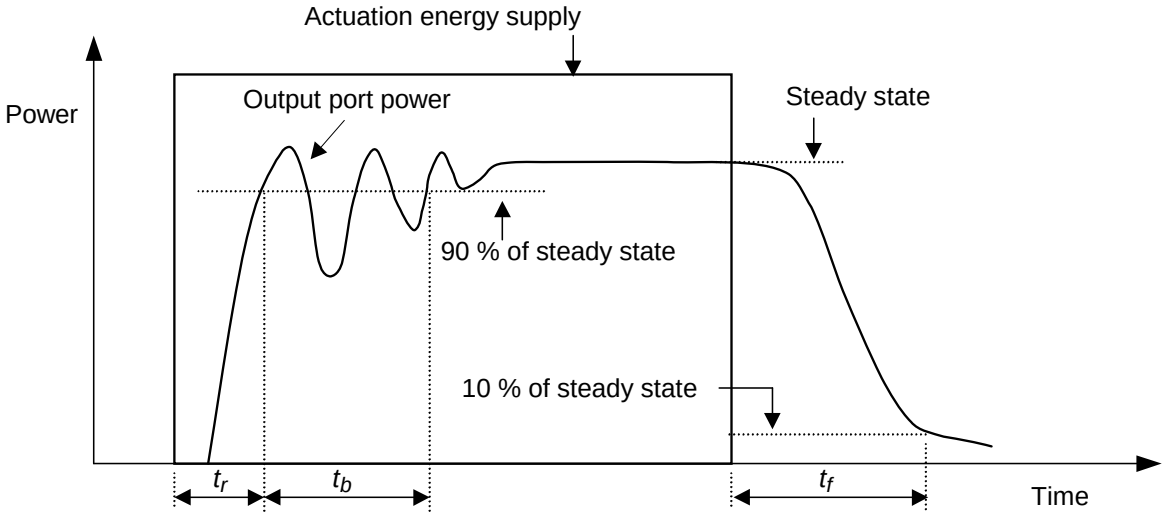
P_2 is the optical power that goes out from the output port 2, and

P_1 is the optical power that goes out from the output port 1 (nominally isolated from port 2)

1.3.16
latching switch
switch that maintains its last state and specified performance level when the actuation energy which initiated the change is removed

1.3.17
non-latching switch
switch that reverts to a home state or undefined state when the actuation energy which initiated a change is removed

1.3.18
switching time
elapsed time it takes the switch to turn path ij on or off from a particular initial state, measured from the time the actuation energy is applied or removed



Switching time: t_r, t_f
Bounce time: t_b

IEC 398/01

1.3.19
bounce time
elapsed time for the insertion loss between two specified ports of a switch to reach and remain within 0,5 dB of its steady-state value from when it initially reaches within 0,5 dB of the steady-state value

1.3.20
switching time matrix
matrix of coefficients in which each coefficient S_{ij} is the longest switching time to turn path ij on or off from any initial state

1.3.21
blocking
blocking and various degrees of non-blocking operation functionality are encompassed by this specification

NOTE "Blocking" refers to the inability to establish a connection from a free input port to a free output port due to the existence of some other established connection.

"Strict-sense non-blocking" refers to a switch matrix in which it is always possible to establish a connection between any free input port and any free output port irrespective of previously established connections.

"Wide-sense non-blocking" refers to a matrix in which it is always possible to establish a desired connection provided that some systematic procedure is followed in setting up connections. Some multistage switching architectures fall into this category.

"Rearrangeably non-blocking" refers to a switch matrix in which any free input port can be connected to any free output port provided that other established connections are unconnected and then reconnected as part of making the new connection.

2 Requirements

The requirements for switches covered by this clause are intended to aid in classifying this device.

2.1 Classification

Fibre optic spatial switches shall be classified as follows:

– type;
– style;
– variant;
– interface standard (when applicable);
– environmental category;
– assessment level;
– normative reference extensions.

The following table is an example of a switch classification.

Table 1 – Example of a typical switch classification

Type:	2 × 2 electrically actuated switch
Style:	– Configuration B – IEC type A1 a fibre – F-SMA connector
Variants:	Means of mounting
Environmental category:	.....
Assessment level:	A
Normative reference extensions:	.....

2.1.1 Type

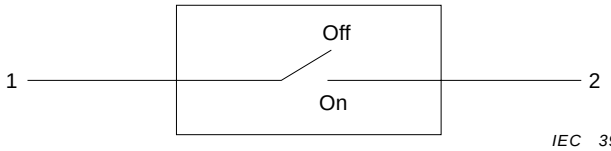
Switches are divided into types by their actuating mechanism and topology (optical switching function).

There are an essentially infinite number of possible topologies. Each topology is illustrated by a schematic diagram and defined by a unique transfer matrix.

The following device topologies include only those which are in common use within industry at present. The schematic diagrams which follow do not necessarily correspond to the physical layout of the switch and its ports.

NOTE The following examples apply to unidirectional switches only, where $t_{ij} = t_{ji}$. For bi-directional switches, $t_{ij} = t_{ji}$ in each transfer matrix below.

