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Fibre optic interconnecting devices and passive components

Part 08: Study of optical power blocking measurement methods for adaptors with an optical power blocking shutter

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TECHNICAL REPORT

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Fibre optic interconnecting devices and passive components – Part 08: Study of optical power blocking measurement methods for adaptors with an optical power blocking shutter

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FIBRE OPTIC INTERCONNECTING DEVICES AND PASSIVE COMPONENTS –

Part 08: Study of optical power blocking measurement methods for adaptors with an optical power blocking shutter

FOREWORD

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IEC TR 62627-08, which is a Technical Report, has been prepared by subcommittee 86B: Fibre optic interconnecting devices and passive components, of IEC technical committee 86: Fibre optics.

The text of this Technical Report is based on the following documents:

Enquiry draft	Report on voting
86B/3931/DTR	86B/3945/RVC

Full information on the voting for the approval of this Technical Report can be found in the report on voting indicated in the above table.

This publication has been drafted in accordance with the ISO/IEC Directives, Part 2.

A list of all parts in the IEC 62627 series, published under the general title *Fibre optic interconnecting devices and passive components*, can be found on the IEC website.

The committee has decided that the contents of this publication will remain unchanged until the stability date indicated on the IEC website under "http://webstore.iec.ch" in the data related to the specific publication. At this date, the publication will be

- reconfirmed,
- withdrawn,
- replaced by a revised edition, or
- amended.

A bilingual version of this publication may be issued at a later date.

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INTRODUCTION

In recent years, optical communication networks have made greater use of optical fibre amplifiers and distributed Raman amplifiers. Optical communication equipment usually has an adaptor on the front of the board as an optical input/output terminal. These adaptors sometimes emit 100 mW or higher optical power. For the purpose of blocking such optical power, an adaptor with an optical power blocking shutter is sometimes used.

This Technical Report details the proposed methods to evaluate the efficacy of these adaptor shutters.

This Technical Report is based on Optoelectronic Industry and Technology Development Association (OITDA) – Technical Paper (TP), TP19/CN-2014, *Investigation of examinations and measurements – Light-blocking performance of optical adaptor with shutter*.

FIBRE OPTIC INTERCONNECTING DEVICES AND PASSIVE COMPONENTS –

Part 08: Study of optical power blocking measurement methods for adaptors with an optical power blocking shutter

1 Scope

This part of IEC 62627, which is a Technical Report, describes two methods used to measure the blocking characteristics of adaptors with an optical power blocking shutter. This document focuses on singlemode fibre (SMF) and two wavelengths, 1 310 nm and 1 550 nm.

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

Void.

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

3.1
adaptor with an optical power blocking shutter
adaptor defined in IEC 61274-1 that has a shutter to block optical power emitted from its aperture

Note 1 to entry: An adaptor with a shutter may have a structure such that the shutter automatically moves to block the aperture when the outer plug is removed. There are two commercially available types of optical adaptors with shutters: one type blocks optical power and the other type blocks dust ingress. Products that focus on optical power blocking may have a metal shutter.

3.2
optical power blocking
attenuation a_b calculated by measuring the maximum emitted optical power when the shutter is fully open (or the shutter is removed) (P_{0max}) and the maximum emitted optical power when the shutter is closed (P_{1max})

$$a_b = -10 \log_{10}\left(\frac{P_{1max}}{P_{0max}}\right)(\text{dB}) \qquad (1)$$

4 Background to the measurement method of blocking characteristics for adaptors with an optical power blocking shutter

4.1 Laser safety requirement for optical fibre communication systems

The safety of laser products are defined in IEC 60825-1 which prescribes the acceptable optical power as the laser safety class. IEC 60825-2, a subdivision standard, provides the safety standards for optical fibre communication systems. Optical communication equipment manufacturers sometimes use an adaptor with an optical power blocking shutter to comply with these laser safety standards.

4.2 Required performance of the power blocking shutter

IEC 60825-2, hazard level 3B, limits optical power at 1 550 nm to 500 mW. However, hazard level 1, the optical power allowed to be seen by the naked eye or with a magnifying scope, is limited to 10,2 mW. If equipment manufacturers ensure laser safety only by using an adaptor with an optical power blocking shutter, the required level of optical power blocking for the shutter is 17 dB, i.e. the ratio of 500 mW to 10,2 mW.

4.3 Standard measurement conditions used to determine laser safety for optical fibre communication systems

IEC 60825-2 defines the measurement conditions used to determine the hazard level of optical fibre communication systems. For wavelengths greater than 1 400 nm, an aperture diameter of 7 mm is used at a measurement distance of 28 mm from the radiating end of the optical fibre. For wavelengths less than or equal to 1 400 nm, the aperture diameter is also 7 mm, but the measurement distance is 70 mm from the radiating end of the optical fibre.

5 Measurement methods used in this Technical Report

5.1 Background

The following two methods have been studied.

Method 1: measuring with an aperture diameter of 7 mm, an integrating sphere and an optical detector.

Method 2: measuring with an optical detector only, having an aperture diameter of less than 7 mm.

In this Technical Report only the 1 310 nm and 1 550 nm wavelengths have been focused upon as these are the ones most commonly used for optical fibre communication systems.

5.2 Test

5.2.1 Measurement set-up

The measurement set-up for Method 1 and Method 2 is as follows.

a) Method 1

   Figure 1 shows an example of measurement set-up for Method 1. Light emitted from an adaptor with an optical power blocking shutter arrives at the aperture plate, diameter d, in front of the integrating sphere, and passes through into the integrating sphere. Distance, l, and aperture diameter, d, are as follows:

   – distance, l: 70 mm (at the wavelength of 1 310 nm);

     28 mm (at the wavelength of 1 550 nm);

   – aperture diameter, d: 7mm.

