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SERIES L: CONSTRUCTION, INSTALLATION AND PROTECTION OF CABLES AND OTHER ELEMENTS OF OUTSIDE PLANT

Optical branching components (non-wavelength selective)

ITU-T Recommendation L.37

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Optical branching components (non-wavelength selective)

Summary

ITU-T Recommendation L.37 describes the main features of fibre-optic branching devices in terms of types, fields of application, configurations and technical aspects.

Furthermore, ITU-T Recommendation L.37 describes the requirements of the mechanical, environmental and physical performance and reliability for optical branching components, which are stipulated in ITU-T Recommendation G.671 with regard to the optical performance of PONs, advising on general requirements and test methods.

Source

ITU-T Recommendation L.37 was approved on 22 February 2007 by ITU-T Study Group 6 (2005-2008) under the ITU-T Recommendation A.8 procedure.

FOREWORD

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Optical branching components (non-wavelength selective)

1 Scope

This Recommendation applies to optical branching components (non-wavelength selective) to be used for passive optical networks (PONs).

This Recommendation:

– gives general information on fundamental types of optical branching components, and their field of application;
– classifies optical branching components into types and configurations;
– provides a general description of the basic operating principle and the fabrication technologies;
– describes the application environments of optical branching components for PONs;
– reports the performance and outlines reliability test methods for optical branching components for PONs.

NOTE – Performance and reliability requirements in this Recommendation relate only to the properties of the optical branching component. This does not include the behaviour of optical connectors that may be used to terminate input and/or output fibres.

2 References

The following ITU-T Recommendations and other references contain provisions which, through reference in this text, constitute provisions of this Recommendation. At the time of publication, the editions indicated were valid. All Recommendations and other references are subject to revision; users of this Recommendation are therefore encouraged to investigate the possibility of applying the most recent edition of the Recommendations and other references listed below. A list of the currently valid ITU-T Recommendations is regularly published. The reference to a document within this Recommendation does not give it, as a stand-alone document, the status of a Recommendation.

[ITU-T G.671] ITU-T Recommendation G.671 (2005), *Transmission characteristics of optical components and subsystems*, plus Amendment 1 (2006).

[ITU-T G.983.1] ITU-T Recommendation G.983.1 (2005), *Broadband optical access systems based on Passive Optical Networks (PON).*

[ITU-T G.983.3] ITU-T Recommendation G.983.3 (2001), *A broadband optical access system with increased service capability by wavelength allocation*.

[ITU-T G.984.2] ITU-T Recommendation G.984.2 (2003), *Gigabit-capable Passive Optical Networks (G-PON): Physical Media Dependent (PMD) layer specification*.

[IEC 60695-11-10] IEC 60695-11-10 (2003), *Fire hazard testing – Part 11-10: Test flames – 50 W horizontal and vertical flame test methods*.

[IEC 61300] IEC 61300-series, *Fibre optic interconnecting devices and passive components – Basic test and measurement procedures*.

[IEC 62005-2] IEC 62005-2 (2001), *Reliability of fibre optic interconnecting devices and passive components – Part 2: Quantitative assessment of reliability based on accelerated ageing test – Temperature and humidity; steady state*.

3 Definitions

This Recommendation defines the following term:

3.1 optical branching component: A passive optical component with three or more ports that shares optical power among its ports in a predetermined fashion, without any amplification, switching or other active modulation.

4 Abbreviations and acronyms

This Recommendation uses the following abbreviations and acronyms:

CVD	Chemical Vapour Deposition
FBT	Fused Biconic Taper
FHD	Flame Hydrolysis Deposition
FIT	Failures In Time (number of device failures in 10^9 device hours)
OLT	Optical Line Termination
ONU	Optical Network Unit
PON	Passive Optical Network

5 Conventions

None.

6 General information

Optical branching components provide a method for splitting optical signals between M input and N output ports (see Figure 6-1); optical branching components are required when an optical signal has to be split into two or more fibre lines or when several signals coming from different fibre lines have to be mixed in a single fibre line; in general, optical branching components are dividers/combiners of transit signals.

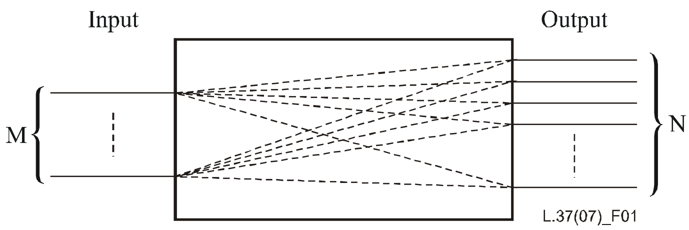

Figure 6-1 – MxN branching component (schematic)

In a point-to-multipoint distribution architecture, optical branching components are used to connect an OLT located at a central office to several ONUs located in outside plant or on subscriber premises.

