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Technical Specification

**Transmission and Multiplexing (TM);
Passive optical components;
Optical fibre connectors for single mode optical
fibre communication systems;
Common requirements and conformance testing**



Reference

RTS/TM-01100

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ETSI

650 Route des Lucioles
F-06921 Sophia Antipolis Cedex - FRANCE

Tel.: +33 4 92 94 42 00 Fax: +33 4 93 65 47 16

Siret N° 348 623 562 00017 - NAF 742 C
Association à but non lucratif enregistrée à la
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Foreword

This Technical Specification (TS) has been produced by ETSI Technical Committee Transmission and Multiplexing (TM).

The present document is a revision of ES 200 671.

1 Scope

The present document specifies requirements of connector sets to be used in single-mode optical fibre telecommunication systems and it applies only to pigtailed connectors, not patchcords. The scope covers the establishment of minimum uniform requirements for the following aspects:

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

Reliability aspects of connector sets are not covered by the present document.

Some users may have additional specific requirements, such as a need to verify performance at lower temperatures. These users should specify connectors conforming to the basic ETSI performance standard, plus additional tests or more severe test conditions.

Connectors for different applications which fall within the scope of the present document have common environmental and mechanical stability requirements, but there are three grades of attenuation requirement and three grades of return loss. The attenuation grades are designated B,C and D The return loss grades are designated 1, 2 and 3

Test methods are in accordance with IEC 61300 series [2].

For a definition of a connector set, see clause 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 and/or edition number or version number) or non-specific.
- For a specific reference, subsequent revisions do not apply.
- For a non-specific reference, the latest version applies.

Referenced documents which are not found to be publicly available in the expected location might be found at <http://docbox.etsi.org/Reference>.

- [1] IEC 60874-1 (including amendment 1): "Connectors for optical fibres and cables - Part 1: Generic specification".
- [2] IEC 61300 (all parts): "Fibre optic interconnecting devices and passive components - Basic test and measurement procedures".
- [3] ETSI EN 300 019-1-3: "Environmental Engineering (EE); Environmental conditions and environmental tests for telecommunications equipment; Part 1-3: Classification of environmental conditions; Stationary use at weatherprotected locations".
- [4] ETSI ES 200 671: "Transmission and Multiplexing (TM); Passive optical components; Fibre optical connectors for single-mode optical fibre communication systems; Common requirements and conformance testing".
- [5] IEC 61753 -1: "Fibre optic interconnecting devices and passive components - Part 1: General and guidance for performance standard".
- [6] EN 50377 (all parts): "Connector sets and interconnect components to be used in optical fibre communication systems - Product specifications".

3 Definition and abbreviations

3.1 Definition

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

connector set: complete set of connector components required to provide demountable coupling between one or more pairs of optical fibres

3.2 Abbreviations

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

OTDR	Optical Time Domain Reflectometer
RL	Return Loss
SFF	Small Form Factor (connectors with ferrule diameter of 1,25 mm)

4 Details, measurements and performance requirements for ETSI environmental classes 3.1, 3.2, 3.3 and IEC environmental category U

All measurements shall be carried out under normal room conditions, unless otherwise stated. Before the insertion 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.

The length of fibre or cable on each side of the connector set shall be 1,5 m (minimum). A minimum length of 1,5 m on each side of the test set shall be exposed to the test conditions of all climatic and environmental tests.

4.1 Visual inspection

4.1.1 Overall inspection of connectors

Each connector shall be properly packed. The package shall be marked with the name of the manufacturer and the production date.

The connector itself shall be legibly and durably marked with the identity mark of the manufacturer and the manufacturing date code (see IEC 61300-3-1 [2]).

4.1.2 Inspection of the end face

The end face shall be clean and free from residues of glue. No scratches or break out of glass pieces shall be seen when using a microscope with a maximum magnification of 200 times. The inspection shall be performed in accordance with IEC 61300-3-42 [2] PAS and meet the requirements as stated in that document.

4.2 Dimensions and mechanical measurements accuracy

Measurement accuracy and standardization shall be established to ensure consistency of production and consistency of performance of inter-mated connectors from different sources.

Mechanical measurement accuracy shall be demonstrated to be in accordance with IEC 60874-1 [1] amendment 1.

4.3 Attenuation

4.3.1 Attenuation against a reference connector

Details:

In accordance with IEC 61300-3-4 [2], method 7 (measurements against a reference plug).