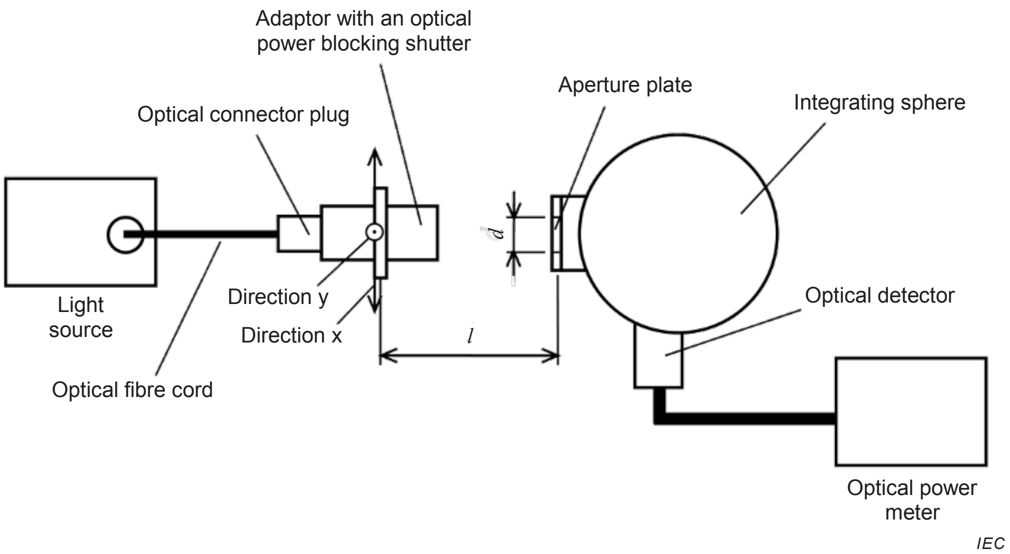


Figure 1 – Example of measurement set-up for Method 1

b) Method 2

Figure 2 shows an example of the measurement set-up for Method 2. Light emitted from the adaptor with an optical power blocking shutter arrives at the aperture plate attached directly to the optical detector. The size of the aperture diameter is different for each of the two chosen wavelengths, and in each case is calculated in order to maintain the same ratio of distance l to the aperture diameter d as is used in Method 1.

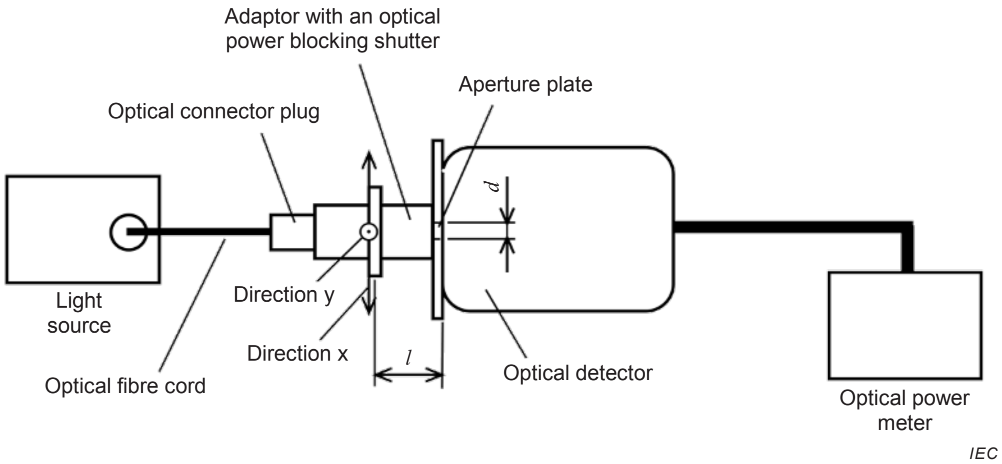


Figure 2 – Example of measurement set-up for Method 2

5.2.2 Study of dynamic range

The optical power of the light source, the sensitivity of the optical detector and any background noise should all be taken into account to achieve an adequate dynamic range for the measurement of optical power blocking greater than 17 dB with a small measurement uncertainty. A dynamic range greater than 30 dB is therefore recommended.

5.2.3 Light source and optical detector

In the case of Method 1, a typical integrating sphere has an attenuation of approximately 40 dB. Therefore, it is recommended that the sensitivity of the optical detector used together with the integrating sphere is −80 dBm or better, and the optical output from the light source is −10 dBm or more in order to achieve the suggested dynamic range of 30 dB minimum.

In the case of Method 2, as attenuation by the aperture plate is a few decibels, it is recommended that the sensitivity of the optical detector is −50 dBm or better, and the optical output from the light source is −10 dBm or more to achieve the suggested dynamic range of 30 dB minimum.

An FP-LD light source is considered to be a better choice than an LED which commonly has a lower optical power, and therefore may not yield a sufficiently large overall system dynamic range.

5.2.4 Measurement environment

In order to reduce the levels of any background optical power, it is recommended that the measurements are made in a dark environment. A space separated by shielding curtains may also be used in order to improve the system dynamic range.

5.3 Measurement of the maximum emitted optical power

When the shutter is open (or the shutter is removed), the maximum emitted power is located approximately on the optical axis (recorded as $P_{0\text{max}}$). However, when the shutter is closed the point of maximum emitted power is unlikely to be on the optical axis but in a peripheral area as demonstrated in Annex A. It is therefore necessary to adjust the position of the adaptor in the x and y directions, whilst maintaining dimension l, to find the point at which the emitted optical power is at its maximum. The optical power can then be recorded ($P_{1\text{max}}$).