7 Types and configurations

Optical branching components can be classified as one or more of the following:

a) **star branching devices**: A branching device typically balanced; possessing more than four ports;

b) **tree branching devices**: A branching device with a single optical input distributed among several outputs, or vice versa.

Optical branching components can be designed to operate at a single wavelength (e.g., 1310 or 1550 nm), to be wavelength flat (e.g., insensitive to wavelength variations within a single window) or to be wavelength independent (e.g., insensitive to wavelength variations within both the second and third windows, 1260-1360 nm and 1450-1600 nm, or 1260-1360 nm and 1450-1660 nm).

8 Technological aspects

There are several methods used to manufacture optical branching components, and they can be grouped into the following classes:

a) **fusion technology**: This technology has proved to be simple, versatile and effective, allowing the industrial implementation of several kinds of branching devices for a variety of applications. With the fused biconic taper (FBT) method, bare or etched fibres are brought into contact, stretched, possibly twisted, and fused so that evanescent mode coupling occurs along the interaction length;

b) **planar optics technology**: Planar waveguide branching devices are made by photolithographic technology, using parallel processing techniques. To produce the refractive index profile, ions are diffused into a substrate such as glass, semiconductor (silicon), $LiNbO_3$ or polymer. Alternatively, doped silica glass is fabricated by chemical vapour deposition (CVD) or by flame hydrolysis deposition (FHD) and consolidation. The optical profile and the geometrical properties of the guiding structure are defined by photolithographic masking techniques followed by etching;

c) **polishing technology**: In order to position fibre cores close enough to allow the overlap of the evanescent fields (coupling conditions), the fibre cladding is removed to within a few microns of the core. This controlled removal of the cladding is achieved by mechanical abrasion (polishing).

9 Optical parameters and performance

Optical branching components for PONs are characterized by several parameters, the most important of which are the following:

– insertion loss;

– reflectance;

– optical wavelength range;

– polarization-dependent loss.

– directivity;

– uniformity.

These parameters are defined in Amendment 1 to [ITU-T G.671].

10 Application environments and test methods for optical branching components

The following describes application environments, and performance and reliability test methods for optical branching components for PONs.

During or after each test, the device should still meet loss criteria according to Amendment 1 to [ITU-T G.671].

Insertion loss measurements should be executed at least at 1310 and 1550 nm, but also at 1625 nm if agreed between user and supplier.

10.1 Application environments

The recommended temperature range in which the performance should be guaranteed is from –40° C up to at least +75° C (for applications in passive nodes).

The recommended humidity range in which the performance should be guaranteed is from 5% to 95% RH.

10.2 Performance and reliability test methods

10.2.1 Basic performance requirements

These requirements apply to all splitters to assess their performance.

10.2.1.1 Vibration

The test procedure should be in accordance with [IEC 61300], part 2-1, and insertion loss measurements are performed before and after this test. The test parameter values are as follows:

– Frequency range: 10-55 Hz.

– Sweep rate: to vary uniformly between 10 and 55 Hz and to return to 10 Hz in approximately 4 min.

– Endurance duration per axis: at least 20 minutes in each of three mutually perpendicular planes.

– Number of axes: 3.

– Vibration amplitude: 1.52 mm.

10.2.1.2 Impact

The test procedure should be in accordance with [IEC 61300], part 2-9, and the insertion loss measurements are performed before and after this test. The test parameter values are as follows:

– Peak acceleration and duration: 500 g; 1 ms pulse duration.

– Number of impacts per direction: 5.

– Number of axes: 3 (two directions per axis).

10.2.1.3 Fibre retention

The test procedure should be in accordance with [IEC 61300], part 2-4, and the insertion loss measurements are performed before and after this test. The test parameter values are as follows:

– Magnitude of the load: 5 N for coated fibres (primary and secondary), 10 N for 4-fibre ribbon.

– Load rate: 400 µm/s for coated fibres until attaining the maximum load.

– Point of application of the tensile load: minimum 0.1 m from the end of the fibre.

– Duration of the test: 1 min while maintaining the load.

10.2.1.4 Fibre side pull

The test procedure should be in accordance with [IEC 61300], part 2-42, and the insertion loss measurements are performed before and after this test. The test parameter values are as follows:

– Magnitude of the load: 2.5 N for single fibre/5 N for ribbon fibre or loose tube.

