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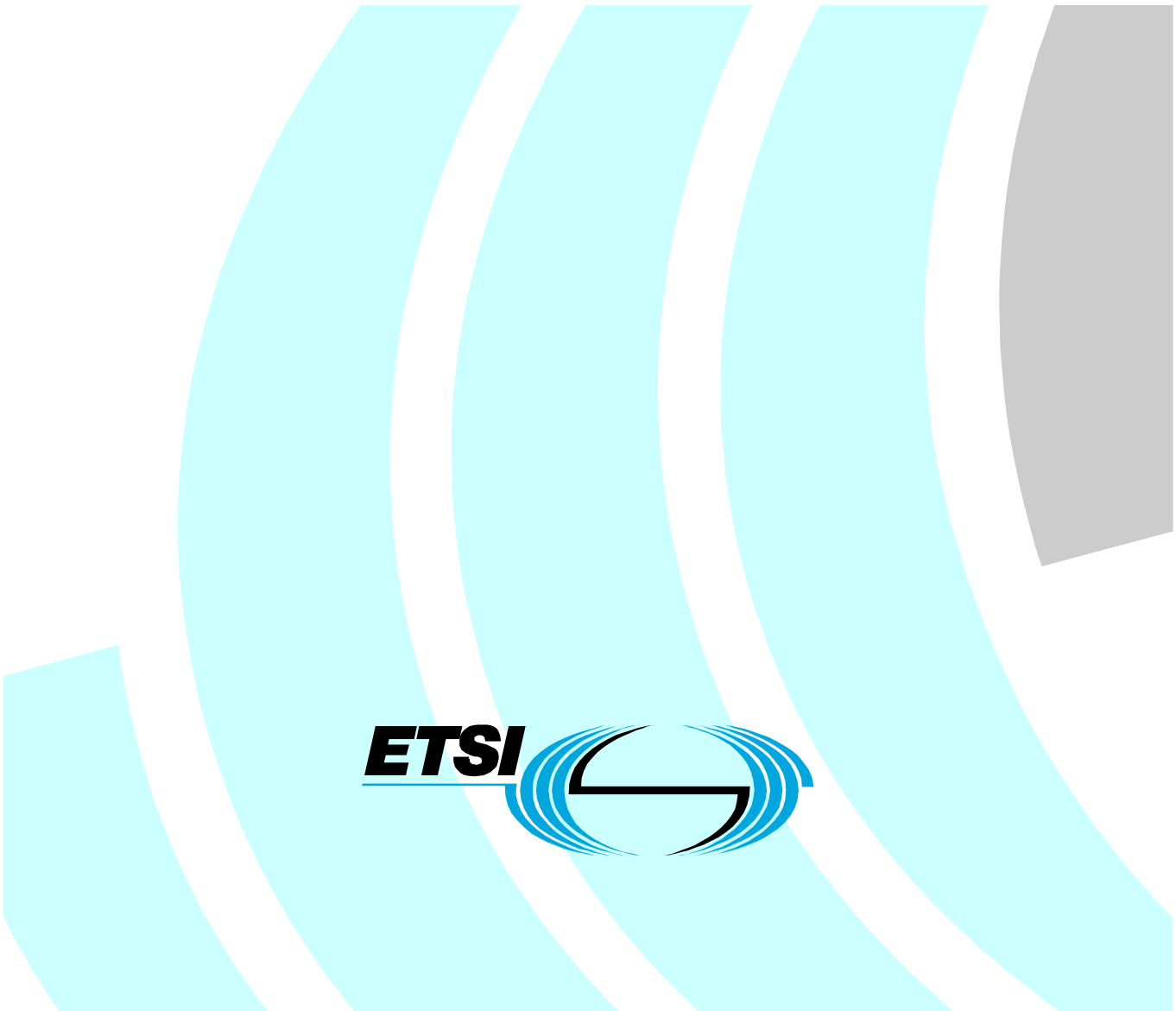
Technical Specification

Transmission and Multiplexing (TM); Dense wavelength division multiplexing devices; Common requirements and conformance testing



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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 201 791 V1.2.1.

1 Scope

The present document applies to pigtailed fibre optic Dense-Wavelength Division Multiplexer (D-WDM) devices to be used in single mode optical transmission networks for signals at a maximum bit rate of 10 Gbit/s, in weather protected, temperature controlled environments corresponding to EN 300 019-1-3 [3], class 3.1.

The scope is to establish minimum uniform requirements for the following aspects:

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

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

Acceptance criteria will be interpreted with respect to 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 IEC 61300 [2] series unless otherwise specified.

A fibre optic D-WDM device is defined in clause 3 of the present document.

NOTE: For connectorized devices the requirements of ES 200 671 [5] should be considered in addition to the present document. In case of conflicting requirements shall the requirements stated in the present document be taken.

