

**Transmission and Multiplexing TM;
Passive optical components;
Connector-type optical fixed attenuators for single-mode
optical fibre communications systems;
Common requirements and conformance testing**



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Foreword

This ETSI Standard (ES) has been produced by ETSI Technical Committee Transmission and Multiplexing (TM), and is now submitted for the ETSI standards Membership Approval Procedure.

1 Scope

The present document defines the requirements for connector-type fixed attenuators to be used in single-mode optical fibre transmission networks. This type of attenuator is sometimes referred to as a build-out attenuator. The present document does not cover variable or pigtailed attenuators. The scope of the Standard is the establishment of minimum uniform requirements for the following aspects:

- optical, environmental and mechanical properties;
- test conditions;
- acceptance criteria.

Reliability aspects of connector-type optical attenuators are not covered by the present document.

Some users may require further testing to be specified. Examples would be extending the lower temperature limit, specifying modal noise limits and extending operation into the 1 600 nm to 1 650 nm wavelength test window. These users should specify the present document plus their additional special requirements.

Acceptance criteria will be interpreted with the consideration that some of the parameters specified in the present document may be affected by measurement uncertainty arising either from measurement or calibration errors. Test methods are in accordance with EN 186000-1 [5], EN 180000 [2] or IEC 61300 series [1], [3], [4].

For a definition of a Connector-type optical attenuator see subclause 3.1 of the present document.

2 References

The following documents contain provisions which, through reference in this text, constitute provisions of the present document.

- References are either specific (identified by date of publication, edition number, version number, etc.) or non-specific.
- For a specific reference, subsequent revisions do not apply.
- For a non-specific reference, the latest version applies.
- A non-specific reference to an ETS shall also be taken to refer to later versions published as an EN with the same number.

- [1] IEC 61300-3-6: "Fibre optic interconnecting devices and passive components; Basic test and measurement procedures; Part 3-6: Examinations and measurements; Return loss".
- [2] EN 180000: "Generic Specification. Fibre Optic Attenuators".
- [3] IEC 61300-3-2: "Fibre optic interconnecting devices and passive components; Basic tests and measurement procedures: Part 3-2: Examinations and measurements; Polarization dependence of a single-mode fibre optic device".
- [4] IEC 61300-2-14: "Fibre optic interconnecting devices and passive components; Basic tests and measurement procedures; Part 2-14: Tests; Maximum Input Power".
- [5] EN 186000-1 (1993): "Generic Specification: Connectors sets for Optical fibres and cables; Part 1: Requirements, test methods and qualification approval procedures".
- [6] ETS 300 019: "Equipment Engineering (EE); Environmental conditions and environmental tests for telecommunications equipment".
- [7] IEC 60068-2-30: "Environmental testing; Part 2: Tests. Test Db and guidance: Damp heat, cyclic (12 + 12-hour cycle)".

- [8] IEC 874-1 (1993), including amendment 1 (1994): "Connectors for optical fibres and cables; Part 1: Generic Specification".

3 Definitions and abbreviations

3.1 Definitions

For the purposes of the present document, the following terms and definitions apply:

optical attenuator: passive optical component which gives a controlled signal attenuation when inserted in an optical path.

connector-type optical attenuator: attenuator consisting of a fibre optic connector in which the element joining the two optical interfaces introduces a signal attenuation, providing a demountable coupling between optical fibres in addition to providing signal attenuation.

3.2 Abbreviations

For the purposes of the present document, the following abbreviations apply:

CW	Continuous wave
OTDR	Optical time domain reflectometer
RL	Return loss

4 Details, measurements and performance requirements

All measurements shall be carried out at normal room conditions, unless otherwise stated. Before the attenuation and return loss measurement, careful cleaning in accordance with manufacturers instructions is necessary.

All optical tests shall be carried out in both the 1 310 nm window and the 1 550 nm window unless otherwise stated. Light sources with peak wavelengths of $1\ 310\ \text{nm} \pm 30\ \text{nm}$ and $1\ 550\ \text{nm} \pm 30\ \text{nm}$ shall be used.

Additionally the wavelength region from 1 600 nm to 1 650 nm is of increasing interest for monitoring telecommunication cable networks. In this case the allowed limits for this region may be specified by the user as an addition to the minimum common performance standards defined in the present document.

4.1 Visual inspection

4.1.1 Overall inspection of attenuators

Each connector-type fixed attenuator shall be adequately packaged to protect from damage in transit before installation. The package shall be marked with the name of the manufacturer and the production date.