– Angle of application to interface: 90°.

– Duration of the load application: 5 s.

– Number of mutually perpendicular directions of load application: 2.

– Point of application of the load: 22 to 28 cm from the component housing.

10.2.1.5 Temperature humidity cycle

The test procedure should be in accordance with [IEC 61300], part 2-48, and the insertion loss measurements are performed before, during and after this test. The test parameter values are as follows (see Figure 10-1):

– Temperature range: –40 to +75° C.

– Humidity range: 10 to 80% RH.

– Thermal profile:

  • from 2 to 32° C, maintain a constant relative humidity of 80 ± 2%;

  • from 32 to 75° C, maintain a constant humidity ratio from 80% RH at 32° C to 10% RH at 75° C;

  • below 2° C, humidity is uncontrolled.

– Minimum duration at extreme temperature: 1 hour.

– Temperature rate of change: 1° C/min.

– Number of cycles: 42 (8 h/cycle).

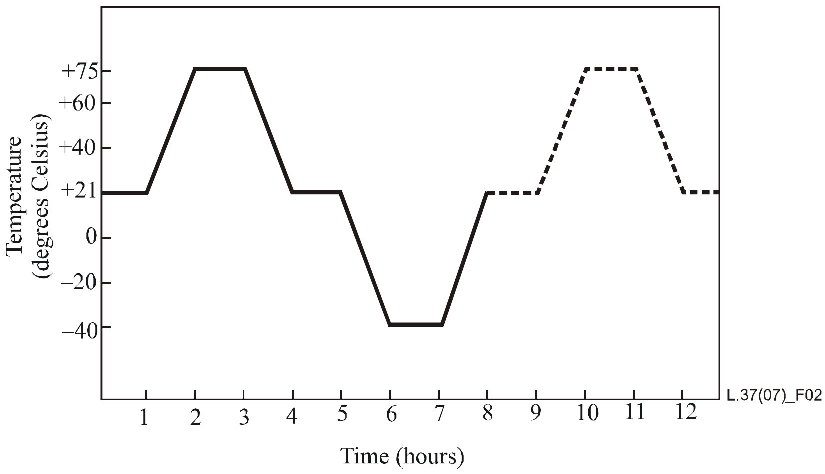

Figure 10-1 – Thermal profile of temperature humidity cycle test

10.2.1.6 Temperature humidity ageing

The test procedure should be in accordance with [IEC 61300], part 2-19, and the insertion loss measurements are performed before and after this test. The test parameter values are as follows:

– Temperature: +75° C (or +85° C as an alternate condition).

– Relative humidity: 85%.

– Duration of exposure: 336 hours.

10.2.1.7 Water immersion

The test procedure should be in accordance with [IEC 61300], part 2-45, and the insertion loss measurements are performed before, during and after this test. The test parameter values are as follows:

– Temperature: 43 ± 2° C.

– pH: 5.5 ± 0.5.

– Duration of exposure: 168 hours.

10.2.1.8 Flammability (for indoor applications)

The test procedure should be in accordance with [IEC 60695-11-10] test method B.

Exposed materials of the splitter housing shall not sustain combustion when an open flame source is removed.

10.2.1.9 Toxicity

All optical branching component materials shall be non-toxic.

10.2.1.10 Fungus resistance

Optical branching component materials shall not support fungus growth.

10.2.1.11 Salt spray

The test procedure should be in accordance with [IEC 61300], part 2-26, and the insertion loss measurements are performed before, during and after this test. The test parameter values are as follows:

– Temperature: 35° C.

– Solution concentration: 5% by weight (NaCl).

– Duration of exposure: 168 hours.

– No visual evidence of corrosion after the test.

10.2.2 Additional reliability requirements

The requirements in this clause are intended to assess reliability on a longer term basis. Applicability is to be agreed between user and supplier.

10.2.2.1 Vibration

The test procedure should be in accordance with [IEC 61300], part 2-1, and insertion loss measurements are performed before and after this test. The test parameter values are as follows:

– Frequency range: 20-2000 Hz.

– Maximum acceleration: 20 g.

– Endurance duration: 4 minutes per cycle and 4 cycles in each of the orientations, X, Y and Z.

10.2.2.2 Impact

The test procedure should be in accordance with [IEC 61300], part 2-9, and the insertion loss measurements are performed before and after this test. The test parameter values are as follows:

– Peak acceleration and duration: 1000 g; 0.5 ms pulse duration.