5.4 Measuring system dynamic range

The dynamic ranges for both Method 1 and Method 2 are measured using the six steps a) to f) below.

a) Fix the adaptor with the optical power blocking shutter in the open position, or removed position.
b) Configure the measurement set-up as described in 5.2.1 having regard to the variables associated with the wavelength being measured, and the connector series in Method 2.
c) Measure the maximum emitted optical power from the adaptor $P_{0\text{max}}$.
d) Turn off the light source.
e) The value measured by the optical power meter is $P^{\text{off}}{}_{0\text{max}}$. If the measured value is not stable it may be necessary to use the averaging function of the optical power meter.
f) Calculate the dynamic range DR (dB) using Formula (2) below.

$$DR = -10\log_{10}\left(\frac{P^{\text{off}}{}_{0\text{max}}}{P_{0\text{max}}}\right)(\text{dB}) \qquad (2)$$

g) Confirm the dynamic range DR is large enough for the required optical power blocking level to be measured.

5.5 Measuring the level of optical power blocking

The levels of optical power blocking for both Method 1 and Method 2 are measured using the six steps a) to f) below.

a) Fix the adaptor with optical power blocking shutter in the open position, or removed position.
b) Configure the measurement set-up described in 5.2.1 having regard to the variables associated with the wavelength being measured, and the connector series in Method 2.
c) Measure the maximum optical power from the adaptor, $P_{0\text{max}}$.
d) Close the shutter or replace and close the shutter if it was removed in step a) above.

e) Adjust the position of the adaptor in the x and y directions, whilst maintaining dimension l, to find the point at which the emitted optical power is at its maximum. The optical power can then be recorded (P_{1max}). If the measured value is not stable it may be necessary to use the averaging function of the optical power meter.

f) Calculate the optical power blocking level a_b (dB) using Formula (1).

6 Demonstration of measurement

6.1 Common measurement conditions

For the purpose of ensuring the validity of two measurement methods proposed in 5.1, multiple measurements were conducted.

The measurement conditions that are common to both Methods 1 and 2 are shown in Table 1.

Table 1 – Common measurement conditions

Item	Conditions
Wavelengths of light source	– 1 310 nm – 1 550 nm
Type of optical fibre	IEC 60793-2-50, B1.1
Types of adaptor with an optical power blocking shutter	– Type SC (IEC 61754-4) – Type LC (IEC 61754-20)
End-face of optical connector plug	– Non-angled PC end-face – 8 degree-angled PC end-face

6.2 Measurement set-up

6.2.1 Method 1

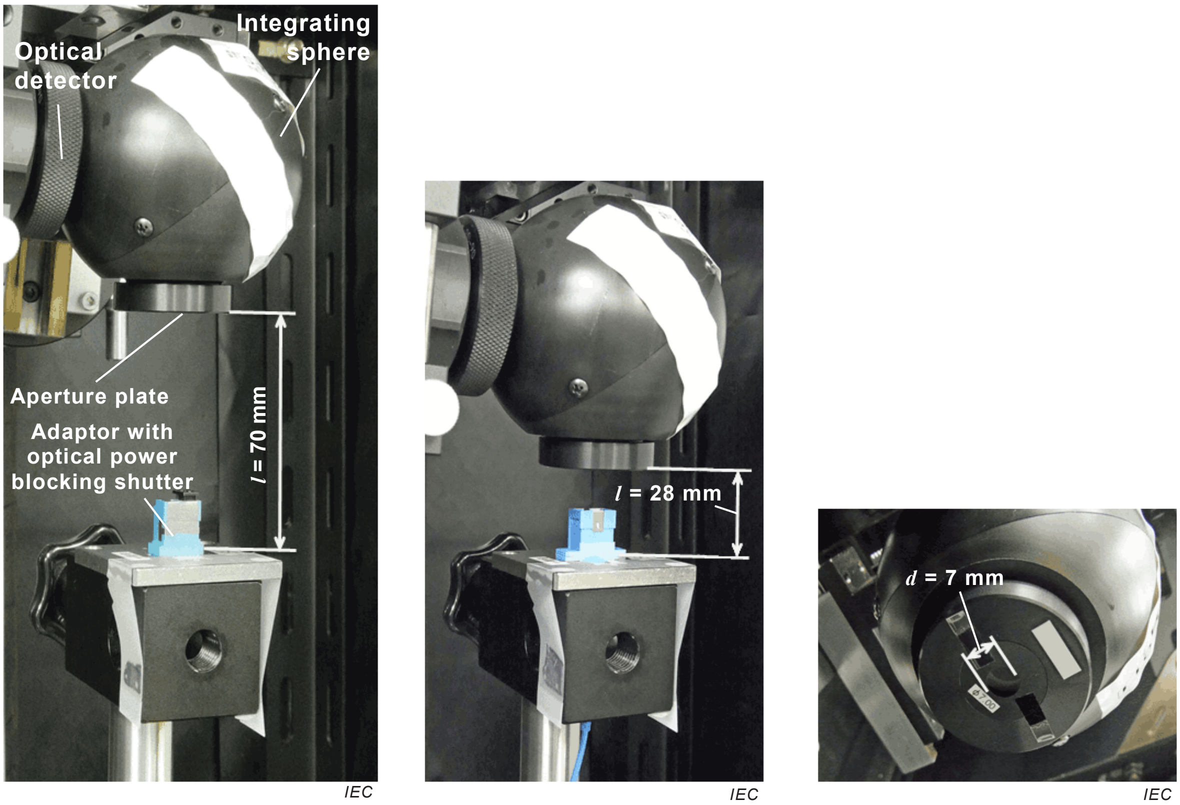
Details of the apparatus used in Method 1 are shown in Table 2, and photographs showing the measurement set-up are shown in Figure 3.

