

JIS

JAPANESE INDUSTRIAL STANDARD

Test Methods of Connectors for Optical Fiber Cords

JIS C 5961—1990

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In the event of any doubt arising,
the original Standard in Japanese is to be final authority.



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J I S

Test Methods of Connectors for Optical
Fiber Cords

C 5961-1990

1. Scope

This Japanese Industrial Standard specifies the general test methods for appearance, construction, dimensions, optical performance, mechanical performance, climatic resistance, etc. of connectors for optical fiber cords, (hereafter referred to as the "optical connectors").

When any difference exists between this Standard and detail specifications, detail specifications shall apply.

Remark: The units and numerical values given in { } in this Standard are based on the traditional units and are currently the criteria in force.

2. Definitions

For the purpose of this Standard, in addition to the definitions given in JIS C 5962, the following principal definitions shall apply:

- (1) output angle The angular difference between the output direction of light and the axial direction of ferrule when the light is emitted from the end of optical fiber cord mated with the optical connector.
- (2) master optical connector The optical connector employed as the reference in the measurement of insertion loss of optical connectors.
- (3) reflection attenuation The relative ratio expressed in decibel of the light power which propagates in an optical fiber cord to enter an optical connector, to the light power which is reflected by the optical connector and propagates in the optical fiber cord in opposite direction.
- (4) NA value (aperture number) The value expressed by $NA = n \sin \theta_{\max}$ here, $\theta_{\max}$ means the maximum divergence angle of far-field pattern when the light is emitted from the end of optical fiber cord, and "n" means the refractive index of the medium in which optical fiber cord is placed.

When the medium is air, an approximation of $n=1$ is permitted.

- (5) effective NA The NA value calculated from the divergence angle where the intensity of light decreases to 1/100 of that at the center in the far-field pattern when the light is emitted from the end of optical fiber cord.

Applicable Standards and Corresponding International Standard: See Page 44.

3. Conditions for Testing

3.1 Standard Conditions Unless otherwise specified, the tests and measurements shall be carried out under the standard conditions [temperature 15 to 35°C, relative humidity 25 to 85 % and air pressure 86 to 106 kPa (860 to 1060 mbar)] specified in 5.3 of JIS C 0010. However, if any doubt arises on the decision based on the measured values under the standard conditions or if especially required, the conditions of 3.2 shall be followed.

3.2 Referee Conditions The referee conditions shall be the referee conditions I temperature Grade 2 and humidity Grade 2 [temperature $20 \pm 2^\circ\text{C}$, relative humidity 60 to 70 % and air pressure 86 to 106 kPa (860 to 1060 mbar)] specified in 5.2 of JIS C 0010.

4. Tests for Appearance, Construction and Dimensions

4.1 Appearance, Construction and Finish The appearance, construction and finish shall be visually checked on the following items:

- (1) Finished state and treatment
- (2) Materials
- (3) Surface conditions
- (4) Loosening and coming off of component

When especially specified, the specimen shall be disassembled and the interior shall be checked.

When it is necessary to use a magnifier or when surface treatment test or surface roughness test is necessary, the detail specification shall be complied with.

4.2 Dimension Test In the dimension test, the dimensions specified in the relevant detail specification shall be checked by means of the vernier calliper specified in JIS B 7507, the micrometer specified in JIS B 7502, a gauge, a projector, a measuring microscope, etc.

However, if the dimensional tolerance is less than 0.01 mm, such dimensions shall be measured by comparing with the gauge blocks specified in JIS B 7506 using a length measuring instrument or the microindicator specified in JIS B 7519, or with the limit gauges specified in JIS B 7420. However, if there is no dispute about the decision other measuring apparatus may be used. The accuracy of the measuring apparatus shall, as a rule, be not more than 1/3 of the tolerance on the dimension. The detailed provisions about the measuring methods, the length measuring instruments, the gauges, etc. shall be specified in detail specifications, if necessary.

The screw thread shall be tested by using the gauge for screw thread specified in JIS B 0251 or JIS B 0252.

Remark: For the definition of the concentricity and the angle JIS B 0621 shall apply.

Examples of the measuring methods are shown in Table 1.