2.1.1.1 Single-pole, single-throw switch



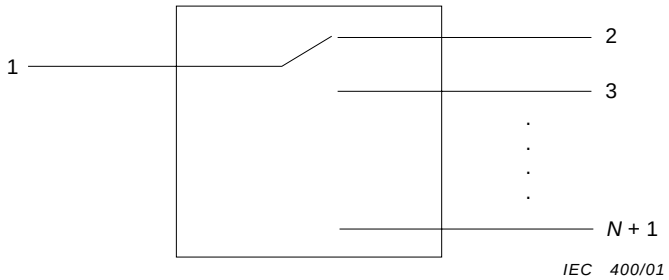
IEC 399/01

This switch has one input and one output port. The transfer matrix describing the device is as follows:

$$T = \begin{bmatrix} t_{11} & t_{12} \\ t_{21} & t_{22} \end{bmatrix}$$

Ideally, t_{12} is 1 and the other coefficients are 0 when the switch is on. When the switch is off, all coefficients are 0.

2.1.1.2 Single-pole, *N*-throw switch



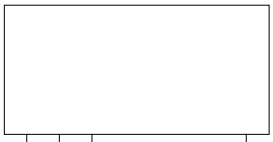
IEC 400/01

This switch has one input port and *N* output ports. The transfer matrix describing the device is as follows:

$$T = \begin{bmatrix} t_{11} & t_{12} & \cdot & \cdot & \cdot & t_{1\,N+1} \\ t_{21} & & & & & \\ \cdot & & & & & \\ \cdot & & & t_{ij} & & \cdot \\ \cdot & & & & & \\ t_{N+1\,1} & \cdot & & & & t_{N+1\,N+1} \end{bmatrix}$$

Ideally, in the first position of the switch, t_{12} is 1 and the other coefficients are 0. In the generic *i*-th position of the switch, the $t_{1\,i+1}$ transfer coefficient is 1 and the others are 0.

2.1.1.3 *N*-port matrix switch



IEC 401/01

This switch has *N* ports. The transfer matrix describing the device is as follows:

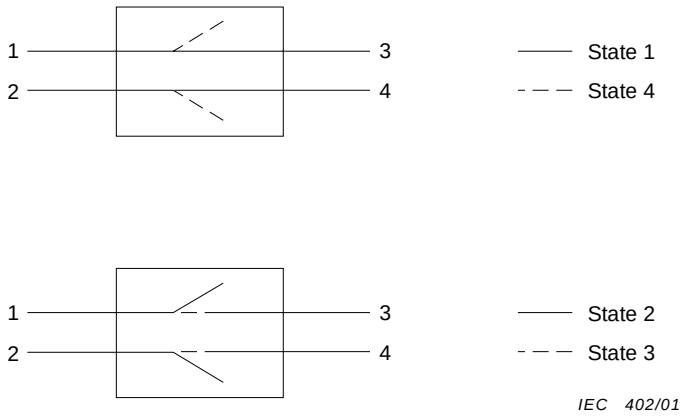
$$T = \begin{bmatrix} t_{11} & t_{12} & \cdot & \cdot & \cdot & t_{1N} \\ t_{21} & & & & & \cdot \\ \cdot & & & & & \cdot \\ \cdot & & & t_{ij} & & \cdot \\ \cdot & & & & & \\ t_{N1} & \cdot & \cdot & \cdot & & t_{NN} \end{bmatrix}$$

A 2 ×2 matrix switch is a particular case with two input and two output ports.

In one type, it is possible to have four positions with the transfer coefficients t_{14} and t_{23} always zero while t_{13} and t_{24} have the values indicated in table 2.

Table 2 – Transfer matrix of a four-port switch without crossover

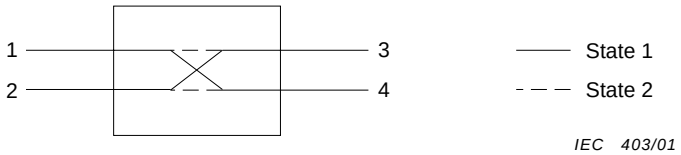
Transfer coefficient	State			
	1	**2**	**3**	**4**
t_{13}	1	0	1	0
t_{24}	1	1	0	0



In another type, a four-port crossover switch or by-pass switch is described. This switch has two input and two output ports. The transfer coefficients are indicated in table 3.

Table 3 – Transfer matrix of a four-port crossover switch

Transfer coefficient	State	
	1	**2**
t_{13}	1	0
t_{24}	1	0
t_{14}	0	1
t_{23}	0	1



IEC 403/01

2.1.2 Style

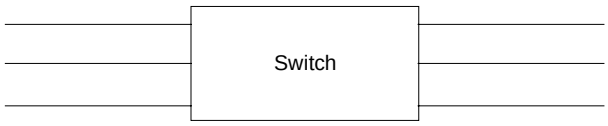
Switches may be classified into styles based upon fibre type, connector type, cable type, housing shape and dimensions and configuration.

Configuration

The configuration of the switch ports is classified as follows.