– Number of impacts: 8 per direction.

– Number of axes: 3 (2 directions per axis).

10.2.2.3 Cyclic moisture resistance

The test procedure should be in accordance with [IEC 61300], part 2-21, and the insertion loss measurements are performed before and after this test. The test parameter values are as follows (see Figure 10-2):

– Temperature range: –40 to +75° C.

– Relative humidity: 85-95% RH at +75° C; uncontrolled at 25° C and –40° C.

– Duration at extreme temperature: 3 to 16 hours.

– Number of cycles: 5 (each cycle has 5 sub-cycles) (35 h/cycle).

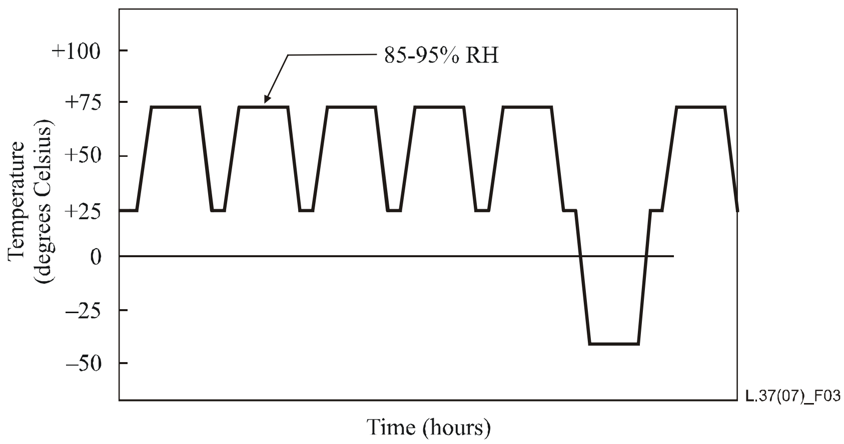

Figure 10-2 – Thermal profile of cyclic moisture resistance test

10.2.2.4 Thermal shock

The test procedure should be in accordance with [IEC 61300], part 2-47, and the insertion loss measurements are performed before and after this test. The test parameter values are as follows:

– Temperature range: 0 to 100° C.

– Duration at extreme temperature: minimum 5 min.

– Change-over time: maximum 10 s.

– Number of cycles: 15.

10.2.2.5 Temperature cycling

The test procedure should be in accordance with [IEC 61300], part 2-22, and the insertion loss measurements are performed before and after this test. The test parameter values are as follows:

– High temperature: +85° C.

– Low temperature: –40° C.

– Temperature rate of change: 1° C/min.

– Number of cycles: 500 (4.5 h/cycle).

10.2.2.6 Low temperature storage

The test procedure should be in accordance with [IEC 61300], part 2-17, and the insertion loss measurements are performed before, during and after this test. The test parameter values are as follows:

– Temperature: –40° C.

– Duration of exposure: 2000 hours (and up to 5000 hours for information).

10.2.2.7 High temperature storage

The test procedure should be in accordance with [IEC 61300], part 2-19, and the insertion loss measurements are performed before, during and after this test. The test parameter values are as follows:

– Temperature: +85° C.

– Relative humidity: +85% RH.

– Duration of exposure: 2000 hours (and up to 5000 hours for information).

10.2.2.8 Maximum input power

The incident light shall not cause any optical branching component to deteriorate.

The test procedure should be in accordance with [IEC 61300], part 2-14.

The maximum input power conditions should be decided by agreement between user and supplier.

10.2.2.9 Failure rate

FIT rates can be determined by applying [IEC 62005-2]. The required application and operational conditions (such as temperature and humidity), as well as the required FIT rate, are to be agreed between user and supplier.

Appendix I

Optional performance requirement

(This appendix does not form an integral part of this Recommendation)

These requirements can be added to the basic test plan in agreement between user and supplier. They have been applied in applications in some regions in the world.

I.1 Low temperature storage

The test procedure should be in accordance with [IEC 61300], part 2-17, and the insertion loss measurements at 1310 and 1550 nm are performed before, during and after this test. The test parameter values are as follows:

– Temperature: –40° C.

– Duration of exposure: 336 hours.

Appendix II

Additional criteria for performance and reliability tests for optical branching components for PONs

(This appendix does not form an integral part of this Recommendation)

These are additional performance criteria, historically used by some operators:

II.1 Introduction

This appendix describes the criteria for performance and reliability tests for optical branching components for PONs.

II.2 Criteria for performance and reliability tests for optical branching components for PONs

The following shows the criteria for performance and reliability tests for optical branching components for PONs.