Table 1. Examples of Measuring Methods

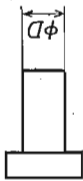
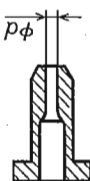
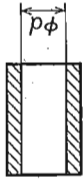
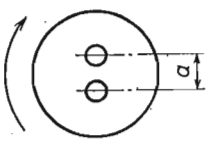
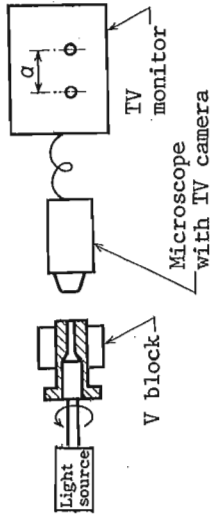
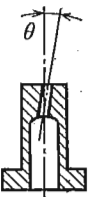
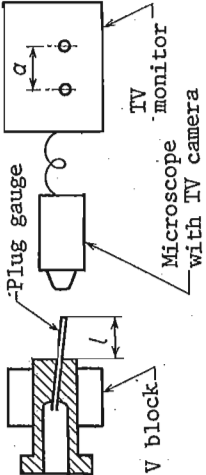
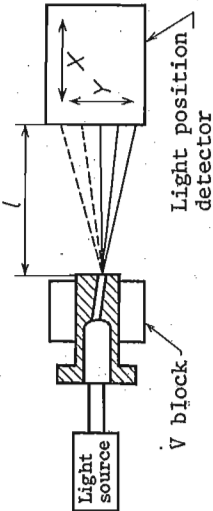
Measurement item	Measurement position	Measuring method	Measuring apparatus
1. Outside diameter	Outside diameter of ferrule 	Method 1: Measure by ring gauges (GO and NO GO gauges) Method 2: Carry out relative measurement to gauge block using the microindicator. Method 3: Measure the outside diameter by length measuring instrument, micrometer, etc.	• Ring gauge • Microindicator • Gauge block • Length measuring instrument • Micrometer
2. Inside diameter	Diameter of insertion hole for optical fiber on ferrule  Inside diameter of non-elastic guide sleeve 	Measure with plug gauge (GO, NO GO gauge)	• Plug gauge

Table 1 (Cont'd)

Measurement item	Measurement position	Measuring method	Measuring apparatus
3. Concentricity	Concentricity referring to the outside diameter 180° rotation 	Method 1: Measure deviation of hole (a) with microscope (TV monitor) by rotating ferrule on V block (or non-elastic cylindrical precise sleeve). Measure concentricity of optical fiber core by introducing light from other end of optical connector with attached optical fiber.  Method 2: Measure deviation of outside circle (a) with electrical micrometer or the like by rotating ferrule with the hole of ferrule as the center. 	• V block (or non-elastic cylindrical precise sleeve) • Microscope with TV camera • TV monitor • Light source • Electrical micrometer

Remark: Deviation = $\frac{\text{Concentricity}}{2} = \frac{a}{2}$

Table 1 (Cont'd)

Measurement item	Measurement position	Measuring method	Measuring apparatus
4. Angle	Angle between ferrule axis and insertion hole for optical fiber 	Protrude (l) plug gauge (or optical fiber) having an outside diameter almost equal to diameter of insertion hole for optical fiber from end face of ferrule, rotate ferrule on V block (or non-elastic cylindrical precise sleeve) and measure deviation (a) of tip end of plug gauge with microscope (TV monitor).  Angular deviation $\theta = \tan^{-1} \frac{a}{2l}$	• Plug gauge (or optical fiber) • V block (or non-elastic cylindrical precise sleeve) • Microscope with TV camera • TV monitor
5. Output angle	Output angle of optical fiber core from ferrule axis 	Rotate optical connector with attached optical fiber through 180 degrees on V block (or non-elastic cylindrical precise sleeve) while light is introduced from other end, and measure deviation (two directions of X and Y) of light spot with light position detector.  Output angle $\theta = \tan^{-1} \frac{\sqrt{X^2 + Y^2}}{2l}$ In output angle, angular deviation of optical fiber and deviation in perpendicularity of end face are included.	• Light source • V block (or non-elastic cylindrical precise sleeve) • Light position detector

4.3 Fitting The fitting test shall be carried out in such a way that the specimens are chosen arbitrary from optical connectors having applicable connecting part, and the specimens are engaged and then disengaged.