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/PAS 62074-1: "Fibre optic WDM devices - Part 1: Generic specification".

[2] IEC 61300 (all relevant 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] ITU-T Recommendation G.692: " Optical interfaces for multichannel systems with optical amplifiers".

[5] ETSI ES 200 671: "Transmission and Multiplexing (TM); Passive optical components; Optical fibre connectors for single mode optical fibre communication systems; Common requirements and conformance testing".

[6] ITU-T Recommendation G.694.1: "Spectral grids for WDM applications: DWDM frequency grid".

[7] IEC/PAS 61300-3-29: "Fibre optic interconnecting devices and passive components - Basic test and measurement procedures - Part 3-29: Examinations and measurements - Measurement techniques for characterizing the amplitude of the spectral transfer function of DWDM components".

3 Definitions and abbreviations

3.1 Definitions

For the purposes of the present document, the following terms and definition applies:

Dense-Wavelength Division Multiplexer (D-WDM): passive optical component which separates (and/or combines) two or more signal at different wavelength from one (two) or more inputs into two (one) or more outputs

NOTE: "Dense" refers to a class of components operating with channel spacing equal or less than 800 GHz.

All the parameter definitions shall be in accordance with IEC 62074-1 [1].

3.2 Abbreviations

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

DWDM	Dense Wavelength Division Multiplexer
NEXT	Near-End CrossTalk
OWR	Operation Wavelength Range
PDL	Polarization Dependent Loss
TLS	Tuneable Laser Source

4 Tests

All measurements shall be carried out at normal room conditions, unless otherwise stated. If the device is provided with an active temperature control, this shall be set at the setpoint specified by the manufacturer.

The requirements apply to every combination of input and output port.

A minimum length of fibre or cable of 1,5 m per port shall be included in all climatic and environmental tests.

4.1 Visual Inspection: In accordance with IEC 61300-3-1

Details: The device shall be examined for defects using a magnifying glass giving a magnification of between 3 and 8 times. Any markings shall be visible without the use of optical aids.

Requirements: The workmanship of the device shall be satisfactory. In particular the protective case shall have no signs of damage or incorrect assembly. The cable or fibre entry points shall be correctly bonded and there should be no damage or bending evident in the cable or fibre.

As a minimum, the package shall be marked with the manufacturers identification mark and a serial number, which allows the date of manufacture to be determined.

4.2 Optical tests

4.2.1 Operating wavelength and general test conditions

Requirements: All the operating wavelengths shall be in accordance with ITU Recommendation G.694.1 [6]. The operation wavelength range (OWR) of every DWDM channel is defined by its nominal wavelength, the optical signal spectral width at the highest specified bit rate, and the maximum acceptable wavelength deviation of the system lasers (e.g. according to ITU-Recommendation G.962 [4]).

Test source stability: < ±0,05 dB over the measuring period or at least 1 hour.
To make sure that only the fundamental optical mode is taken as a test signal, a launch fibre of > 2m length shall be used.
Detector linearity: Within ±0,05 dB over the dynamic range to be measured.
All unused DWDM ports shall be non reflective optically terminated.

4.2.2 Attenuation

Method: IEC 61300-3-29 PAS [7].

Condition: Attenuation shall be determined as the worst case over all states of polarization.

Details: The measurement set-up is according to IEC 61300-3-29 [7] figures 2 or 3.
The tracking filter in figure 2 can be omitted for this application.
The polarization dependent insertion loss of the DWDM is measured according to IEC 61300-3-29 [7] in the operation wavelength range (OWR) of every channel. The wavelength resolution shall be better than 2 % of the channel spacing, which in most cases requires the Method A (tuneable laser with wavelength monitoring, polarization controller and optical power meter). The wavelength steps shall be chosen smaller than 1 % of the channel spacing.

For the attenuation measurement the worst case insertion loss values are noted for each channel.

Requirements: Maximum allowable attenuation:

- Grade S: $(n \times 0,5 + 0,8)$ dB;
- Grade P: $(n \times 0,5 + 0,5)$ dB,

where n is the total number of output ports or the total number of input ports, whichever is greater.

4.2.3 1 dB -bandwidth

Method: IEC 61300-3-29 [7].

Condition: The 1 dB -bandwidth shall be determined as the worst case over all the states of polarization.

Details: The test set-up is the same as for attenuation.
The polarization dependent insertion loss of the selected DWDM channel is measured according to IEC 61300-3-29 [7] and the peak of the spectral response inside the OWR of the selected channel is determined. Looking up and down from the peak wavelength, the wavelengths $\lambda+$ and $\lambda-$ are determined, where the filter transfer function drops below - 1 dB for the first time ([7] clause 4.3.3). The wavelength resolution shall be < 2 % of the channel spacing Δf for Class I and < 4 % of Δf for Classes II and III and the wavelength steps for the measurement shall be < 1 % of Δf for Class I and < 2 % of Δf for Classes II and III, which in most cases requires the application of Method A [7] (tuneable laser with wavelength monitoring, polarization controller and optical

Requirements: Minimum 1 dB -bandwidth (centred at the nominal operating wavelength):

- Class I: 0,35 Δf;
- Class II: 0,5 Δf,

where Δf is the channel spacing.