The body of the connector-type fixed attenuator itself shall be legibly and durably marked with the identity mark of the manufacturer, the manufacturing date code and the nominal attenuation.

4.1.2 Inspection of the end faces

The end faces shall be clean and free from residues of glue. Using a microscope with a maximum magnification of 200x, no significant scratches shall be permitted in the core region of the fibre and no break out of glass pieces shall be seen. There shall also be no heavy scratches visible on any other part of the polished fibre surfaces. Where applicable, there shall also be no significant scratches or marks on the optical interfaces of the attenuating element.

4.2 Dimensions and mechanical measurement accuracy

Measurements accuracy and standardization shall be established to ensure consistency of production and consistency of performance of intermitted connector-type attenuators from different sources.

Mechanical measurement accuracy shall be demonstrated to be in accordance with IEC 874-1 amendment 1 [8] or EN 186000-1 [5].

4.3 Attenuation

Details:

In accordance with EN 180000 [2], subclause 4.4.5, method 3 (measurements against 2 reference plugs). The eccentricity of the reference connector plugs (centre of fibre to centre of ferrule) shall be $\leq 0,3 \mu\text{m}$. The other parameters of the reference plugs depend on the connector type and shall be specified by the user.

Modal conditions: Only the fundamental mode shall propagate at the fixed attenuator interface and at the detector.

Requirements:

The upper and lower limits of attenuation value are given in table 1. The values in this table are the initial attenuation limits. A further variation of $\pm 0,5 \text{ dB}$ is allowed during environmental and mechanical testing.

Table 1

Nominal attenuation (dB)	Minimum initial attenuation (dB)	Maximum initial attenuation (dB)
5	4,5	5,5
10	9,5	10,5
15	14,0	16,0
20	18,5	21,5
30	27,5	32,5

4.4 Return loss

Details:

In accordance with EN 186000-1 [5], subclause 4.4.12, method 3 (coupler method).

- Launch fibre length: $2\text{m} \leq L \leq 4\text{m}$.
- Source stability: $\pm 0,20 \text{ dB}$ over the measuring period or at least one hour.
- Reference connector: the reference connector shall conform to the same specification as the attenuator under test.

Alternatively, the return loss may be measured using an OTDR in accordance with IEC 61300-3-6 [1] subclause 4.2, method B.

Requirements:

Minimum return loss (RL) for every mating:

- RL grade S: $\geq 25 \text{ dB}$ for standard return loss mated connector-type fixed attenuators.
- RL grade T: $\geq 35 \text{ dB}$ for high return loss mated connector-type fixed attenuators.
- RL grade U: $\geq 50 \text{ dB}$ for ultra high return loss mated connector-type fixed attenuators.
- RL grade V: $\geq 55 \text{ dB}$ for ultra high return loss connector-type fixed attenuators where return loss remains at this grade in both mated and unmated condition.

4.5 Spectral dependence of attenuation

Details:

In accordance with EN 180000 [2], subclause 4.4.7.

Requirements:

The attenuation values measured in the wavelength regions of 1 260 nm to 1 360 nm and 1 480 nm to 1 580 nm shall be between the maximum and minimum values given in table 1.

4.6 Polarization dependence of attenuation

Details:

In accordance with IEC 61300-3-2 [3], method A (all polarization states).

Requirements:

- Allowable attenuation variation: $\pm 0,5$ dB.

4.7 Maximum input power (optical power handling)

Details:

In accordance with IEC 61300-2-14 [4].

- Wavelength: 1 550 nm.
- CW test: optical power: 10 mW;
test duration: 10 minutes.
- Pulsed light test: peak power: 10 mW;
pulse duration: 0,2 ms to 0,8 ms;
light pulses: 10^4 ;
repetition rate: 10 pulses/s to 1 000 pulses/s.

Requirements:

- Allowable attenuation variation after the test: $\pm 0,5$ dB.

4.8 Vibration (sinusoidal)

Details:

In accordance with EN 186 000-1 subclause 4.5.1.

- Frequency range: 10 Hz to 55 Hz.
- Endurance duration per axis: 0,5 hours.
- Number of axes: three orthogonal.
- Number of cycles (10-55-10): 15.
- Vibration amplitude: 0,75 mm.

Requirements:

Allowable attenuation variation: $\pm 0,5$ dB.

- Return loss: the connector-type fixed attenuator shall satisfy the requirements for the specified class.

The attenuation shall be measured before, during and after the test as specified in subclause 4.3. The maximum sampling interval during the test shall be 2 seconds.