Configuration A

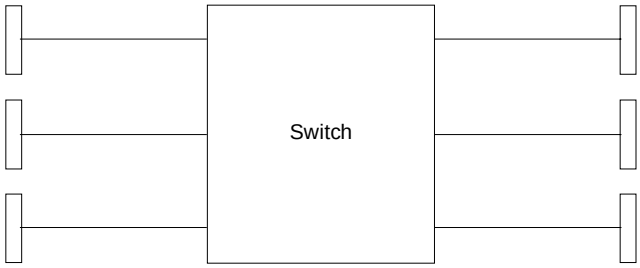
A device containing integral fibre optic pigtails without connectors.



IEC 404/01

Configuration B

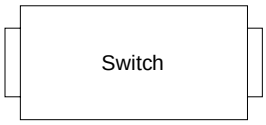
A device containing integral fibre optic pigtails, with a connector on each pigtail.



IEC 405/01

Configuration C

A device containing a fibre optic connector as an integral part of the device housing.



IEC 406/01

Configuration D

A device containing some combination of the interfacing features of the preceding configurations.

2.1.3 Variant

The switch variant identifies those features which encompass structurally similar components (see 3.2).

Examples of features which define a variant include, but are not limited to the following:

– orientation of ports on housing;
– means for mounting.

2.1.4 Interface standard

Where a particular switch variant possesses an integral interface intended to mate to a connector, the interface shall conform to the relevant connector interface standard.

2.1.5 Environmental category

Various environmental categories are given in the blank detail specifications associated with this standard which define the test sequences needed for quality assurance.

Detail specification writers may add tests and/or groups of tests to a particular environmental category.

However, the detail specification writer shall not remove tests nor alter the sequence of an environmental category standard.

When a detail specification writer adds tests to a specified category, the environmental category shall be given a plus (+) designation.

EXAMPLE environmental category ii +

environmental category v (+)

The blank detail specification for environmental category 99 is available for use where the category standards are not suitable.

2.1.6 Assessment level

Assessment level defines the inspection levels and the acceptable quality level (AQL) of groups A and B and the periodicity of inspection of groups C and D. Detail specifications shall specify one or more assessment levels, each of which shall be designated by a capital letter.

The following are the preferred levels.

Assessment level A

– group A inspection: inspection level II, AQL = 4 %
– group B inspection: inspection level II, AQL = 4 %
– group C inspection: 24-month periods
– group D inspection: 48-month periods

Assessment level B

– group A inspection: inspection level II, AQL = 1 %
– group B inspection: inspection level II, AQL = 1 %
– group C inspection: 18-month periods
– group D inspection: 36-month periods

Assessment level C

– group A inspection: inspection level II, AQL = 0,4 %
– group B inspection: inspection level II, AQL = 0,4 %
– group C inspection: 12-month periods
– group D inspection: 24-month periods

One additional assessment level may be added in the detail specification. When this is done, the capital letter X shall be used.

2.1.7 Normative reference extension

Normative reference extensions are used to identify integrated independent standards specifications or other reference documents into blank detail specifications.

Unless specified exception is noted, additional requirements imposed by an extension are mandatory. Usage is primarily intended to merge associated components to form hybrid devices, or integrated functional application requirements that are dependent on technical expertise other than fibre optics.

Published reference documents produced by the ITU, consistent with the scope statements of the relevant IEC specification series may be used as extensions. Published documents produced by other regional standardization bodies such as TIA, ETSI, JIS, etc., may be referenced in a bibliography attached to the generic specification.

Some spatial switch configurations require special qualification provisions which shall not be imposed universally. This accommodates individual component design configurations, specialized field tooling or specific application processes. In this case, requirements are necessary to assure repeatable performance or adequate safety and provide additional guidance for complete product specification and they shall be defined in the relevant specification. These extensions are mandatory whenever they are used to prepare, assemble or install a spatial switch either for field application usage or preparation of qualification test specimens. The relevant specification shall clarify all stipulations. However, design and style-dependent extensions shall not be imposed universally.

In the event of conflicting requirements, precedence, in descending order, shall be the generic specification over mandatory extension, over blank detail, over detail specification, over application-specific extension.

Examples of optical connector extensions are given as follows:

- using IEC 61754-4 and IEC 61754-2 to partially define a future IEC 60874 specification for a duplex type “SC”/“BFOC/2,5” hybrid connector adapter;
- using IEC 61754-13 and IEC 60869-1-1 to partially define a future IEC 60874 specification for an integrated type "FC" preset attenuated optical connector;
- using IEC 61754-2 and IEC 61073-4 to partially define a future IEC 60874 specification for a duplex "BFOC/2,5" receptacle incorporating integral mechanical splices.

Other examples of requirements for normative extensions are as follows.

- Some commercial or residential building applications may require direct reference to specific safety codes and regulations or incorporate other specific material flammability or toxicity requirements for specialized locations.
- Specialized field tooling may require an extension to implement specific ocular safety, electrical shock, burn hazard avoidance requirements, or require isolation procedures to prevent potential ignition of combustible gases.

2.2 Documentation

2.2.1 Symbols

Graphical and letter symbols shall, whenever possible, be taken from IEC 60027, IEC 60617 and IEC 61930.

2.2.2 Specification system

This specification is part of the IEC specification system. Subsidiary specifications shall consist of blank detail specifications and detail specifications. This system is shown in table 4. There are no sectional specifications for switches.