Distance l and aperture diameter d are in accordance with those shown in 5.2.1 a):

- distance, l: 70 mm (wavelength of 1 310 nm);
  28 mm (wavelength of 1 550 nm);
- aperture diameter, d: 7 mm.

Table 2 – Details of apparatus used for Method 1

Apparatus	Details
Light source	Anritsu Corporation – MG9002A Stabilized Light Source (Frame) – MG0937C LD Source 1,31 μm SM (Unit) Light source: FP-LD Wavelength: 1 310 nm ± 20 nm [a] Optical output power level: from -4 dBm to -2,5 dBm [a] – MG0938C LD Source 1,55 μm SM (Unit) Light source: FP-LD Wavelength: 1 550 nm ± 20 nm [a] Optical output power level:from -4 dBm to -2 dBm [a]
Aperture plate	Thickness: 1 mm Aperture diameter d: 7 mm
Integrating sphere	Agilent Technologies – 81002FF Integrating Sphere Aperture size: 9 mm [a] Attenuation: from 41 dB to 42 dB [a]
Optical power meter and optical detector	Hewlett-Packard – 8153A Lightwave Multimeter (Frame) – 81533B Optical Head Interface (Unit) – 82521B Optical Head (Optical detector) Optical detector:Ge-PD, 5 mm [a] Wavelength range: from 900 nm to 1 700 nm [a] Power range: from -80 dBm to +3 dBm [a]
[a] This information is given for the convenience of users of this document and does not constitute an endorsement by IEC. Equivalent products may be used if they can be shown to lead to the same results.	



a) Measured wavelength: 1 310 nm

b) Measured wavelength: 1550 nm

c) Aperture plate

Figure 3 – Measurement set-up, Method 1

6.2.2 Method 2

Details of the measurement set-up for Method 2 are shown in Table 3, and a photograph of the measurement set-up is shown in Figure 4.

Distance l is the total of the distance from the optical reference plane of the adaptor to the end face plus the thickness of the aperture plate, as shown below:

- Type SC adaptor: 14,7 mm
- Type LC adaptor: 15,6 mm

Aperture diameter d is calculated as follows.

- Wavelength of 1 310 nm

  Type SC: 7 (mm) / 70 (mm) × 14,7 (mm) = 1,47 (mm)

  Type LC: 7 (mm) / 70 (mm) × 15,6 (mm) = 1,56 (mm)
- Wavelength of 1 550 nm

  Type SC: 7 (mm) / 28 (mm) × 14,7 (mm) = 3,675 (mm)

  Type LC: 7 (mm) / 28 (mm) × 15,6 (mm) = 3,9 (mm)

Aperture diameters used are as follows.

- Wavelength of 1 310 nm

  Type SC: 1,5 (mm)

Type LC: 1,5 (mm)

- Wavelength of 1 550 nm

  Type SC: 3,7 (mm)

  Type LC: 3,9 (mm)

Table 3 – Details of apparatus used for Method 2

Apparatus	Details
Light source	Ando Electric Co., Ltd. – AQ2140 Optical Multimeter (Optical multimeter frame) – AQ4213 1,31／1,55 LD Unit (Light source unit) Light source: FP-LD Main wavelength: 1 310 nm ± 20 nm [a] 1 550 nm ± 20 nm [a] Optical output power level: -1 dBm or more [a]
Aperture plate	Thickness: 1 mm Aperture diameter: 1,5 mm (wavelength of 1 310 nm) 3,7 mm (wavelength of 1 550 nm) 3,9 mm (wavelength of 1 550 nm)
Optical power meter and optical detector	Ando Electric Co., Ltd. – AQ2140 Optical Multimeter (Optical multimeter frame) – AQ2730 OPM Interface Umit (Unit) – AQ2742 Power Sensor (Optical detector) Optical detector: Ge-PD, 5 mm [a] Wavelength range: from 750 nm to 1 800 nm [a] Power range: from -60 dBm to +10 dBm [a]
[a] This information is given for the convenience of users of this document and does not constitute an endorsement by IEC. Equivalent products may be used if they can be shown to lead to the same results.	

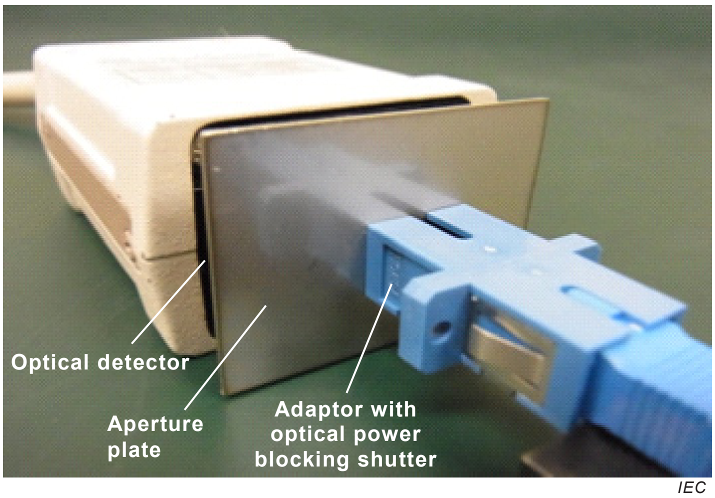


Figure 4 – Measurement set-up, Method 2

6.3 Dynamic range

6.3.1 Method 1

The dynamic range obtained in the measurement set-up of Method 1 was from 38 dB to 40 dB, which was considered to be a sufficient dynamic range.