The return loss shall be measured as specified in subclause 4.4, before, during and after the test. The maximum sampling interval during the test shall be 2 seconds.

4.9 Bending moment

Details:

In accordance with EN 186000-1 [5], subclause 4.5.7.

- Magnitude of the load: 10 N (smoothly applied).
- Duration of the test (maintaining the load): 60 s.
- Point of application of the load: 25 mm from the optical interface.

Requirements:

- Allowable attenuation variation: $\pm 0,5$ dB.
- Return loss: the connector-type fixed attenuator shall satisfy the requirements for the specified class.

The attenuation shall be measured before, during, and after the test as specified in subclause 4.3. During the test the attenuation shall be measured at least once which the load is at the maximum level.

The return loss shall be measured (as specified in subclause 4.4) before and after the test.

4.10 Strength of coupling mechanism

Details:

In accordance with EN 186000-1 [5], subclause 4.5.6.

- Magnitude of coupling torque: (screw type) $\leq 0,15$ Nm.
- Magnitude of the tensile load: (push-pull type) 40 N.
- Rate of application of the load: 2 N/s.
- Point of application of the load: 0,2 m from the specimen.
- Duration of the test (maintaining the load): 120 s.

Requirements:

- Allowable attenuation variation: $\pm 0,5$ dB.
- Return loss: the connector-type fixed attenuator shall satisfy the requirements for the specified class.

The attenuation shall be measured before and after the test as specified in subclause 4.3.

The return loss shall be measured (as specified in subclause 4.4.) before and after the test.

4.11 Drop test

Details:

In accordance with EN 186000-1 [5], subclause 4.5.14.

- Number of drops: 5.
- Drop height: 1,5 m.

Requirements:

- Allowable attenuation variation: $\pm 0,5$ dB.
- Return loss: the connector-type fixed attenuator shall satisfy the requirements for the specified class.

The attenuator may be cleaned after each drop, before measurement.

The attenuation and the return loss shall be measured before and after each drop as specified in subclauses 4.3 and 4.4.

4.12 Cold

Details:

In accordance with EN 186000-1 [5], subclause 4.5.17.

- Temperature: -25 °C.
- Duration of exposure: 16 hours.
- Pre-conditioning procedure: standard atmospheric conditions for 2 hours (see EN 180000 [2], subclause 4.10).
- Recovery procedure: allow specimen to return to 20 °C in period not exceeding 2 hours.

Requirements:

- Allowable attenuation variation: $\pm 0,5$ dB.
- Return loss: the connector-type fixed attenuator shall satisfy the requirements for the specified class.

The attenuation shall be measured before, at a maximum interval of 1 hour during, and after the test as specified in subclause 4.3.

The return loss shall be measured (as specified in subclause 4.4) before and after the test.

4.13 Dry heat

Details:

In accordance with EN 180000 [2], subclause 4.5.18.

- Temperature: 70 °C.
- Duration of exposure: 96 hours.
- Pre-conditioning procedure: standard atmospheric conditions for 2 hours (see EN 180000 [2], subclause 4.10).
- Recovery procedure: allow specimen to return to 20 °C in period not exceeding 2 hours.

Requirements:

Allowable attenuation variation $\pm 0,5$ dB.

- Strength of coupling mechanism: as in subclause 4.10.
- Return loss: the connector-type fixed attenuator shall satisfy the requirements for the specified class.

The attenuation shall be measured before, at a maximum interval of 1 hour during the first 16 hours and thereafter at a maximum interval of 24 hours until completion of the test.

The return loss shall be measured (as specified in subclause 4.4) before and after the test.

4.14 Damp heat (steady state)

Details:

In accordance with EN 186000-1 subclause 4.5.19.

- Temperature: 40 °C.
- Relative humidity: 93 % ± 2 %.
- Duration of exposure: 96 hours.
- Pre-conditioning procedure: standard atmospheric conditions for 2 hours (see EN 180000 [2], subclause 4.10).
- Recovery procedure: allow specimen to return to 20 °C in period not exceeding 2 hours.

Requirements:

Allowable attenuation variation: ± 0,5 dB.

- Return loss: the connector-type fixed attenuator shall satisfy the requirements for the specified class.

The attenuation shall be measured before, at a maximum interval of 1 hour during, and after the test as specified in subclause 4.3.

The return loss shall be measured (as specified in subclause 4.4) before and after the test.

4.15 Damp heat (cycling)

This test shall be carried out on attenuators which are to be used in weather protected environments corresponding to ETS 300 019 [6], subclasses 3.3, 3.4 or 3.5.