The 1 dB -bandwidth shall be in any case greater than the electrical bandwidth of the signal.

4.2.4 Cumulative inter-channel isolation

Method: IEC 61300-3-29 [7], clause 4.3.5.2

Condition: The cumulative inter-channel isolation shall be determined as the worst case over allstates of polarization.

Details: The test set-up is according to [7], figure 2 (Method A). If the TLS cannot guarantee > 50 dB suppression of side-modes and spontaneous emission, the tracking filter shall be used. Test wavelengths: OWRs of all channels. The wavelength step width shall be < 1 % of the channel spacing.
The measurement and evaluation is performed according to [7], clause 4.3.5.2.
The polarization dependent worst case cross-talk contributions have to be determined for every channel OWR separately and added according to [7], clause 4.3.5.2.

Requirements: Minimum allowable value for the cumulative inter-channel isolation of optical dense wavelength division demultiplexers:

- Isolation Grade S: 15 dB;
- Isolation Grade P: 20 dB.

Optical DWDMs, which are designed for the wavelength combination at the transmit side only, shall meet isolation requirements, which are 13 dB less stringent.

4.2.5 Uniformity

Method: IEC 61300-3-29 [7].

Condition: Uniformity shall be determined as the worst case over all states of polarization.

Details: The measurement is the same as for attenuation. For the calculation of the uniformity not only the worst case insertion loss but also the best case insertion loss values from all channels are taken into account. The uniformity is the difference between the highest worst case loss and the lowest best case loss found.

Requirements:

Table 1

Channel number	Maximum allowable uniformity
≤ 8	1,5 dB
> 8 ≤ 16	2,0 dB
> 16	2,5 dB

4.2.6 Return loss

Method: IEC 61300-3-29 [7].

Condition: The return loss shall be determined as the worst case over all states of polarization.

Details: The measurement set-up, calibration and evaluation is according to IEC 61300-3-29 [7], appendix A, figure A1.

If a directional coupler is used, it shall be a 50/50 coupler with > 55 dB directivity.

Every DWDM port is tested at the OWRs of all channels; the wavelength resolution and the minimum step width are the same as for attenuation measurement.

Requirements: Minimum allowable return loss:

- Grade 1 35dB.

4.2.7 Bi-directional near-end crosstalk (NEXT) attenuation (directivity)

Method: IEC 61300-3-20 [2]; IEC 61300-3-29 [7].

Condition: These measurements are applicable to bi-directional DWDMs only. The wavelengths used for the transmit direction are all different from the receive wavelengths.
The bi-directional NEXT attenuation shall be determined as the worst case over all states of polarization.

Details: The test set-up is according to [7], figure 2. The optical signal from the TLS and the polarization controller is fed to one transmit ports of the DWDM and for every receive port the polarization dependent attenuation is measured with detector D1. The input power to the transmit port is monitored by detector D2.
The TLS shall provide at least 40 dB SSR, otherwise a tracking filter should be added.
The measurement is performed in the OWR of the chosen transmit port.
This procedure is repeated for all transmit ports successively.
All ports not under test shall be optically terminated to avoid unwanted reflections to contribute to the measurement.
The bi-directional NEXT attenuation is the level difference observed with the detectors D1 and D2.

Requirements: Minimum allowable bi-directional NEXT attenuation:

- 50 dB.

4.2.8 Polarization dependent loss (PDL)

Method: IEC 61300-3-12 [2].

Condition: The PDL shall be determined over the OWR of every channel.

Details: The same as for "Attenuation", using the Mueller Matrix Method. For every channel the attenuation is measured in the passband as a function of the polarization state and the difference between the worst case and the best case attenuations for every wavelength is determined. The PDL is the maximum difference found this way.

Requirements: Maximum allowable PDL:

- Grade S: 0,2 dB;
- Grade P: 0,3 dB.

4.3 Environmental tests

The following requirements and details apply for all the tests:

Requirements: Attenuation: The test limits of clause 4.2.2 shall be met.

Return loss: The test limits of clause 4.2.6 shall be met.

4.3.1 Cold

Method: IEC 61300-2-17 [2].

Details:

temperature:	-10°C.
duration of exposure:	96 hours.
preconditioning procedure:	standard atmospheric conditions for 2 hours.
recovery procedure:	allow specimen to return to 20°C in period not exceeding 2 hours.
measurements required:	before and after test

4.3.2 Dry heat

Method: IEC 61300-2-18 [2].