4.4 Marking The test for marking shall be carried out by visual check unless otherwise specified.

4.5 Items to Be Specified in Detail Specifications The following items shall be specified in detail specifications:

- (1) Test items (see 4.1 to 4.4)
- (2) Internal structure (if necessary) (see 4.1)
- (3) Necessity of magnifier and its magnification (if necessary) (see 4.1)
- (4) Measuring apparatus (if necessary) (see 4.2)
- (5) Marking (if necessary) (see 4.4)

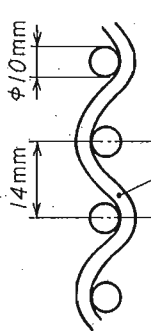
5. Optical Performance Test

5.1 Insertion Loss

5.1.1 Equipment

- (1) Light Source Kinds of light source shall be specified in detail specifications with the symbols shown in Table 2. When light sources other than that shown in Table 2 are used, the details (kind of light emitting element, peak wavelength, output stability, half-width of spectrum, etc.) shall be specified in detail specifications.
- (2) Launching Unit Unless otherwise specified the launching unit which satisfies the requirements of Table 2 shall be used. In other cases, the kind, optical fiber length, attenuation (if mode scrambler), etc. shall be clearly stated in detail specifications.
- (3) Optical Power Meter Unless otherwise specified the optical power meter which satisfies the requirements of Table 2 shall be used. In other cases, the details (linearity, dynamic range, accuracy, wavelength range, etc.) shall be clearly stated in detail specifications.
- (4) Master Optical Connector Unless otherwise specified the master optical connector shall satisfy the requirements of Table 2. In other cases, the dimensional accuracy or the kind shall be clearly stated in detail specifications.
- (5) Optical Fiber for Measurement The optical fiber for measurement shall be specified in the relevant detail specification with types specified in JIS C 6820. In other cases, the refractive index distribution (GI, SI, etc.), core diameter, difference in specific refractive index, clad diameter, etc. shall be specified in detail specifications. However, the length shall be not less than 1 m but not more than 10 m, if the length is not specified in the detail specification.

Table 2. Measurement Conditions

Kind of optical fiber	Silica glass multimode						Silica glass singlemode				Multi-component glass multimode	Plastic cladding multimode	All plastic multimode	
	A	B	C	D	E	F	G	H						
Symbol														
Light emitting element	LED	LED	LD	LD	LED	LED	LD	LD	LED	LED	LED	LED	LED	LED
Peak wave-length mm	850 ± 30	1300 ± 30	850 ± 30	1300 ± 30	1300 ± 30	1550 ± 30	1300 ± 30	1550 ± 30	1550 ± 30	850 ± 30	850 ± 30	850 ± 30	850 ± 30	660 ± 30
Output stability dB/h	Under 0.05	Under 0.05	Under 0.05	Under 0.05	Under 0.05	Under 0.05	Under 0.05	Under 0.05	Under 0.05	Under 0.05	Under 0.05	Under 0.1	Under 0.1	Under 0.1
Half-width of spectrum nm	Under 150	Under 150	Under 10	Under 10	Under 150	Under 150	Under 10	Under 10	Under 10	Under 150	Under 150	Under 150	Under 150	Under 100
Input into optical fiber μW	More than 10	More than 10	More than 500	More than 500	More than 0.5	More than 0.5	More than 500	More than 500	More than 500	More than 10	More than 10	More than 10	More than 10	More than 30
Launching unit	Launching unit having effective NA (1) corresponding to the output far field pattern (FFP) of optical fiber of 5 km or more. (Launching system having effective NA 0.195 ± 0.01, when SGI-50/125)						Dummy optical fiber is 2 m or more. The launching unit may be included in the cord with master optical connector.				Dummy optical fiber is 5 m or more. The launching unit may be included in the cord with master optical connector.			
Preparing method of mode scrambler														
Example:														
S 2 to 5 m D P₀ ↓ Bending S  D P₁ or S  D P₁  Optical fiber cord (Construction of mode scrambler) Launching unit may be included in the cord with master optical connector. where, S: light source D: light power meter P₀, P₁: output power of optical fiber (W) When light source is LED, there is 1.5 dB mode scrambler $[-10 \log_{10} \frac{P_1}{P_0}] = 1.5 \text{ (dB)}$ as an example.														

Note (1) When light source is LED, there is 1.5 dB mode scrambler as an example.

