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# S+C+L波段WDM 系统用宽谱截止波长位移单模光纤

# WIDE SPECTRUM CUTOFF-WAVELENGTH SHIFTED SINGLE-MODE FIBRE FOR S+C+L WDM SYSTEM

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亚太光纤光缆产业协会(APC)
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# WIDE SPECTRUM CUTOFF-WAVELENGTH SHIFTED SINGLE-MODE FIBRE FOR S+C+L WDM SYSTEM

## Introduction

This Recommendation describes the geometrical, transmissible, mechanical, and environment attributes of wide spectrum cutoff-wavelength shifted single-mode fibre(SCL fibre), which is suitable for S+C+L band wavelength division multiplexing (WDM) communication system. The fibre can effectively improve the available spectrum bandwidth to meet the demand of high speed and large capacity optical transmission.

According to the division of optical bands by ITU-T G. sup39, the traditional S-band is 1460-1530nm, the C-band is 1530-1565nm, and the L-band is 1565-1625nm. In this Recommendation, the S+C+L band referred to 1460nm to 1625nm wavelength.

Note - To support the transmission of C6T+L6T WDM system, the application of 1626.43 nm wavelength can also refer to this Recommendation.

**Keywords**

Single-mode optical fibre, Broad-spectrum transmission fibre, SCL fibre, WDM communication system

**Notes on previous revisions of this Recommendation**:

| History edition | Recommendation No. | Release date | Study Group |
|---|---|---|---|
| V1.0 | APC FAT-0002 V1.0 (2025) | October 10, 2025 | APC Technical Development Committee |
| | | | |

# Contents

# Wide spectrum cutoff-wavelength shifted single-mode fibre for S+C+L WDM system

## 1 Scope

This Recommendation describes the attributes of a wide spectrum cutoff-wavelength shifted fibre for S+C+L WDM system, referred to as SCL fibre. The transmissible, geometrical, mechanical, and environmental parameters are presented below in five categories of attributes:

— The attenuation coefficients are limited at 1460 nm, 1550 nm and 1625 nm, and the maximum values are specified;

— The attenuation warp parameters of optical fiber are defined, and the attenuation warp (FAWD) values in three bands are specified, that is $\triangle \alpha_{1460}$, $\triangle \alpha_{1530}$and $\triangle \alpha_{1625.}$

— The fiber transmission characteristics in the C+L band are compatible with the G.654. E optical fibre in ITU-T G.654, and the transmission characteristics in the S-band are extended.

— The geometric size has two sizes of 250 μm and 200 μm for coating diameter;

— The mechanical and environmental performance must be consistent with those of B-654. E optical fibre of IEC 60793-2-50.

## 2 Normative references

The following ITU-T Recommendations and other references constitute essential provisions of this Recommendation through normative references. Where, only the edition corresponding to the date is applicable to this Recommendation. Undated citations, the latest version of which (including all amendments) applies.

ITU-T Recommendation G.650.1 *Parameter definitions and test methods for single-mode optical fiber and cable with linear and deterministic properties*

ITU-T Recommendation G.650.2 *Parameter definitions and test methods for single-mode optical fiber and cable with statistical and nonlinear properties*

ITU-T Recommendation G.654 *Cutoff-wavelength shift single-mode optical fiber and cable characteristics*

IEC 60793-2-50 *Product Specification Part 2-50 Specification for B Class Single Mode Optical Fiber*

IEC/TR 62048 *Power rate theory of fiber reliability*

## 3 Terms and definitions

In addition to terms and definitions established in ITU-T G.650.1 and ITU-T G.650.2 are applicable to this Recommendation, the following terms and definitions also apply to this Recommendation.

### 3.1 Wide spectrum cutoff-wavelength shifted single-mode fibre for S+C+L system (SCL fibre)

A single-mode fiber with large effective area and optimized attenuation performance for wideband WDM systems can operate in the S+C+L band, with cutoff-wavelength shifted to the short wavelength side.

### 3.2 Fibre attenuation coefficient warping degree (FAWD)

Within 1460 nm-1625 nm wavelength range, when the attenuation coefficient is u-shaped with the wavelength, the difference between the attenuation coefficient at a particular wavelength and the minimum attenuation coefficient within the wavelength range is called the attenuation coefficient warping degree (FAWD). FAWD at 1460nm, 1530nm and 1625nm are represented by $\triangle\alpha_{1460,}$ $\triangle\alpha_{1530}$and $\triangle\alpha_{1625}$, respectively.