6.3.2 Method 2

The dynamic range obtained in the measurement set-up of Method 2 was more than 50 dB, which was also considered to be a sufficient dynamic range.

6.3.3 Samples measured

Adaptors with an optical power blocking shutter used for the measurements were of two types: Type SC adaptors and Type LC adaptors, both of which are widely adopted in the market. Samples (i) to (v) shown below were used. All of these samples are made by Japanese optical connector manufacturers and are widely available.

- Type-SC simplex adaptor (IEC 61754-4)

  Sample (i): Leaf spring type metallic plate shutter.

  Sample (ii): Shutter where the metallic plate rotates about a hinge.
- Type LC duplex adaptor (IEC 61754-20)

  Sample (iii): Leaf spring type metallic plate shutter.

  Sample (iv): Leaf spring type metallic plate shutter.

  Sample (v): Leaf spring type metallic plate.

Photographs of adaptors with an optical power blocking shutter are shown below in Table 4.

Table 4 – Adaptors with an optical power blocking shutter

Type SC simplex adaptor		Type LC duplex adaptor		
Sample (i)	**Sample (ii)**	**Sample (iii)**	**Sample (vi)**	**Sample (v)**
 IEC	 IEC	 IEC	 IEC	 IEC

6.4 Measurement results

Annex B contains four tables showing the results obtained using SC and LC adaptors with power blocking shutters. For each measurement combination, as shown in Table 1, five power blocking results are given. These allowed averages and standard deviations to be calculated.

Figures 5 to 8 show the measurement results of the average of optical power blocking in Method 1 and Method 2, and the comparison of standard deviations of repeated measurements.

The summary of the measurement results are as follows.

- Optical power blocking measured in Methods 1 and 2 show the same trend in each sample.
- The measured values in Method 1 are from 25,6 dB to 38 dB, and those in Method 2 are from 23,0 dB to 35,7 dB.
- The average of measured values in Method 2 is different from that in Method 1 with the range of +0,7 dB to −4,8 dB.
- The standard deviations of measured values in repeated measurement are from 0 dB to 1,34 dB in Method 1 and from 0,02 dB to 0,77 dB in Method 2, respectively.

- The difference in the averages of measured values for Method 1 and Method 2 is larger than the standard deviation of measured values in repeated measurements.

Therefore, it is considered that the measurement method used as well as the measurement uncertainties influence the results.

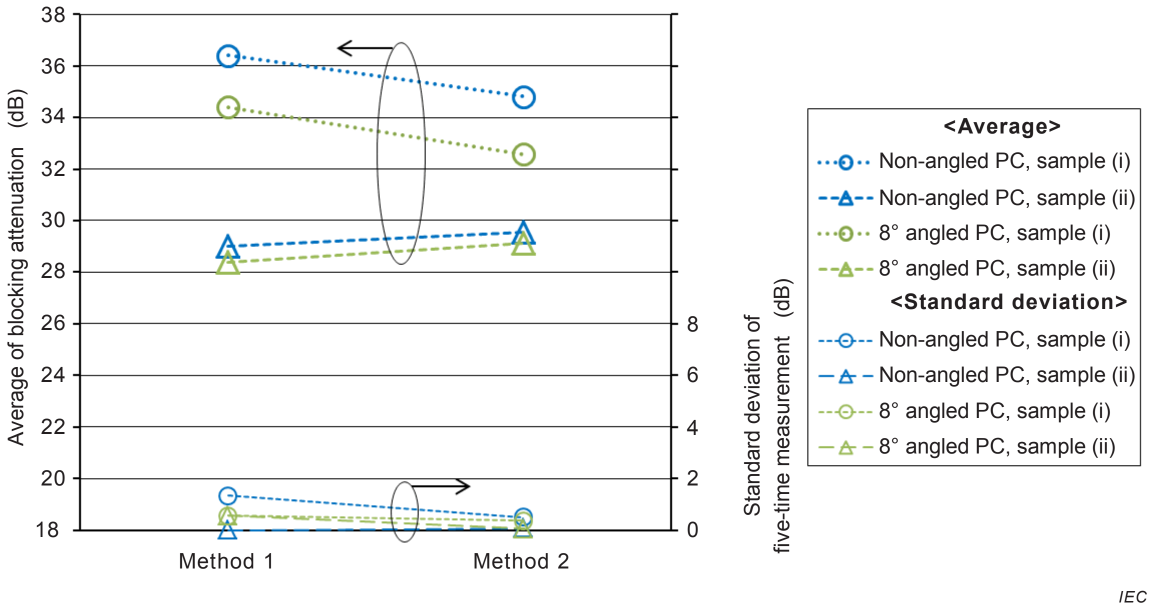


Figure 5 – Comparison between average of optical power blocking and the standard deviations (Type SC, wavelength of 1 310 nm)