Table 2 (Cont'd)

Kind of optical fiber		Silica glass multimode	Silica glass singlemode
Light power meter	Linearity dB	Under 0.05	Under 0.05
	Dynamic range dB	More than 20	More than 20
	Accuracy (2) %	± 5 (wavelength 850 nm or 1300 nm)	± 5 (wavelength 1300 nm or 1550 nm)
	Wavelength range	To match with light source	To match with light source
Master optical connector		As specified in detail specification. If there is no provision in detail specification, either of the following connectors shall be employed: (1) Such an optical connector that the variation in connection loss is within 0.1 dB when one of the engaged plugs (through adapter) is rotated about its axis, and the insertion loss is not more than 0.4 dB. (2) Such an optical connector that its plug has the dimensional accuracy prescribed below. Deviation of core from ferrule 1 μm max. Output angle 0.2° max. Accuracy of outside diameter of ferrule $\pm 1 \mu\text{m}$	As specified in detail specification. If there is no provision in detail specification, either of the following connectors shall be employed: (1) Such an optical connector that the variation in connection loss is within 0.1 dB when one of the engaged plugs (through adapter) is rotated about its axis, and the insertion loss is not more than 0.4 dB. (2) Such an optical connector that its plug has the dimensional accuracy prescribed below. Deviation of core from ferrule 0.5 μm max. Output angle 0.2° max. Accuracy of outside diameter of ferrule $\pm 0.5 \mu\text{m}$
Optical fiber		The optical fibers connected at the measurement shall be the same ones (3). The optical fibers used for master optical connector shall, as a rule, be the same (3) as the optical fiber having structural parameters (core diameter, core non-circularity, difference in specific refractive index) equal to their nominal values.	Unless otherwise specified the optical fibers connected at the measurement shall be such that they are identical each other in the nominal values and tolerances, of structural parameters. The structural parameters mean the mode field diameter and cut off wavelength.

Notes (2) The accuracy when the light input is - 20 dBm.

(3) The same means that two optical fibers satisfy all the following requirements:

- (1) The difference in core diameter shall be within 2 %.
- (2) Each non-circularity shall be within 2 %.
- (3) The difference in the specific refractive index shall have a value which will not cause trouble in the measurement.

(4) The same means that two optical fibers satisfy all the following requirements:

- (1) The difference in core diameter shall be within 4 %.
- (2) Each non-circularity shall be within 4 %.
- (3) The difference in the specific refractive index shall have a value which will not cause trouble in the measurement.

Table 2 (Cont'd)

Multicomponent glass multimode	Plastic cladding multimode	All plastic multimode
Under 0.05 More than 25 ± 5 (wavelength 850 nm) To match with light source	Under 0.05 More than 25 ± 5 (wavelength 850 nm) To match with light source	Under 0.05 More than 25 ± 5 (wavelength 660 nm) To match with light source
As specified in detail specification. If there is no provision in detail specification, either of the following connectors shall be employed: (1) Such an optical connector that the variation in connection loss is within 0.2 dB when one of the engaged plugs (through adapter) is rotated about its axis, and the insertion loss is not more than 1 dB. (2) Such an optical connector that its plug has the performance and the dimensional accuracy prescribed below: Connection loss 1 dB max. Deviation of core from ferrule 0.015 mm max. Accuracy of outside diameter of ferrule ± 0.005 mm	As specified in detail specification. If there is no provision in detail specification, either of the following connectors shall be employed: (1) Such an optical connector that the variation in connection loss is within 0.2 dB when one of the engaged plugs (through adapter) is rotated about its axis, and the insertion loss is not more than 1 dB. (2) Such an optical connector that its plug has the performance and the dimensional accuracy prescribed below: Connection loss 1 dB max. Deviation of core from ferrule 0.015 mm max. Accuracy of outside diameter of ferrule ± 0.005 mm	As specified in detail specification. If there is no provision in detail specification, either of the following connectors shall be employed: (1) Such an optical connector that the variation in connection loss is within 0.2 dB when one of the engaged plugs (through adapter) is rotated about its axis, and the insertion loss is not more than 1 dB. (2) Such an optical connector that its plug has the performance and the dimensional accuracy prescribed below: Connection loss 1 dB max. Deviation of core from ferrule 0.1 mm max. Accuracy of outside diameter of ferrule ± 0.01 mm

The optical fibers connected at the measurement shall be the same ones ⁽⁴⁾.
The optical fiber used for master connector shall, as a rule, be the same ⁽⁴⁾ as the optical fiber having structural parameters (core diameter, core non-circularity, difference in specific refractive index) equal to their nominal values.

5.1.2 Preparation The end face of optical connector, side face of ferrule and inside face of adapter, etc. shall be cleaned, if necessary. Light receiver which can be connected to optical connector or bare optical fiber shall be used.