Table 4 – The IEC specification structure

Specification level	Examples of information to be included	Applicable to
Basics	Assessment system rules Inspection rules Optical measurement methods Environmental test methods Sampling plans Identification rules Marking standards Dimensional standards Terminology Symbol standards Preferred number series SI units	Two or more component families or sub-families
Generic	Specific terminology Specific symbols Specific units Preferred values Marking Quality assessment procedures Selection of tests Qualification approval procedures Capability approval procedures	Component family
Blank detail	Quality conformance test schedule Inspection requirements Information common to a number of types	Groups of types having a common test schedule
Detail	Individual values Specific information Completed quality conformance test schedules	Individual type

2.2.2.1 Blank detail specification

Blank detail specifications are not, by themselves, a specification level. They are associated with the generic specification.

Each blank detail specification shall be limited to one environmental category.

Each blank detail specification shall contain

– the minimum mandatory test schedules and performance requirements;
– one or more assessment levels;
– the preferred format for stating the required information in the detail specification;
– in case of hybrid components, including connectors, add appropriate entry fields to show the reference normative document, document title and issue date.

2.2.2.2 Detail specification

A specific switch is described by a corresponding detail specification, which is prepared by filling in the blanks of the blank detail specification. Within the constraints imposed by this generic specification, the blank detail specification may be filled in by any national committee of the IEC, thereby defining a particular switch design as an official IEC standard.

Detail specifications shall specify the following, as applicable:

– type (see 2.1.1);
– style (see 2.1.2);
– variant(s) (see 2.1.3);
– environmental category (see 2.1.5);
– assessment level (see 2.1.6);
– qualification procedure method (see 3.3);
– part identification number for each variant (see 2.7.1);
– drawings and dimensions required (see 2.2.3);
– quality assessment test schedules (see 2.1.5);
– performance requirements (see 2.6).

2.2.3 Drawings

The drawings and dimensions given in detail specifications shall not restrict themselves to details of construction, nor shall they be used as manufacturing drawings.

2.2.3.1 Projection system

Either first-angle or third-angle projection shall be used for the drawings in documents covered by this specification. All drawings within a document shall use the same projection system and the drawings shall state which system is used.

2.2.3.2 Dimensional system

All dimensions shall be given in accordance with ISO 129, ISO 286-1 and ISO 1101.

The metric system shall be used in all specifications.

Dimensions shall not contain more than five significant digits.

When units are converted, a note shall be added in each detail specification.

2.2.4 Test and measurements

2.2.4.1 Test and measurements procedures

The test and measurement procedures for optical, mechanical and environmental characteristics of switches to be used shall be defined and selected preferably from the IEC 61300 series.

The size measurement method to be used shall be specified in the detail specification for dimensions which are specified within a total tolerance zone of 0,01 mm or less.

2.2.4.2 Reference components

Reference components for measurement purposes, if required, shall be specified in the detail specification.

2.2.4.3 Gauges

Gauges, if required, shall be specified in the detail specification.

2.2.4.4 Test reports

Test reports shall be prepared for each test conducted as required by a detail specification. These reports shall be included in the qualification report (see 3.3.9) and in the periodic inspection report (see 3.4.2.6).

The reports shall contain the following information as a minimum:

– title of test and date;
– specimen description including the variant identification number (see 2.7.1);
– test equipment used and date of latest calibration;
– all applicable test details;
– all measurement values and observations;
– sufficiently detailed documentation to provide traceable information for failure analysis (see 3.3.7 and 3.4.2.5).

2.2.5 Instructions for use

Instructions for use, when required, shall be given by the manufacturer and shall include

– assembly and connection instructions;
– cleaning method;
– safety aspects;
– additional information, as necessary.

2.3 Standardization system

2.3.1 Interface standards

Interface standards provide both manufacturer and user with all the information they require to make or use products conforming to the physical features of that standard interface. Interface standards fully define and dimension the features essential for the mating and unmating of optical fibre connectors and other components. They also serve to position the optical datum target, where defined, relative to other reference datum.

Interface standards ensure that connectors and adapters that comply with the standard will fit together. The standards may also contain tolerance grades for ferrules and alignment devices. Tolerance grades are used to provide different levels of alignment precision.

The interface dimensions may also be used to design other components that will mate with the connectors. For example, an active device mount can be designed using the adapter interface dimensions. The use of these dimensions, combined with those of a standard plug, provides the designer with the assurance that the standard plugs will fit into the optical device mount. They also provide the location of the optical datum target of the plug.

Standard interface dimensions do not, by themselves, guarantee optical performance. They only guarantee connector mating at a specified fit. Optical performance is currently guaranteed via the manufacturing specification. Products from the same or different manufacturing specifications using the same standard interface will always fit together. Guaranteed performance can be given by any single manufacturer only for products delivered to the same manufacturing specification. However, it can be reasonably expected that some level of performance will be obtained by mating products from different manufacturing specifications, although the level of performance cannot be expected to be any better than that of the lowest specified performance.

2.3.2 Performance standards

Performance standards contain a series of tests and measurements (which may or may not be grouped into a specified schedule depending on the requirements of that standard) with clearly defined conditions, severities and pass/fail criteria. The tests are intended to be run on a "once-off" basis to prove any product's ability to satisfy the "performance standards" requirement. Each performance standard has a different set of tests, and/or severities (and/or groupings) which represents the requirements of a market sector, user group or system location.