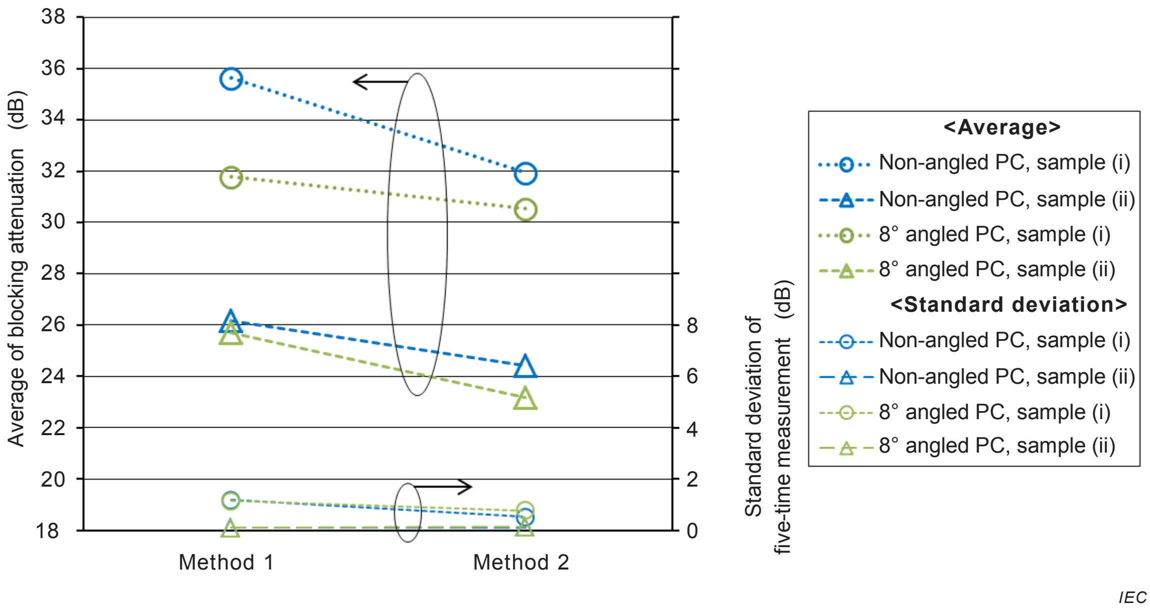


Figure 6 – Comparison between average of optical power blocking and the standard deviations (Type SC, wavelength of 1 550 nm)

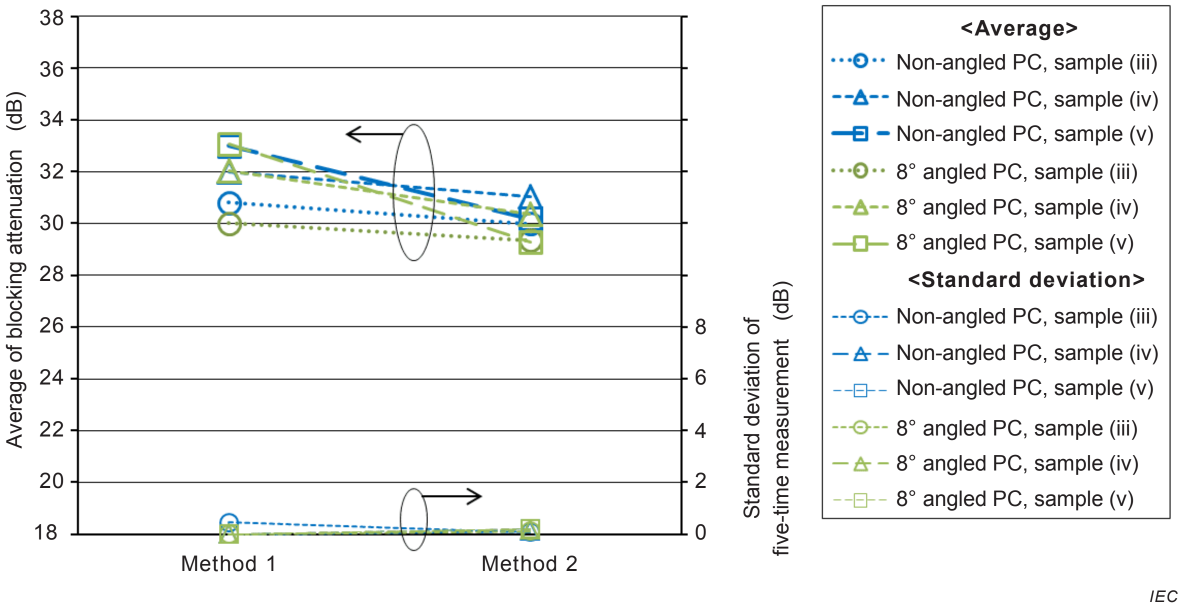


Figure 7 – Comparison between average of optical power blocking and the standard deviations (Type LC, wavelength of 1 310 nm)