Reference plug:

- Type A): For qualification testing to determine the loss of connector sets when one side is a defined reference, the eccentricity of the reference connector plug (centre of fibre core to centre of ferrule) shall be $\leq 0,3 \mu\text{m}$. The reference plug shall in all other respects conform to the same detail or product specification as the connector under test.
- Type B): For environmental, mechanical and climatic testing detailed in the present document, the reference plug shall be selected randomly from the regular production of the connector sets that are undergoing qualification testing. For these tests, the initial loss of the connector sets that are to be tested shall be less than 1,0 dB for plugs conforming to grade D or less than 0,50 dB for plugs conforming to grade C and less than 0,25 for plugs conforming to grade B.

Only the fundamental mode shall propagate at the connector interface and at the detector.

Requirements:

Attenuation: $\leq 0,50$ dB when mated to reference plug Type A. (This is the maximum for any mating of plugs of grade D and C , and).
 $\leq 0,30$ dB when mated to reference plug Type A (This is the maximum for any mating of plugs of grade B).

4.3.2 Attenuation of random mated connectors

Details:

In accordance with IEC 61300-3-34 [2].

Only the fundamental mode shall propagate at the connector interface and at the detector.

Statistical attenuation requirements:

attenuation grade D: Mean $\leq 0,50$ dB;
 1,0 dB maximum for ≥ 97 % of mating combinations.

attenuation grade C: Mean $\leq 0,25$ dB;
 0,50 dB maximum for ≥ 97 % of mating combinations.

attenuation grade B: Mean $\leq 0,12$ dB;
 0,25 dB maximum for ≥ 97 % of mating combinations.

4.4 Return Loss (RL) of random mated connectors

Details:

In accordance with IEC 61300-3-6 method 2 (coupler method) [2]:

launch fibre length (L): $2 \text{ m} \leq L \leq 4 \text{ m}$;

source stability: Better than $\pm 0,20$ dB over the measurement period.

Alternatively, the return loss may be measured using an Optical Time Domain Reflectometer (OTDR) in accordance with IEC 61300-3-6 [2] method 2. It is recommended to calibrate OTDR against coupler based measurements or reference reflector.

Reference connector: The reference connector shall conform to the same product specification as the connector under test.

Requirements:

RL (minimum return loss for every mating):

RL grade 3: ≥ 35 dB for low reflection connectors (as measured when mated);

RL grade 2 ≥ 45 dB for ultra low reflection connectors (as measured when mated);

RL grade 1 ≥ 60 dB for ultra low reflection connectors as measured when mated and ≥ 55 dB as measured when unmated).

4.5 Vibration (sinusoidal)

Details:

In accordance with IEC 61300-2-1 [2]:

frequency range: 10 Hz to 55 Hz;

endurance duration per axis: 0,5 hour;

number of axes: three, orthogonal;

number of cycles (10-55-10): 15;

vibration amplitude: 0,75 mm.

Requirements:

allowable attenuation variation: $\leq 0,20$ dB, measured at $1\ 550\ \text{nm} \pm 30\ \text{nm}$;

allowable return loss variation: return loss shall not fall below the minimum for the grade.

The attenuation shall be measured at $1\ 550\ \text{nm} \pm 30\ \text{nm}$ before, during and after the test as specified in clause 4.3.1. The sampling interval during the test shall be 2 ms. The measurement during shall be done according IEC 61300-3-28 [2] measurement method for transient loss.

The return loss shall be measured as specified in clause 4.4 before, and after the test, at $1\ 550\ \text{nm} \pm 30\ \text{nm}$.

4.6 Fibre/Cable retention

Details:

In accordance with IEC 61300-2-4 [2]:

magnitude and rate of application of the tensile load: $100\ \text{N} \pm 5\ \text{N}$ applied at 5 N/s for reinforced cables;
 $70\ \text{N} \pm 5\ \text{N}$ applied at 5 N/s for reinforced cables and SFF connectors;
 $5\ \text{N} \pm 0,5\ \text{N}$ applied at 0,5 N/s for coated fibres.

duration of the test (maintaining the load): 120 s for reinforced cables;
 60 s for coated fibres.

point of application of the tensile load: 0,3 m from the end-face of the connector.

Requirements:

allowable attenuation variation: $\leq 0,20$ dB, measured at $1\ 550\ \text{nm} \pm 30\ \text{nm}$;

allowable return loss variation: return loss shall not fall below the minimum for the grade.

The attenuation shall be measured at $1\,550\text{ nm} \pm 30\text{ nm}$ before, during and after the test as specified in clause 4.3.1. During the test the attenuation shall be measured at least once while the load is at the maximum level.