A product that has been shown to meet all the requirements of a performance standard can be declared as complying with a performance standard but should then be controlled by a quality assurance/quality conformance programme.

It is possible to define a key point of the test and measurements standards for their application (particularly with regard to attenuation and return loss) in conjunction with the interface standards of inter-product compatibility. Conformance on each individual product to this standard will be ensured.

2.3.3 Reliability standards

Reliability standards are intended to ensure that a component can meet performance specifications under stated conditions for a stated time period.

For each type of component, the following shall be identified (and appear in the standard):

– failure modes (observable, general mechanical or optical effects of failure);
– failure mechanisms (general causes of failure, common to several components);
– failure effects (detailed causes of failure, specific to the component).

These are all related to environmental and material aspects.

Initially, just after component manufacture, there is an "infant mortality phase" during which many components would fail if they were deployed in the field. To avoid early field failure, all components shall be subjected to a screening process in the factory, involving environmental stresses that may be mechanical, thermal, or humidity-related. This is to induce known failure mechanisms in a controlled environmental situation to occur earlier than would normally be seen in the unscreened population. For those components that survive (and are then sold), there is a reduced failure rate since these mechanisms have been eliminated.

Screening is an optional part of the manufacturing process, rather than a test method. It will not affect the "useful life" of a component, defined as the period during which it performs according to specifications. Eventually, other failure mechanisms appear and the failure rate increases beyond some defined threshold. At this point, the useful life ends, the "wear-out stage" begins and the component must be replaced.

At the beginning of useful life, performance testing on a sample population of components may be applied by the supplier, by the manufacturer or by a third party. This is to ensure that the component meets performance specifications over the range of intended environments at this initial time. Reliability testing, on the other hand, is applied to ensure that the component meets performance specifications for at least a specified minimum useful lifetime or specified maximum failure rate. These tests are usually carried out by utilizing performance testing, but with increased duration and severity to accelerate the failure mechanisms.

A reliability theory relates component reliability testing to component parameters and to lifetime or failure rate under testing. The theory then extrapolates these to lifetime or failure rate under less stressful service conditions. The reliability specifications include values of the component parameters needed to ensure the specified minimum lifetime or maximum failure rate in service.

2.3.4 Interlinking

Standards currently under preparation are given in figure 1. A large number of the test and measurement standards exist already, and the quality assurance qualification approval standards, recognized by the term IECQ, exist already and have done so for many years. As previously mentioned, alternative methods of quality assurance/quality conformance are being developed under the headings "capability approval" and "technology approval", covered by IEC QC 001001, IEC QC 001002, and IEC Guide 102.

With regard to interface, performance and reliability standards, once all these three standards are in place, the matrix given in figure 2 demonstrates some of the other options available for product standardization.

Product A is fully IEC standardized, having a standard interface and meeting defined performance standards and reliability standards.

Product B is a product with a proprietary interface but which meets a defined IEC performance standard and reliability standard.

Product C is a product which complies with an IEC standard interface but does not meet the requirements of either an IEC performance standard or reliability standard.

Product D is a product which complies with both an IEC standard interface and performance standard but does not meet any reliability requirements.

Obviously, the matrix is more complex than is shown, since there will be a number of interface, performance and reliability standards which will be able to be cross-related. In addition, the products may all be subject to a quality assurance programme that could be under IEC qualification approval, capability approval, technology approval (as table 4 attempts to demonstrate), or even a national or company quality assurance system.