II.2.1 Mechanical integrity

The criteria for the mechanical integrity requirements of optical branching components for PONs are shown in Table II.1. The criteria values are the differences between the insertion loss values (wavelengths: 1310 and 1550 nm) before and after each test procedure. The number of output ports of optical branching components for PONs is 4, 8, 16 or 32.

Table II.1 – Mechanical integrity criteria

Test	Criteria (at 1310 and 1550 nm)	
	Output port: 4, 8	**Output port: 16, 32**
Vibration (basic)	+0.2/–0.2 dB, before and after test	+0.5/–0.5 dB, before and after test
Vibration (additional)	+0.2/–0.2 dB, before and after test	+0.5/–0.5 dB, before and after test
Impact (additional)	+0.2/–0.2 dB, before and after test	+0.5/–0.5 dB, before and after test
Impact (basic)	+0.2/–0.2 dB, before and after test	+0.5/–0.5 dB, before and after test
Fibre retention	+0.2/–0.2 dB, before and after test	+0.5/–0.5 dB, before and after test
Fibre side pull	+0.2/–0.2 dB, before and after test	+0.5/–0.5 dB, before and after test

II.2.2 Short-term reliability

The criteria of the short-term reliability requirements for optical branching components for PONs are shown in Table II.2. The criteria values are the differences between the insertion loss values (wavelengths: 1310 and 1550 nm) before and after each test procedure. The number of output ports of optical branching components for PONs is 4, 8, 16 or 32.

Table II.2 – Short-term reliability criteria

Test	Criteria (at 1310 and 1550 nm)	
	Output port: 4, 8	**Output port: 16, 32**
Temperature humidity cycle	+0.3/–0.3 dB, before, during and after test	+0.5/–0.5 dB, before, during and after test
Low temperature storage	+0.2/–0.2 dB, before, during and after test	+0.5/–0.5 dB, before, during and after test
Temperature humidity ageing	+0.3/–0.3 dB, before and after test	+0.5/–0.5 dB, before and after test
Cyclic moisture resistance	+0.3/–0.3 dB, before and after test	+0.5/–0.5 dB before and after test
Thermal shock	+0.3/–0.3 dB, before and after test	+0.5/–0.5 dB before and after test

II.2.3 Long-term reliability

The criteria of the long-term reliability requirements for optical branching components for PONs are shown in Table II.3. The criteria values are the differences between the insertion loss values (wavelengths: 1310 and 1550 nm) before and after each test procedure. The number of output ports of optical branching components for PONs is 4, 8, 16 or 32.

Table II.3 – Long-term reliability criteria

Test	Criteria (at 1310 and 1550 nm)	
	Output port: 4, 8	**Output port: 16, 32**
Temperature cycling	+0.3/–0.3 dB, before and after test	+0.5/–0.5 dB before and after test
Low temperature storage	+0.3/–0.3 dB, before, during and after test	+0.5/–0.5 dB, before, during and after test
High temperature storage	+0.3/–0.3 dB, before, during and after test	+0.5/–0.5 dB, before, during and after test

II.2.4 Weather resistance

The weather resistance criteria for optical branching components for PONs are shown in Table II.4. The criteria values are the differences between the insertion loss values (wavelengths: 1310 and 1550 nm) before and after each test procedure. The number of output ports of optical branching components for PONs is 4, 8, 16 or 32.

Table II.4 – Weather resistance criteria

Test	Criteria (at 1310 and 1550 nm)	
	Output port: 4, 8	**Output port: 16, 32**
Salt spray	+0.2/–0.2 dB, before, during and after test	+0.5/–0.5 dB, before, during and after test
Water immersion	+0.2/–0.2 dB, before, during and after test	+0.5/–0.5 dB, before, during and after test
Toxicity	Non-toxic	Non-toxic
Fungus resistance	Does not support fungus growth	Does not support fungus growth
Flammability	V-0	V-0

II.2.5 Optical power characterization

The optical power characterization criterion for optical branching components for PONs is shown in Table II.5.

Table II.5 – Optical power characterization criterion

Test	Criterion
	1550 nm
Maximum input power	20 dBm, guaranteed for 20 years

II.2.6 Failure rate

The information specifications that are required to describe the failure rate of optical branching components for PONs should be provided by the suppliers.

The FIT rate for a range of application temperature and humidity over the lifetime of the component shall be calculated from the results of suitable accelerated life tests. For example, [IEC 62005-2] provides a methodology for carrying out these calculations.

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