Details:

temperature:	+60 ± 2°C.
duration of exposure:	96 hours.
preconditioning procedure:	standard atmospheric conditions for 2 hours.
recovery procedure:	allow specimen to return to 20°C in period not exceeding 2 hours.
measurements required:	before and after test

4.3.3 Damp heat (steady state)

Method: IEC 61300-2-19 [2].

Details:

temperature:	40°C.
relative humidity:	93 % ± 2 %.
exposure duration:	96 hours.
preconditioning procedure:	standard atmospheric conditions for 2 hours.
recovery procedure:	allow specimen to return to 20°C in period not exceeding 2 hours.
measurements required:	before and after test.

Additional requirement: Change of attenuation shall be $\leq$ 0,4 dB in the OWR.

4.3.4 Change of temperature

Method:	IEC 61300-2-22 [2].	
Details:	high temperature:	+60°C.
	low temperature:	-10°C.
	duration at extreme temperatures:	1 hour.
	number of cycles:	5.
	rate of temperature change:	1°C/minute.
	preconditioning procedure:	standard atmospheric conditions for 2 hours.
	recovery procedure: 2 hours.	allow specimen to return to 20°C in period not exceeding
	measurements required:	before, during (at the extremes after 30 minutes) and after the test, performed on a single input/output combination.
Additional requirements:	Change of attenuation shall be ≤ 0,4 dB in the OWR. Cumulative inter-channel isolation shall meet the requirements of clause 4.2.4. 1 dB-bandwidth shall meet the requirements of clause 4.2.3.	

4.4 Mechanical test without continuous monitoring

The following requirements apply for all the tests, unless otherwise specified.

Requirements: Attenuation: On completion of the test the limit of clause 4.2.2 shall be met.
However, the change in attenuation shall < 0,5 dB with respect to the initial value.
Return loss: Within the limits of clause 4.2.6.

4.4.1 Fibre/Cable retention

Method:	IEC 61300-2-4 [2].	
Details:	point of load application:	between the module and the cable at 30 cm distance from the module
	magnitude of tensile load:	50 ± 2 N for reinforced cable 5 ± 0,5 N for coated fibre
	rate of application:	5 N/s for reinforced cable 0,5 N/s for coated fibre
	duration at peak load:	20 s for reinforced cable 60 s for coated fibre
	measurement required:	before and after the test (5 min recovery period)

4.5 Mechanical tests with continuous monitoring

4.5.1 Vibration

To take into account the in-service vibrations of the DWDMs introduced by the cooling fans in the transmitter and receiver racks, the following optional vibration test is required.

Method:	IEC 61300-2-1 [2] in combination with transient loss measurement IEC 61300-3-28 [2].	
Details:	frequency range:	10 Hz to 55 Hz at 1 octave /min.
	amplitude:	0,75mm
	number of axis:	three orthogonal
	duration per axis and frequency:	30 min.
	test wavelengths:	nominal wavelengths of first, last and one centre channel of the DWDM
Requirements:	Attenuation: The test limits of clause 4.2.2 shall be met before and after the test. However, the change in attenuation during the test (61300-3-28) < 0,5 dB with respect to the initial value. Return loss: The test limits of clause 4.2.6 shall be met before and after the test.	

4.5.2 Shock

Method:	IEC 61300-2-9 [2] in combination with transient loss measurement IEC 61300-3-28 [2].	
Details:	severity:	for modules between 125 grams and 225 grams amplitude shall be 200 G.
		for modules between 225 grams and 1 000 grams amplitude shall be 50 G
	number of shocks	2 per direction
	number of axis:	6
	duration per axis and frequency:	for modules between 125 and 225 grams, 1 ms, half sine wave.
		for modules between 225 and 1 000 grams, 11ms half sine wave.
	test wavelengths before and after :	all channels of the module
	monitoring wavelengths during:	all channels
Requirements:	Attenuation: The test limits of clause 4.2.2 shall be met before and after the test. However, the change in attenuation during the test (61300-3-28) shall be < 0,2 dB with respect to the initial value.	

5 Acceptance criteria

5.1 Basic optical requirements

A minimum sample size of 4 shall be measured in accordance with clauses from clauses 4.2.2 to 4.2.8.

5.2 Other optical and environmental 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 (with continuous monitoring). Environmental acceptance obtained from these tests may apply to other devices of the same design, which have different attenuation values. Products, which can be approved on the basis of commonality of design, shall be agreed between the user and the supplier. The user may require a number of additional tests.

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.

Annex A (informative): Bibliography

ITU-T Recommendation G.671: " Transmission characteristics of optical components and subsystems".

ITU-T Recommendation G.976: " Test methods applicable to optical fibre submarine cable systems".

History

Document history		
V1.2.1	October 2000	Publication as ES 201 791
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