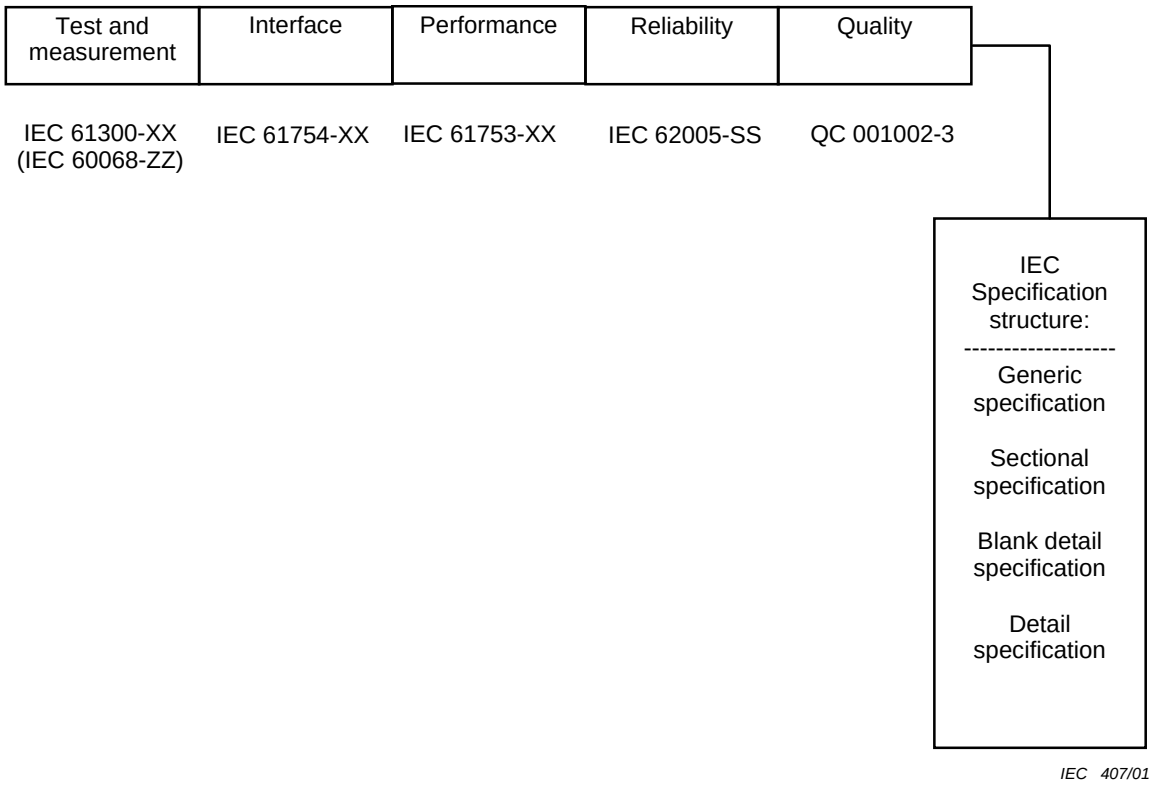


Figure 1 – Standards

Table 5 – Standards interlink matrix

	Interface standard	Performance standard	Reliability standard
Product A	Yes	Yes	Yes
Product B	No	Yes	Yes
Product C	Yes	No	No
Product D	Yes	Yes	No

Table 6 – Quality assurance options

	Company A			Company B			Company C		
	QA	CA	TA	QA	CA	TA	QA	CA	TA
Product A	X			X					X
Product B	X				X				X
Product C	X				X				X
Product D	X					X			X
NOTE QA: Quality assurance; CA: Capability approval; TA: Technology approval.									

2.4 Design and construction

2.4.1 Materials

2.4.1.1 Corrosion resistance

All materials used in the construction of switches shall be corrosion resistant or suitably finished to meet the requirements of the relevant specification.

2.4.1.2 Non-flammable materials

When non-flammable materials are required, the requirement shall be specified in the specification and reference made to IEC 60695-2-2.

2.4.2 Workmanship

Components and associated hardware shall be manufactured to a uniform quality and shall be free of sharp edges, burrs or other defects that would affect life, service ability or appearance. Particular attention shall be given to neatness and thoroughness of marking, plating, soldering, bonding, etc.

2.5 Quality

Switches shall be controlled by the quality assessment procedures of clause 3. The measurement and test procedures of the IEC 61300 series shall be used, as applicable, for quality assessment.

2.6 Performance

Switches shall meet the performance requirements specified in the relevant specification.

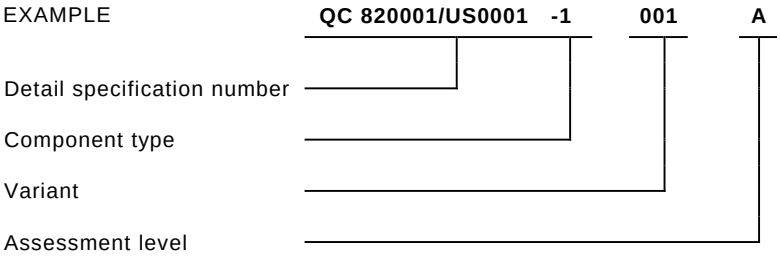
2.7 Identification and marking

Components, associated hardware and shipping packages shall be permanently and legibly identified and marked when required by the detail specification.

2.7.1 Variant identification number

Each variant in a detail specification shall be assigned a variant identification number. The number shall consist of the number assigned to the detail specification followed by a four-digit dash number and a letter designating the assessment level. The first digit of the dash number shall be sequentially assigned to each component type covered by the detail specification. The last three digits shall be sequentially assigned to each variant of the component.

EXAMPLE



2.7.2 Component marking

Component marking, if required, shall be specified in the detail specification. The preferred order of marking is as follows:

a) port identification;

b) manufacturer's part number (including serial number, if applicable);

c) manufacturer's identification mark or logo;

d) manufacturing date;

e) variant identification number;

f) any additional marking required by the detail specification.

If space does not allow for all the required marking on the component, each unit shall be individually packaged with a data sheet containing all of the required information which is not marked.

2.7.3 Package marking

Package marking, if required, shall be specified in the detail specification. The preferred order of marking is as follows:

a) manufacturer's identification mark or logo;

b) manufacturer's part numbers;

c) manufacturing date codes (year/week; see ISO 8601);

d) variant identification number(s) (see 2.7.1);

e) assessment level;

f) type designations (see 2.1.1);

g) environmental category;

h) any additional marking required by the detail specification.

When applicable, individual unit packages (within the sealed package) shall be marked with the reference number of the certified record of released lots, the manufacturer's factory identity code and the component identification.

2.8 Packaging

Packages shall include instructions for use when required by the specification (see 2.2.6).

2.9 Storage conditions

Where short-term degradable materials such as adhesives are supplied with the package, the manufacturer shall mark these with the expiry date (year and week numbers, see ISO 8601) together with any requirements or precautions concerning safety hazards or environmental conditions for storage.