Details:

The test should be carried out in accordance with IEC 60068-2-30 [7]. Test cycle variant 1 is preferred but this cycle requires special test chambers and variant 2 is acceptable for qualification.

- Test cycle: variant 1 or 2.
- High temperature: 55 °C.
- Low temperature: 25 °C.
- Duration of extreme each cycle: 24 hours.
- Number of cycles: 6.
- Pre-conditioning procedure: standard atmospheric conditions for 2 hours (see EN 180000 [2], subclause 4.10).
- Recovery procedure: allow specimen to return to 20 °C in period not exceeding 2 hours.

Requirements:

Allowable attenuation variation: ± 0,5 dB.

- Return loss: the connector-type fixed attenuator shall satisfy the requirements for the specified class.

The attenuation shall be measured before, at a maximum interval of 1 hour during, and after the test as specified in subclause 4.3.

The return loss shall be measured (as specified in subclause 4.4) before and after the test.

4.16 Change of temperature

Details:

In accordance with EN 186000-1 subclause 4.5.22.

- High temperature: 70 °C.
- Low temperature: -25 °C.
- Duration of extreme temperatures: 1 hour.
- Temperature rate of change: 1 °C/minute.
- Number of cycles: 12.
- Pre-conditioning procedure: standard atmospheric conditions for 2 hours (see EN 180000 [2], subclause 4.10).
- Recovery procedure: allow specimen to return to 20 °C in period not exceeding 2 hours.

Requirements:

Allowable attenuation variation: $\pm 0,5$ dB.

- Return loss: the connector-type fixed attenuator shall satisfy the requirements for the specified class.

The attenuation shall be measured before, at a maximum interval of 10 minutes during and after the test as specified in subclause 4.3.

The return loss shall be measured (as specified in subclause 4.4) before and after the test.

4.17 Mechanical endurance

Details:

In accordance with EN 186000-1 subclause 4.5.32.

- Coupling mechanism to be cycled: plug adapter on both sides of the attenuator.
- Number of cycles: 500 minimum for each part.

NOTE: The connector-type attenuator may be cleaned at a specified interval (not less than 10 mating cycles) during the test and it may be cleaned before measurement on completion of the test.

Requirements:

Allowable attenuation variation: $\pm 0,5$ dB.

- Return loss: the connector-type fixed attenuator shall satisfy the requirements for the specified class.

The attenuation shall be measured before, during and after the test as specified in subclause 4.3. The attenuation shall be measured after each mating.

The return loss shall be measured (as specified in subclause 4.4) before and after the test.

4.18 Corrosive atmosphere (salt mist)

This test shall be carried out on attenuators which are to be used in weather protected environments corresponding to ETS 300 019 [6] subclasses 3.3, 3.4, or 3.5 or in non-weather protected environments corresponding to ETS 300 019 [6] subclass 4.1.

Details:

In accordance with EN 186000-1 [5] subclause 4.5.26.

- Atmosphere: salt solution 5 % NaCl, pH 6,5 to 7,2.
- Temperature: 35 °C.
- Duration of test: 96 hours.
- Pre-conditioning procedure: standard atmospheric conditions for 2 hours (see EN 180000 [2], subclause 4.10).
- Recovery procedure: allow specimen to return to 20 °C in period not exceeding 2 hours.

Requirements:

Allowable attenuation variation: $\pm 0,5$ dB

- Return loss: the connector-type fixed attenuator shall satisfy the requirements for the specified class.

Measurements shall be carried out before and after the test at standard atmospheric conditions. Attenuation shall be measured as specified in subclause 4.3. Return loss shall be measured as specified in subclause 4.4

4.19 Industrial atmosphere

This test shall be carried out on attenuators which are to be used in weather protected environments corresponding to ETS 300 019 [6] subclasses 3.3, 3.4 or 3.5 or in non-weather protected environments corresponding to ETS 300 019 [6] subclass 4.1.

Details:

In accordance with EN 186000-1 [5] subclause 4.5.28.

- Atmosphere: sulphur dioxide (SO₂) 25 ppm.
- Temperature: 25 °C.
- Relative humidity: 75 %.
- Duration of test: 96 hours.
- Pre-conditioning procedure: standard atmospheric conditions for 2 hours (see EN 180000 [2], subclause 4.10).
- Recovery procedure: allow specimen to return to 20 °C in period not exceeding 2 hours.

Requirements:

- Allowable attenuation variation: $\pm 0,5$ dB.
- Return loss: the connector-type fixed attenuator shall satisfy the requirements for the specified class.