The return loss shall be measured as specified in clause 4.4 before, during and after the test, at $1\,550\text{ nm} \pm 30\text{ nm}$. During the test the return loss shall be measured at least once while the load is at the maximum level.

4.7 Torsion

Details:

In accordance with IEC 61300-2-5 [2]:

magnitude of the tensile load:	15 N for reinforced cable; 2 N for coated fibre.
point of application of the tensile load:	0,2 m from the end face of the connector;
duration of the test:	25 cycles (not to exceed the cable specification).

Requirements:

allowable attenuation variation: $\leq 0,20\text{ dB}$, measured at $1\,550\text{ nm} \pm 30\text{ nm}$.

The attenuation shall be measured at $1\,550\text{ nm} \pm 30\text{ nm}$ before and after the test as specified in clause 4.3.1.

4.8 Bending moment

Details:

In accordance with IEC 61300-2-7 [2]

magnitude of the load:	10 N;
point of application of the tensile load:	25 mm from the centre line defined by the optical interface;
duration of the test:	5 s.

Requirements:

allowable attenuation variation: $\leq 0,20\text{ dB}$, measured at $1\,550\text{ nm} \pm 30\text{ nm}$.

Allowable return loss variation return loss shall not fall below the minimum for the grade.

The attenuation shall be measured at $1\,550\text{ nm} \pm 30\text{ nm}$ before , at least once when the load is at the maximum level and after the test as specified in clause 4.3.1.

4.9 Cable Flexing

Details:

In accordance with IEC 61300-2-44 [2]

magnitude of the load:	15 N for reinforced cable; 2 N for coated fibre.
point of application of the tensile load:	0,2 m from the end face of the connector;
duration of the test:	25 cycles (not to exceed the cable specification).

Requirements:

allowable attenuation variation: $\leq 0,20\text{ dB}$, measured at $1\,550\text{ nm} \pm 30\text{ nm}$.

The attenuation shall be measured at $1\,550\text{ nm} \pm 30\text{ nm}$ before and after the test as specified in clause 4.3.1.

4.10 Strength of coupling mechanism

In accordance with IEC 61300-2-6 [2].

Details:

magnitude of the tensile load:	40 N;
rate of application of the load:	2 N/s;
point of application of the load:	0,3 m from the end face of the connector;
duration of the test (maintaining the load):	120 s.

Requirements:

allowable attenuation variation:	$\leq 0,20$ dB, measured at $1\ 550\ \text{nm} \pm 30\ \text{nm}$;
allowable return loss variation:	return loss shall not fall below the minimum for the grade.

The attenuation shall be measured at $1\ 550\ \text{nm} \pm 30\ \text{nm}$ before, during and after the test as specified in clause 4.3.1. During the test the attenuation shall be measured at least once while the load is at the maximum level.

The return loss shall be measured as specified in clause 4.4 before, during and after the test, at $1\ 550\ \text{nm} \pm 30\ \text{nm}$. During the test the return loss shall be measured at least once while the load is at the maximum level.

4.11 Impact

Details:

In accordance with IEC 61300-2-12 method A2 [2].

number of drops:	5;
drop height:	1,5 m.

NOTE: The connector may be cleaned after the test, before measurement.

Requirements:

Allowable attenuation variation:	$\leq 0,20$ dB, measured at $1\ 550\ \text{nm} \pm 30\ \text{nm}$;
Allowable return loss variation:	return loss shall not fall below the minimum for the grade.

The attenuation shall be measured at $1\ 550\ \text{nm} \pm 30\ \text{nm}$ before, during and after the test as specified in clause 4.3.1. During the test the attenuation shall be measured after each drop.

The return loss shall be measured as specified in clause 4.4 before, during and after the test, at $1\ 550\ \text{nm} \pm 30\ \text{nm}$. During the test the return loss shall be measured after each drop.

4.12 Static side load

In accordance with IEC 61300-2-42 [2].

Details:

number of directions of load application:	1;
magnitude and duration of the tensile load:	1 N for 1 hour (reinforced cable); 0,2 N for 5 minutes (buffered fibre).

Requirements:

Allowable attenuation variation:	$\leq 0,20$ dB, measured at $1\ 550\ \text{nm} \pm 30\ \text{nm}$.
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The attenuation shall be measured at $1\,550\text{ nm} \pm 30\text{ nm}$ before, during and after the test as specified in clause 4.3.1. During the test the attenuation shall be measured at a maximum interval of 3 minutes.

4.13 Cold

In accordance with IEC 61300-2-17 [2].