2.10 Safety

Optical switches, when used on an optical fibre transmission system and/or equipment, may emit potentially hazardous radiation from an uncapped or unterminated output port or fibre end.

Manufacturers of optical switches shall make available sufficient information to alert system designers and users about the potential hazard and shall indicate the required precautions and working practices.

In addition, each detail specification shall include the following.

WARNING

Care should be taken when handling small diameter fibre to prevent puncturing the skin, especially in the eye area. Direct viewing of the end of an optical fibre, or an optical fibre connector when it is propagating energy, is not recommended unless prior assurance has been obtained as to the safety energy output level.

Reference shall be made to IEC 60825-1, the relevant standard on safety.

3 Quality assessment procedures

Procedures for quality assessment and release of components consist of the following:

– qualification approval procedures (see 3.3);
– quality conformance inspection (see 3.4).

3.1 Primary stage of manufacture

The manufacturing stage when the parts which make up the individual components are aggregated into the product defined in the detail specification. Subcontracting of the primary stage and subsequent stages is permitted under the terms of IEC QC 001002.

3.2 Structurally similar components

Structurally similar components are those components that may be grouped together within a common detail specification for the purpose of qualification approval and quality conformance inspection. For the purpose of sampling inspection, passive components are considered structurally similar if they are

– produced by one manufacturer with essentially the same design, materials, process and method;
– constructed such that the results of any required test carried out on one of these components can be regarded as valid for the other components.

The specific grouping of structurally similar components for the purpose of qualification approval and quality conformance testing shall be approved by the National Supervising Inspectorate (refer to IEC QC 001002).

3.3 Qualification approval procedures

Qualification approval procedures are specified both in this standard and in the detail specification. Manufacturers may approve complete switches or individual components.

Manufacturers shall

– comply with the general requirements of clause 3 of IEC QC 001002-3;
– comply with the requirements for the performance of the primary stage of manufacture for the components to be qualified;
– produce test evidence showing successful completion of the qualification test procedures.

The procedures of 3.3.1 and 3.3.2 are alternative methods for qualification as prescribed in 3.1.4 of IEC QC 001002-3. The detail specification shall specify which procedure is to be used.

3.3.1 Fixed sample procedure

The fixed sample procedure consists of subjecting a sample of specimens to the fixed sample qualification test sequence as specified in the detail specification. The sample shall be drawn from current production.

3.3.2 Lot-by-lot and periodic procedures

The lot-by-lot and periodic procedures consists of performing lot-by-lot inspection on a specified number of inspection lots (minimum of three) taken in as short a time as possible. The periodic tests are then performed on samples selected from at least one of the lots. The detail specification shall specify the sample size and periodicity for this procedure. Samples shall be selected from the lots in accordance with IEC 60410. Normal inspection on the sample sizes shall be used, but when the sample size is so small that acceptance based on zero defects, is implied, additional specimens shall be taken to meet the sample size requirements for acceptance of one defect.

3.3.3 Qualifying specimen

When simultaneously qualifying all components of a set, the qualifying specimen shall be a complete switch. The components being qualified shall be units produced with equipment and procedures used in current production.

3.3.4 Sample size

The detail specification shall specify the sample size for qualification approval by the fixed sample procedure. Following completion of the group "0" tests for a particular environmental category, the specimens for the other groups shall be randomly selected from the group "0" sample. In addition, one specimen of each component to be qualified by structural similarity shall be provided.

3.3.5 Preparation of specimens

The detail specification or the relative test method shall specify the preparation and the preconditioning of specimen for testing. Specimens shall be assembled according to the manufacturer’s instructions for use (see 2.2.6).

3.3.6 Qualification testing

Qualification specimens shall meet the performance requirements given in the detail specification.

3.3.7 Qualification failures

Manufacturers shall immediately notify the National Supervising Inspectorate (NSI) when a failure occurs during qualification testing. If the NSI determines that the failure has not been adequately explained and corrected, the manufacturer's Chief Inspector may be directed to conduct a formal failure analysis. When complete, the manufacturer shall prepare and submit a failure report to the NSI. Failure reports shall describe the failure and its cause, together with recommended corrective action to be taken. The NSI shall then decide the steps to be taken. All failure reports, including the recommendations of the NSI, shall be included in the qualification report (see 3.3.9). One or more unresolved failures shall be cause for refusal to grant qualification approval.

3.3.8 Maintenance of qualification approval

Qualification approval shall be maintained for components by continuously submitting them for the quality conformance requirements as specified in 3.4.

Qualification approval shall be verified if any of the following conditions exist:

– the production programme is such that the periodic tests cannot be carried out at the specified frequency;
– the conformity of the components to the initial qualification approval is doubtful. For example, technical modifications may potentially change the performance of the component;
– a change has been made to the specification.

Qualification approval shall be verified by the procedures defined in 3.1.7.3 and 3.1.7.4 of IEC QC 001002-3.

3.3.9 Qualification report

Qualification testing results shall be recorded in a qualification approval report in accordance with 3.1.4 of IEC QC 001002-3.