[From： APC FAT-0001 V2.0 (2024) A super high capacity single-mode fibre for C+L WDM system]

## 4 Abbreviations

This Recommendation uses the following abbreviations:

WDM: Wavelength Division Multiplexing

FWM: Four Wave Mixing

PMD: Polarization Mode Dispersion

$PMD_Q$: Link Polarization Mode Dispersion

FAWD: Fibre Attenuation coefficient Warping Degree

## 5 Fibre attributes

### 5.1 Geometric parameters

The geometric parameters of SCL optical fibre should comply with the provisions in Table 1

**Table 1 - Geometric parameters of SCL optical fibre**

| Attribute | Unit | Value | |
|---|---|---|---|
| | | 250 microns | 200 microns |
| Cladding diameter | μm | 125.0±1 | 125.0±1 |
| Core concentricity error | μm | ≤0.8 | ≤0.8 |
| Cladding non-circularity | – | ≤2.0% | ≤2.0% |
| Coating layer diameter (uncolored) | μm | 235～255 | 190～210 |
| Coating layer diameter (colored) | μm | 235～265 | 190～220 |
| Cladding concentricity error | μm | ≤12.5 | ≤10.0 |
| Note1 - The geometric parameters of the fibre in the fibre ribbon can be more stringent.<br>Note2 -Fibers with a coating diameter of 200 μm may affect the sensitivity of microbending loss, especially for fibers with a mode field greater than 10.5 μm. In this case, the fiber coating material, structure, cable design and manufacturing process, and temperature change conditions should be considered to prevent the increasing of microbending loss. | | | |

### 5.2 Transmission performance

#### 5.2.1 Cut-off wavelength

The cut-off wavelength shall be tested with 22-meter-long optical fiber, λcc is not greater than 1460 nm, and the cut-off wavelength of 22 meters fibre after cabling should be able to guarantee single-mode transmission in the S+C+L band.

Note - If the monitoring channel in WDM system is considered, the cutoff-wavelength should be moved to an appropriate value to the short wavelength.

#### 5.2.2 Macrobending loss

The macrobending loss of SCL fibre should comply with the provisions in Table 2.

The macrobending loss at 1625 nm wavelength is selected as the indicator. Macrobending losses at other wavelengths can be agreed upon by the supplier and the user if necessary, such as 1460 nm. Under the same bending radius, the maximum allowable macrobending loss should be proportional to the index in the table for the test with other bending turns.

**Table 2 - The macrobending loss of SCL fibre**

| Test Conditions | | Units | Technical indicators |
|---|---|---|---|
| Bend radius mm | Number of laps | | 1625 nm |
| 30 | 100 | dB | 0.1 |
| Note1 -If practical reasons, less than 100 circles are selected for the test with a bending radius of 30 mm, it is recommended that at least 40 circles are used, and the macrobending loss should be reduced proportionally.<br>Note2 -To ensure that the bending loss is easy to measure, one or more circles of small radius loop fiber can be used to instead of 100 circles of fiber for the test. In this case, to ensure the accuracy of measurement, the number of circles, the radius of the loop, and the maximum allowable bending loss should all be chosen to be comparable to the loss value for the 100 circles of fiber with a radius of 30 mm. | | | |

**5.2.3 Attenuation coefficient**

The attenuation coefficient of SCL fibre should comply with the provisions in Table 3.

**Table 3 - The attenuation coefficient of SCL fibre**

| Attribute | | Unit | Value | | |
|---|---|---|---|---|---|
| | | | Level A | Level B | Level C |
| Attenuation coefficient | Maximum at 1460-1530 nm | dB/km | 0.290 | 0.250 | 0.210 |
| | Maximum at 1530-1612 nm | dB/km | 0.220 | 0.200 | 0.180 |
| | Maximum at 1550 nm | dB/km | 0.190 | 0.180 | 0.170 |
| | Maximum at 1612-1625 nm | dB/km | 0.230 | 0.210 | 0.190 |
| FAWD Δα | Maximum at $\Delta\alpha_{1460}$ | dB/km | 0.060 | 0.055 | 0.050 |
| | Maximum at $\Delta\alpha_{1530}$ | dB/km | 0.015 | 0.011 | 0.008 |
| | Maximum at $\Delta\alpha_{1625}$ | dB/km | 0.030 | 0.025 | 0.022 |
| Note - When applying the three bands of S+C+L, the warping degree at the band of 1530 nm can be ignored. | | | | | |