Details:

temperature:	-25°C;
duration of exposure:	96 hours;
pre-conditioning procedure:	2 hours at normal ambient conditions;
recovery procedure:	2 hours at normal ambient conditions.

Requirements:

allowable attenuation variation:	$\leq 0,20\text{ dB}$, measured at $1\,550\text{ nm} \pm 30\text{ nm}$.
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The attenuation shall be measured at $1\,550\text{ nm} \pm 30\text{ nm}$ before, during and after the test as specified in clause 4.3.1. During the test the attenuation shall be measured at a maximum interval of 1 hour.

4.14 Dry heat

In accordance with IEC 61300-2-18 [2].

Details:

temperature:	+70°C;
duration of exposure:	96 hours;
pre-conditioning procedure:	2 hours at normal ambient conditions;
recovery procedure:	2 hours at normal ambient conditions.

Requirements:

allowable attenuation variation:	$\leq 0,20\text{ dB}$, measured at $1\,550\text{ nm} \pm 30\text{ nm}$;
allowable return loss variation:	return loss shall not fall below the minimum for the grade;
strength of coupling mechanism:	as in clause 4.9.

The attenuation shall be measured at $1\,550\text{ nm} \pm 30\text{ nm}$ before, during and after the test as specified in clause 4.3.1. During the test the attenuation shall be measured at a maximum interval of 1 hour.

The return loss shall be measured as specified in clause 4.4 before, during and after the test, at $1\,550\text{ nm} \pm 30\text{ nm}$. During the test the return loss shall be measured at a maximum interval of 1 hour.

The strength of the coupling mechanism shall be measured on completion of the dry heat test after the recovery procedure.

4.15 Damp heat (steady state)

Details:

In accordance with IEC 61300-2-19 [2]:

temperature:	+40°C;
relative humidity:	$93 \pm 2\%$;
duration of exposure:	96 hours;
pre-conditioning procedure:	2 hours at normal ambient conditions;
recovery procedure:	2 hours at normal ambient conditions.

Requirements:

allowable attenuation variation: $\leq 0,20$ dB, measured at $1\ 550\ \text{nm} \pm 30\ \text{nm}$;

allowable return loss variation: return loss shall not fall below the minimum for the grade.

The attenuation shall be measured at $1\ 550\ \text{nm} \pm 30\ \text{nm}$ before, during and after the test as specified in clause 4.3.1. During the test the attenuation shall be measured at a maximum interval of 1 hour.

The return loss shall be measured as specified in clause 4.4 before, during and after the test, at $1\ 550\ \text{nm} \pm 30\ \text{nm}$. During the test the return loss shall be measured at a maximum interval of 1 hour.

4.16 Change of temperature

In accordance with IEC 61300-2-22 [2].

Details:

high temperature: $+70^{\circ}\text{C}$;

low temperature: -25°C ;

duration at extreme temperatures: 1 hour;

rate of change of temperature: 1 C/minute;

number of cycles: 12;

pre-conditioning procedure: 2 hours at normal ambient conditions;

recovery procedure: 2 hours at normal ambient conditions.

Requirements:

allowable attenuation variation: $\leq 0,20$ dB, measured at $1\ 550\ \text{nm} \pm 30\ \text{nm}$;

allowable return loss variation: return loss shall not fall below the minimum for the grade.

The attenuation shall be measured at $1\ 550\ \text{nm} \pm 30\ \text{nm}$ before, during and after the test as specified in clause 4.3.1. During the test the attenuation shall be measured at a maximum interval of 10 minutes.

The return loss shall be measured as specified in clause 4.4 before, during and after the test, at $1\ 550\ \text{nm} \pm 30\ \text{nm}$. During the test the return loss shall be measured at a maximum interval of 10 minutes.

4.17 Mechanical endurance

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

Details:

coupling mechanism to be cycled: plug-adaptor (one side of the connector set only);

number of cycles: 500.

NOTE: The connector may be cleaned in accordance with manufacturers instruction (not less than 10 mating cycles) during the test. The number of cleaning shall be reported.

Requirements:

allowable attenuation variation: $\leq 0,20$ dB, measured at $1\ 310\ \text{nm} \pm 30\ \text{nm}$;

allowable return loss variation: return loss shall not fall below the minimum for the grade.

The attenuation shall be measured at $1\ 310\ \text{nm} \pm 30\ \text{nm}$ before, during, and after the test as specified in clause 4.3.1. The attenuation shall be measured after each mating.

The return loss shall be measured at $1\,310\text{ nm} \pm 30\text{ nm}$ as specified in clause 4.4 before, during and after the test. The return loss shall be measured after each mating.