3.4 Quality conformance inspection

Quality conformance inspection consists of the lot-by-lot and periodic inspections specified herein and in the detail specification. Manufacturers shall comply with the general requirements of the rules and procedures governing quality conformance inspection of components (3.2.3 of IEC QC 001002-3). Lot-by-lot and periodic inspection schedules shall specify the groupings and be established in accordance with 3.2.3.2 and 3.2.3.3 of IEC QC 001002-3.

3.4.1 Lot-by-lot inspection

Lot-by-lot inspection consists of subjecting a sample of specimens to the group A and B tests specified in the detail specification. Specimens shall be drawn from each inspection lot in accordance with the specified sampling plan, and shall be drawn in a random fashion.

3.4.1.1 Formation of inspection lots

An inspection lot may consist of one production lot or of several lots which have been aggregated under the following safeguards:

– inspection lots shall consist of structurally similar production lots (see 3.2);
– the period over which the production lots were aggregated shall not exceed one month.

The plan for the aggregation of production lots into inspection lots shall be approved by the National Supervising Inspectorate.

3.4.1.2 Rejected lots

Specimens found to be defective during lot-by-lot testing shall be treated in accordance with the requirements of 3.2.4 of IEC QC 001002-3. Rejected lots may be reworked to correct the defects or to screen them out. The reworked lot shall then be submitted for re-inspection using tightened inspection. They shall be separated from new lots and shall be clearly identified as re-inspected lots.

3.4.2 Periodic inspection

Periodic inspection consists of subjecting a sample of specimens to the group C and D tests specified in the detail specification. Each group shall be conducted at the period specified for the relevant assessment level (see 2.1.5). The periods shall be maintained relative to each other so that the group D inspection replaces the group C inspection during the group D period.

3.4.2.1 Periodic inspection specimen

The periodic inspection specimen shall be a complete switch. The specimens shall be the same variants as were used for qualification. The specimens being inspected shall be units produced with equipment and procedures used in current production.

3.4.2.2 Sample size

The detail specification shall specify the sample size for periodic inspection. The specimens shall be complete switches and shall be selected from inspection lots which satisfied the lot-by-lot inspections of 3.4.1 during the time since the previous periodic inspection. Following completion of the group "C0" or "D0" tests for a particular environmental category, the specimens for the other groups shall be randomly selected from the group "C0" or "D0" samples.

3.4.2.3 Preparation of specimens

The preparation of specimens is the same as that specified in 3.3.5.

3.4.2.4 Periodic inspections

Periodic inspection specimens shall meet the performance requirements given in the detail specification.

3.4.2.5 Periodic inspection failures

Failures shall be treated according to the procedures of 3.3.7. If a specimen fails to satisfy the requirements of that periodic test, the manufacturers' chief inspector shall immediately initiate the requirements of 3.1.8 of IEC QC 001002-3. One or more unresolved failures shall be a reason for withdrawing qualification approval.

3.4.2.6 Periodic inspection report

Periodic testing results shall be maintained in accordance with the requirements of 3.2.5 of IEC QC 001002-3.

3.5 Certified records of released lots

Detail specifications shall specify if a certified record of released lots is required. When required, the record shall be prepared in accordance with 1.5 of IEC QC 001002-2 and contain the following information as a minimum:

– attribute information (i.e. number of components tested and number of defective components) for tests in the subgroups covered by periodic inspection without reference to the parameter for which rejection was made;

– variable information for the change of any optical performance parameter after tests as required in the detail specification.

3.6 Delayed deliveries

Released components which have been in store for a period longer than two years following the release of the lot shall be re-examined before delivery. The re-examination procedure shall be recommended by the manufacturer and be approved by the National Supervising Inspectorate. Re-inspected products may be placed back into stores for another two years.

3.7 Delivery release before completion of group B tests

When the conditions of IEC 60410 for changing to reduced inspection have been satisfied for all group B tests, the manufacturer is permitted to release components before completion of these tests.

3.8 Alternative test methods

Test methods alternative to those specified in the detail specification may be used. However, the manufacturer shall satisfy the National Supervising Inspectorate that the alternative method will give results equivalent to those obtained by the methods specified. In case of dispute, only the test method specified in the detail specification shall be used.

3.9 Unchecked parameters

Only those component parameters which have been specified in a detail specification and which were tested can be assumed to be within the specified limits. It should not be assumed that unspecified parameters will be uniform and unchanged from one component to another. If it should be necessary to control parameters other than those specified, a new, more extensive detail specification shall be written and used. The additional test method(s) shall be described and appropriate performance limits and assessment levels specified.

Bibliography

IEC 60068 (all parts), *Environmental testing*

IEC 60869-1-1:1994, *Fibre optic attenuators – Part 1-1: Blank detail specification*

IEC 60874 (all parts), *Connectors for optical fibres and cables*

IEC 61073-4:1994, *Splices for optical fibres and cables – Part 4: Sectional specification – Mechanical splices for optical fibres and cables*

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

IEC 61754-2:1996, *Fibre optic connector interfaces – Part 2: Type BFOC/2,5 connector family*

IEC 61754-4:1997, *Fibre optic connector interfaces – Part 4: Type SC connector family*

IEC 61754-13:1999, *Fibre optic connector interfaces – Part 13: Type FC-PC connector family*

IEC 62005 (all parts), *Reliability of fibre optic interconnecting devices and passive optical components*

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