Measurements shall be carried out before and after the test at standard atmospheric conditions. Attenuation shall be measured as specified in subclause 4.3. Return loss shall be measured as specified in subclause 4.4.

4.20 Dust

This test shall be carried out on attenuators which are to be used in weather protected environments corresponding to ETS 300 019 [6] subclasses 3.3, 3.4 or 3.5 or in non-weather protected environments corresponding to ETS 300 019 [6] subclass 4.1.

Details:

In accordance with EN 186000-1 [5] subclause 4.5.27.

- Dust particle size: $d < 150 \mu\text{m}$.
- Dust type: talc.
- Temperature: $+35 \text{ }^\circ\text{C}$.
- Relative humidity: 60 %.
- Duration of test: 10 minutes.

Requirements:

- Allowable attenuation variation: $\pm 0,5 \text{ dB}$
- Return loss: the connector-type fixed attenuator shall satisfy the requirements for the specified class.

Measurements shall be carried out before and after the test at standard atmospheric conditions. Attenuation shall be measured as specified in subclause 4.3. Return loss shall be measured as specified in subclause 4.

4.21 Condensation

This test shall be carried out on attenuators which are to be used in non-weather protected environments corresponding to ETS 300 019 [6] subclass 4.1.

Details:

In accordance with EN 186000-1 [5] subclause 4.5.21.

- High temperature: $65 \text{ }^\circ\text{C}$.
- Low temperature: $-10 \text{ }^\circ\text{C}$.
- Duration at 65°C : 4 hours + 4 hours.
- Duration at -10°C : 4 hours.
- Maximal relative humidity: 93 %.
- Duration of the cycle: 24 hours.
- Number of cycles: Under consideration.
- Pre-conditioning procedure: standard atmospheric conditions for 2 hours (see EN 180000 [2], subclause 4.10).
- Recovery procedure: allow specimen to return to $20 \text{ }^\circ\text{C}$ in period not exceeding 2 hours.

Requirements:

- Allowable attenuation variation: $\pm 0,5 \text{ dB}$.
- Return loss: the connector-type fixed attenuator shall satisfy the requirements for the specified class.

The attenuation shall be measured before, during and after the test as specified in subclause 4.3. During the test the attenuation shall be measured at a maximum interval of 1 hour.

The return loss shall be measured as specified in subclause 4.4 before and after the test.

4.22 Intermateability

To verify the intermateability between two different sources of the same type of connector-type fixed attenuators as specified in EN 186000-1 [5], Sectional Specification (with the same nominal characteristics) the following tests shall be performed on a minimum of 10 samples from each source's regular production.

4.22.1 Attenuation measurement

The measurement is performed in accordance with subclause 4.3 of the present document, but the reference connector is replaced by each of the sample connectors. All possible mating combinations shall be performed.

Allowable attenuation: In accordance with the values given in table 1 for 100 % of mating combinations.

4.22.2 Return loss measurement

The measurement is performed in accordance with subclause 4.4 of the present document.

4.22.3 Change of temperature

The measurement is performed in accordance with subclause 4.16 of the present document.

4.22.4 Mechanical endurance

The measurement is performed in accordance with subclause 4.17 of the present document.

4.22.5 Strength of coupling mechanism

The measurement is performed in accordance with subclause 4.10 of the present document.

5 Acceptance criteria

5.1 Attenuation and return loss

A minimum sample size of 20 shall be measured at the required operation wavelength in accordance with subclause 4.3 (Attenuation) and subclause 4.4 (Return loss).

5.2 Other optical, environmental and mechanical requirements

A minimum sample size of 4 shall be subjected to each test.

Any parallel or serial grouping of tests can be used, provided that each test or serial group of tests is preceded by visual inspection and followed by the change of temperature test.

5.3 Pass/fail criteria

To satisfy the qualification approval requirements of the present document performance specification there shall be no failures of any in the sample groups for any test parameter. If a failure does occur this shall be investigated and the cause of failure identified and corrected. The test which is affected shall then be repeated using the minimum sample size stated in the present document.

A fully documented test report and supporting data shall be prepared and shall be available for inspection. Failures and the corrective action taken to eliminate failures shall be documented and evidence shall be presented to show that the corrective action will have no detrimental effect on the performance in any of the other tests. Design changes, as opposed to improvements in quality control, will usually be deemed to necessitate a repeat of the full qualification programme.

History

Document history		
V1.1.1	March 1999	Membership Approval Procedure MV 9922: 1999-03-30 to 1999-05-28