4.18 Damp heat (cycling)

This test shall be carried out on connectors which are to be used in weather protected environments corresponding to EN 300 019-1-3 [3] classes 3.3, 3.4 or 3.5 or in non-weather protected environments corresponding to EN 300 019-1-3 [3] class 4.1.

This test should be carried out in accordance with IEC 61300-2-46 [2]

Details:

test cycle:	variant 2;
high temperature:	+55° C;
low temperature:	+25° C;
duration of extreme each cycle:	24 hours;
number of cycles:	6;
pre-conditioning procedure:	2 hours at normal ambient conditions;
recovery procedure:	2 hours at normal ambient conditions.

Requirements:

allowable attenuation variation:	$\leq 0,20\text{ dB}$, measured at $1\,550\text{ nm} \pm 30\text{ nm}$;
allowable return loss variation:	return loss shall not fall below the minimum for the grade.

The attenuation shall be measured at $1\,550\text{ nm} \pm 30\text{ nm}$ before, during and after the test as specified in clause 4.3.1. During the test the attenuation shall be measured at a maximum interval of 1 hour.

The return loss shall be measured as specified in clause 4.4 before, during and after the test, at $1\,550\text{ nm} \pm 30\text{ nm}$. During the test the return loss shall be measured at a maximum interval of 1 hour.

4.19 Intermateability

CENELEC has published Euro Norms for product performance specifications of standardized connector interfaces. These Euro Norms, in series EN 50377 [6], include all details to ensure intermateability of products made by different manufacturers. When the users refer to products of these EN 50377 [6] series testing of intermateability is not required.

When the users refers to other documents intermateability testing might be necessary.

To verify the intermateability of connectors made to the same detail or product specification the following optical, mechanical and environmental tests shall be performed on connector sets assembled using plugs and/or adapters from the regular production of each source.

The combination of components making up the connector sets to be tested will be dependent on whether the second source intends to supply plugs only, plugs and adapters or adapters only. The intermateability tests will usually be performed for the supply of connectors to a user who already has connectors of the same performance standard from another source.

Where the second (or subsequent) supplier intends to supply complete connector sets these sets shall first be qualified in accordance with the present document (see clause 5.1.3).

4.19.1 Attenuation measurement

Details and requirements in accordance with clause 4.3.2.

4.19.2 Return loss measurement

The measurement is performed as described in clause 4.4.

4.19.3 Change of temperature

The measurement is performed as described in clause 4.15.

4.19.4 Mechanical endurance

The measurement is performed as described in clause 4.16.

4.19.5 Strength of coupling mechanism

The measurement is performed as described in clause 4.9.

5 Acceptance criteria

The requirements for each test are given in the relevant clauses of the present document. There is no defined sequence in which the tests shall be run. No deviations from the specified test methods are allowed. This clause specifies the minimum sample sizes required for qualification and defines the pass/fail criteria.

5.1 Minimum sample size for qualification

5.1.1 Qualification to minimum uniform

Visual inspection (clause 4.1):	20 connector sets.
Attenuation against a reference connector (clause 4.3.1):	10 plugs (with 10 different adapters for plug-adapter-plug connectors sets).
Attenuation of random mated connectors (clause 4.3.2):	20 randomly mated connectors (total of 190 measurements). For plug-adapter-plug connector sets, 10 adapters, randomly selected, should be used (19 measurements per adapter).
Return loss (clause 4.4):	20 randomly mated connectors (total of 190 measurements). For plug-adapter-plug connector sets, 10 adapters, randomly selected, should be used (19 measurements per adapter).
Vibration (clause 4.5):	4 connector sets.
Cable pulling (clause 4.6):	4 connector sets (test on one side only).
Torsion (clause 4.7):	4 connector sets (test on one side only).
Bending moment (clause 4.7):	4 connector sets.
Cable flexing (clause 4.9):	4 connector sets (test on one side only).
Strength of coupling mechanism (clause 4.10):	4 connector sets (test on one side only).
Impact (clause 4.11):	4 connector sets.
Static side load (clause 4.12):	4 connector sets (test on one side only).
Cold (clause 4.13):	4 connector sets.

Dry heat (clause 4.14):	4 connector sets.
Damp heat (clause 4.15):	4 connector sets.
Change of temperature (clause 4.16):	4 connector sets.
Mechanical endurance (clause 4.17):	4 connector sets.
Damp heat (cycling) (clause 4.18):	4 connector sets.

To reduce the number of specimens it is recommended to build the groups of tests. The number of 20 specimens is recommended as a minimum number.

5.2 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		
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