**5.2.4 Chromatic dispersion**

In the wavelength region from 1460 nm to 1625 nm, the dispersion coefficient limit D (λ) at any wavelength λ be calculated according to formula (1)：

$$D_{1550\min} + S_{1550\min}(\lambda - 1550) \le D(\lambda) \le D_{1550\max} + S_{1550\max}(\lambda - 1550) \quad \text{.....（1）}$$

In this formula：

$D_{1550min}$——1550n m Minimum dispersion coefficient at 1550 nm, and the unit is picosecond per nanometer per kilometer（ps/(nm·km)）；

$D_{1550max}$——1550 nm Maximum dispersion coefficient at 1550 nm, and the unit is picosecond per nanometer per kilometer（ps/(nm·km)）；

λ——Wavelength, and the unit is nanometer（nm）；

$S_{1550min}$——1550 nm Minimum dispersion slope at 1550 nm, and the unit is picosecond per nanometer squared per kilometer（ps/($nm^2$·km)）；

$S_{1550max}$——1550 nm Maximum dispersion slope at 1550 nm, and the unit is picosecond per nanometer squared per kilometer（ps/($nm^2$·km)）

The chromatic dispersion requirements of SCL fibre should comply with the provisions of Table 4.

**Table 4 The chromatic dispersion requirements of SCL fibre**

| Attribute | Unit | Value |
|---|---|---|
| Minimum dispersion slope at 1550 nm | ps/($nm^2$·km) | 0.050 |
| Maximum dispersion slope at 1550 nm | ps/($nm^2$·km) | 0.070 |
| Minimum dispersion at 1460 nm | ps/(nm·km) | 12.5 |
| Maximum dispersion at 1460 nm | ps/(nm·km) | 16.7 |
| Minimum dispersion at 1550 nm | ps/(nm·km) | 17 |
| Maximum dispersion at 1550 nm | ps/(nm·km) | 23 |
| Minimum dispersion at 1625 nm | ps/(nm·km) | 20.75 |
| Maximum dispersion at 1625 nm | ps/(nm·km) | 28.25 |

### 5.2.5 Mode field diameter

The mode field diameter requirements of SCL fiber should comply with the provisions of Table 5.

**Table 5 The mode field diameter of SCL fibre**

| Attribute | Unit | Value |
|---|---|---|
| 1550 nm mode field diameter | μm | 11.5 ～ 12.5 |
| Tolerance | μm | ±0.5 |

### 5.2.6 Intermittent attenuation

At 1550 nm wavelengths, the point of discontinuity between the corresponding continuous length of the optical fibre should not exceed 0.1 dB.

### 5.2.7 Attenuation uniformity

At the wavelength of 1550 nm, the worst value of the difference between the measured attenuation coefficient and the average attenuation coefficient of the whole length of the optical fiber backscattering curve at any 2000 m length should not be greater than 0.03 dB/km.

### 5.2.8 Polarization mode dispersion coefficient

This Recommendation only specifies the link PMD coefficient, and its maximum $PMD_Q$ should conform to the provisions of Table 6.

**Table 6 Maximum PMD coefficient of the link**

| Attribute | | Unit | Value |
|---|---|---|---|
| PMD coefficient | M (Number of fiber segments) | Period of | 20 |
| | Q(probability) | % | 0.01 |
| | PMD coefficient of an unwired fiber link Specifies the maximum $PMD_Q$ value | ps/$\sqrt{km}$ | 0.20 |

### 5.3 Mechanical property

#### 5.3.1 Tensile test

SCL fibre mechanical strength screening test requirements shall comply with the provisions of Table 7.