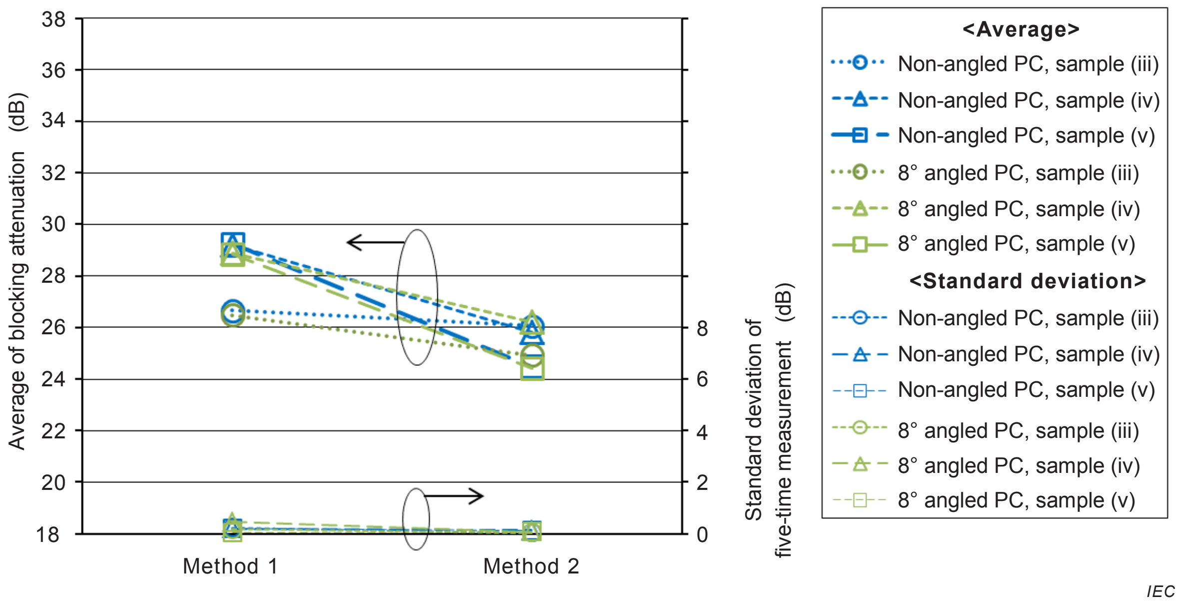


Figure 8 – Comparison between average of optical power blocking and the standard deviations (Type LC, wavelength of 1 550 nm)

6.5 Study of the factors affecting measurement uncertainty

It was confirmed that the measurement set-ups shown in 6.2 are capable of measuring the optical power blocking of 17 dB or more in both Method 1 and Method 2. However, the difference in measured values between Method 1 and Method 2 was larger than the standard deviation obtained through repeated measurements which indicates measurement uncertainty. Possible factors for such measurement uncertainty are as follows:

- inability to find the maximum power position when measuring the maximum optical power;
- size of diameter of the aperture in the aperture plate;
- thickness and shape of aperture plate;

- incident angle of emitted light to the aperture plate;
- polarization dependence of sensitivity of optical detector;
- sensitivity distribution of the detection area of optical detector;
- incident angle of incident of emitted light to the optical detector;
- background light noise in the measurement environment.

7 Summary

a) The need for adaptors with an optical power blocking shutter was explained, as was the necessity of the standardization of measurement methods to determine the level of optical power blocking for adaptors with an optical power blocking shutter, which is one of the significant performance issues to ensure laser safety in optical fibre communication systems.

b) Required performance of the power blocking shutter, based on the laser safety standards was suggested.

c) Two measurement methods have been applied.

d) It was confirmed that the two measurement methods had sufficient dynamic range to measure the level of optical power blocking.

e) Measurement of the commercial samples was carried out.

f) Measurement uncertainty factors were addressed.

g) The measurement results show that the two test methods cannot be interchanged and could lead to different results.

Annex A
(informative)

Observation of emitted light using a visible light source

The light emitted from an adaptor with an optical power blocking shutter is the result of multiple reflections from the diverse parts of the adaptor and shutter. It was assumed that the emitted optical power would not be uniformly distributed around the optical axis but would have a bias in a certain direction. In order to confirm this assumption, visible light was used to enable direct observation of the light emitted from an adaptor with an optical power blocking shutter.

The observation conditions are as follows:

- light source: He-Ne laser (wavelength of 633 nm);
- type of optical fibre: IEC 60793-2-50, B1.1;
- end-face of optical connector plug: non-angled PC end-face.

Figure A.1 shows the off-axis light being emitted from the Type LC adaptor with an optical power blocking shutter when illuminated using a 633 nm red light laser source.

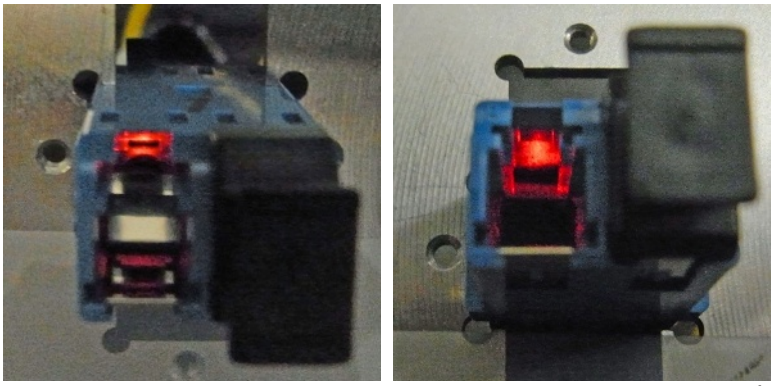


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Figure A.1 – Example of off-axis emitted visible light (Type LC duplex adaptor with an optical power blocking shutter)

Annex B
(informative)

Detailed measured levels of blocking characteristics (Measured values of light quantity shielded by adaptors with an optical power blocking shutter)

Tables B.1 and B.2 show the measured levels of optical power blocking with wavelengths of 1 310 nm and 1 550 nm respectively for Type SC adaptors with an optical power blocking shutter.

Tables B.3 and B.4 show the measured levels of optical power blocking with wavelengths of 1 310 nm for Type LC adaptors (non-angled PC end face/8 degree-angled PC end face) with an optical power blocking shutter.

Tables B.5 and B.6 show the measured levels of optical power blocking with wavelengths of 1 550 nm for Type LC adaptors (non-angled PC end face/8 degree-angled PC end face) with an optical power blocking shutter.

Each measurement combination was conducted five times.

NOTE In Tables B.1 and B.3 the measured values with a wavelength of 1 310 nm using Method 1 were not stable to one decimal place even after using the averaging function of the measuring equipment. It was decided therefore to only use integer results for these combinations. For all other combinations (Method 1, 1 550 nm wavelength and Method 2, both wavelengths) stable figures to one decimal place were possible.