**Table 7 Tensile test requirements**

| Attribute | Unit | Value |
|---|---|---|
| Proof stress | GPa | ≥0.69 |
| Stress–strain | - | ≥1.0 |
| Note - For a quartz fiber with a cladding diameter of 125 microns, The proof stress value of 0.69 GPa is approximately equal to 1.0% strain or 8.8N tensile value. Please see IEC/TR 62048 for conversions between the three different units. | | |

If the bending radius is less than 30 mm, the probability of fibre fracture increases with the decrease of the bending radius. The mechanical reliability is affected by cable structure, construction technology and routing conditions. Therefore, in the case of minimal bending applications, the tensile test grade or other influencing parameters can be appropriately increased to ensure the mechanical reliability and life requirements of the optical fibre.

The tensile test grade and the recommended mechanical reliability that can be achieved during the service life are determined by negotiation between the supplier and the user.

#### 5.3.2 Tensile strength

The minimum tensile strength requirements for the SCL optical fiber before aging should meet the requirements in Table 8.

**Table 8 The minimum tensile strength of SCL fiber before aging**

| Gauge length | Tensile strength when Weibull distribution is 15% | Tensile strength when Weibull distribution is 50% |
|---|---|---|
| 0.5 m | 3.14 GPa | 3.80 GPa |
| During the test, the gauge length of the fibre can be 10 m or 20 m. The longer the gauge length, the smaller the minimum tensile strength. | | |

#### 5.3.3 Radius of curvature

The radius of curvature R of SCL fibre should not be less than 4 m.

#### 5.3.4 Other mechanical properties

Other mechanical properties of SCL optical fiber shall comply with the provisions of Table 9.

**Table 9 Other mechanical properties of SCL fibre**

| Attribute | Unit | Value | |
|---|---|---|---|
| | | 250 μm optical fiber | 200 μm optical fiber |
| Peeling force of coating layer (mean) | N | 1.0～5.0 | 0.4～5.0 |
| Peeling force of coating layer (peak) | N | 1.0～8.9 | 0.4～8.9 |
| Dynamic fatigue parameter | — | ≥20 | |
| Note - The mean value or peak value of the peeling force of coating layer is defined during the test and can be agreed between the supplier and the user. | | | |

### 5.4 Environmental performance

#### 5.4.1 Overview

The environmental performance of SCL fibre includes the change of light attenuation after environmental test and the mechanical performance requirements after environmental test.

#### 5.4.2 The variation of light attenuation after environmental test.

The variation requirements of light attenuation after environmental test shall comply with the provisions in Table 10.

**Table 10 The variation requirements of light attenuation after environmental tests**

| Attribute | Detail | Wavelength nm | Allowable attenuation variation dB/km |
|---|---|---|---|
| Steady damp-heat | The temperature is 85 ° C ±2 ° C and the relative humidity is not less than 85%. Leave for 30 days. | 1550, 1625 | ≤0.05 |
| Dry heat | Set the temperature at 85 ° C ±2 ° C (no more than 50% relative humidity at 35 ° C) for 30 days. | 1550, 1625 | ≤0.05 |
| Temperature | Temp. Range -60 ° C to +85 ° C, cycle time=2 | 1550, 1625 | ≤0.05 |
| Soaking | Soak in 23 ℃±5 ℃ water for 30 days. | 1550, 1625 | ≤0.05 |

#### 5.4.3 Mechanical properties after environmental test

Mechanical properties after environmental test shall be in accordance with Table 11.

**Table 11 The mechanical properties requirements after environmental tests**

| Attribute | Mean peeling force N | | Peak peeling force N | | Tensile strength when Weibull distribution is 15% | Tensile st rength when Weibull distribution is 50% | Dynamic fatigue parameter |
|---|---|---|---|---|---|---|---|
| | 250 μm | 200 μm | 250 μm | 200 μm | | | |
| Steady damp-heat | 1.0～5.0 | 0.4～5.0 | 1.0～8.9 | 0.4～8.9 | ≥2.76 | ≥3.03 | ≥20 |
| Soaking | 1.0～5.0 | 0.4～5.0 | 1.0～8.9 | 0.4～8.9 | — | — | — |
| Gauge length 0.5 m | | | | | | | |

### References

[1] IEC 60793-1-40:2019,Optical fibres-Part 1-40: Measurement methods and test procedures-Attenuation

[2] IEC 60793-1-47:2017,Optical fibres-Part 1-47: Measurement methods and test procedures - Macrobending loss