Table B.1 – Measured values of optical power blocking (Type SC, measured wavelength of 1 310 nm)

Unit: dB

	Non-angled PC end face				8 degree-angled PC end face			
	Sample (i)		Sample (ii)		Sample (i)		Sample (ii)	
	Method 1	Method 2	Method 1	Method 2	Method 1	Method 2	Method 1	Method 2
1	37	35,7	29	29,6	35	33,2	28	29,1
2	35	34,6	29	29,5	35	32,3	29	29,1
3	37	34,5	29	29,5	34	32,6	28	29,1
4	35	34,6	29	29,7	34	32,4	28	29,2
5	38	34,8	29	29,6	34	32,3	29	29,1
Maximum	38	35,7	29	29,7	35	33,2	29	29,2
Minimum	35	34,5	29	29,5	34	32,3	28	29,1
Average	36,4	34,8	29,0	29,6	34,4	32,6	28,4	29,1
Standard deviation	1,34	0,49	0,00	0,08	0,55	0,37	0,55	0,05

Table B.2 – Measured values of optical power blocking (Type SC, measured wavelength of 1 550 nm)

Unit: dB

	Non-angled PC end face				8 degree-angled PC end face			
	Sample (i)		Sample (ii)		Sample (i)		Sample (ii)	
	Method 1	Method 2	Method 1	Method 2	Method 1	Method 2	Method 1	Method 2
1	36,1	32,3	26,3	24,3	32,2	31,4	25,7	23,1
2	36,6	31,1	26,2	24,4	32,9	29,8	25,6	23,0
3	36,1	32,2	26,1	24,6	32,3	31,3	25,8	23,2
4	33,6	31,9	26,1	24,4	29,9	29,9	25,8	23,3
5	35,7	32,2	26,1	24,5	31,6	30,3	25,7	23,3
Maximum	36,6	32,3	26,3	24,6	32,9	31,4	25,8	23,3
Minimum	33,6	31,1	26,1	24,3	29,9	29,8	25,6	23,0
Average	35,6	31,9	26,2	24,4	31,8	30,5	25,7	23,2
Standard deviation	1,17	0,51	0,09	0,11	1,15	0,77	0,08	0,13

Table B.3 – Measured values of optical power blocking (Type LC, measured wavelength of 1 310 nm) for non-angled PC end face

Unit: dB

	Non-angled PC end face					
	Sample (iii)		Sample (vi)		Sample (v)	
	Method 1	Method 2	Method 1	Method 2	Method 1	Method 2
1	31	30,0	32	30,9	33	30,1
2	31	30,1	32	31,2	33	30,4
3	30	29,9	32	31,0	33	29,9
4	31	30,0	32	31,2	33	30,1
5	31	30,0	32	31,0	33	30,4
Maximum	31	30,1	32	31,2	33	30,4
Minimum	30	29,9	32	30,9	33	29,9
Average	30,8	30,0	32,0	31,0	33,0	30,2
Standard deviation	0,45	0,06	0,00	0,12	0,00	0,20

Table B.4 – Measured values of optical power blocking (Type LC, measured wavelength of 1 310 nm) for 8 degree-angled PC end face

Unit: dB

	8 degree-angled PC end face					
	Sample (iii)		Sample (vi)		Sample (v)	
	Method 1	Method 2	Method 1	Method 2	Method 1	Method 2
1	30	29,4	32	30,3	33	29,5
2	30	29,5	32	30,6	33	29,3
3	30	29,2	32	30,2	33	29,3
4	30	29,3	32	30,5	33	29,1
5	30	29,4	32	30,3	33	29,2
Maximum	30	29,5	32	30,6	33	29,5
Minimum	30	29,2	32	30,2	33	29,1
Average	30,0	29,4	32,0	30,4	33,0	29,3
Standard deviation	0,00	0,11	0,00	0,16	0,00	0,18

Table B.5 – Measured values of optical power blocking (Type LC, measured wavelength of 1 550 nm) for non-angled PC end face

Unit: dB

	Non-angled PC end face					
	Sample (iii)		Sample (vi)		Sample (v)	
	Method 1	Method 2	Method 1	Method 2	Method 1	Method 2
1	26,3	26,1	28,9	25,8	29,2	24,4
2	26,6	26,1	29,4	26,0	29,6	24,6
3	26,8	26,1	29,2	25,7	29,2	24,6
4	26,9	26,0	29,3	25,8	29,1	24,5
5	26,7	26,1	29,2	25,7	29,2	24,4
Maximum	26,9	26,1	29,4	26,0	29,6	24,6
Minimum	26,3	26,0	28,9	25,7	29,1	24,4
Average	26,7	26,1	29,2	25,8	29,3	24,5
Standard deviation	0,23	0,03	0,19	0,12	0,19	0,11

Table B.6 – Measured values of optical power blocking (Type LC, measured wavelength of 1 550 nm) for 8 degree-angled PC end face

Unit: dB

	8 degree-angled PC end face					
	Sample (iii)		Sample (vi)		Sample (v)	
	Method 1	Method 2	Method 1	Method 2	Method 1	Method 2
1	26,2	24,9	29,2	26,2	28,9	24,5
2	26,5	24,9	28,1	26,3	28,8	24,4
3	26,5	24,9	29,1	26,2	28,8	24,3
4	26,6	25,0	29,1	26,3	28,9	24,5
5	26,6	24,9	29,0	26,2	28,8	24,4
Maximum	26,6	25,0	29,2	26,3	28,9	24,5
Minimum	26,2	24,9	28,1	26,2	28,8	24,3
Average	26,5	24,9	28,9	26,2	28,8	24,4
Standard deviation	0,16	0,02	0,45	0,07	0,05	0,08

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