For coupling the bare optical fiber, a bare optical fiber adapter which has enough accuracy to avoid doubt at the test shall be used.

5.1.3 Tests The insertion loss of optical connector shall be measured in accordance with one of the methods 1 to 6 prescribed below. Among these methods, the methods 1 to 3 are the methods for measurement of insertion loss of a plug. Method 1 is an ideal measuring method, method 2 is a simple measuring method but includes some error, and method 3 is a method with less error by using a master optical connector.

Method 4 is the measuring method for an adapter, methods 5 and 6 are the methods for measuring the insertion losses of two plugs of optical connector with optical fiber cord at the same time, method 5 is a simple method but includes some error and method 6 is a method with less error by using a master optical connector.

In the measurement of variation of insertion loss versus time, if there is no dispute on the variation of the input quantity of light, the measurement of input quantity of light may be carried out once at the initiation or completion of test.

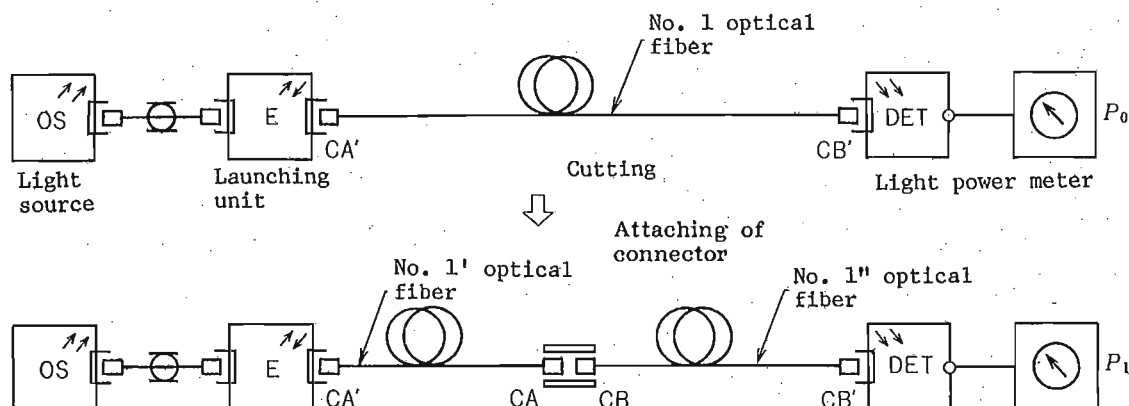
(1) Method 1 (see Fig. 1)

- (a) Connect the specified light source and launching unit with an optical fiber.
- (b) Couple optical plugs CA' and CB' at both ends of No. 1 optical fiber with the launching unit and light power meter respectively, and measure output power P_0 (W) of No. 1 optical fiber.
- (c) Confirm that the output of light source does not fluctuate, cut No. 1 optical fiber at almost midway, and call them No. 1' and No. 1'' optical fibers.
- (d) Attach plug CA to the cut part of No. 1' optical fiber, and plug CB to the cut part of No. 1'' optical fiber.
- (e) Connect plugs CA and CB, and measure output power P_1 (W) of No. 1'' fiber.
- (f) Calculate the insertion loss of optical connector from the following formula.

$$\text{Insertion loss of optical connector (dB)} = -10 \log_{10} \frac{P_1}{P_0}$$

Remark: Adapters on which enough characteristics have been verified by the measuring method shown in method 4 shall be used.

Fig. 1. Method 1



(2) Method 2 (see Fig. 2)

- (a) Connect the specified light source and launching unit with an optical fiber.
- (b) Couple end CA' of No. 1 optical fiber opposite to optical connector plug CA to be measured with the launching unit.
- (c) Couple end CB' of No. 2 optical fiber opposite to optical connector plug CB to be measured with the light power meter.
- (d) Connect plugs CA and CB, and measure output power P_1 (W) of No. 2 optical fiber.
- (e) Disconnect plugs CA and CB.
- (f) Connect plug CA to the light power meter, and measure output power P_0 (W) of No. 1 optical fiber.

In this procedure, output power P_0 (W) may be measured by cutting the optical fiber in the vicinity (several cm) of plug CA and connecting the cut part to the light power meter.

- (g) Calculate the insertion loss of optical connector from the following formula.

$$\text{Insertion loss of optical connector (dB)} = -10 \log_{10} \frac{P_1}{P_0} - \alpha$$

where, α : transmission loss of No. 2 optical fiber (dB)

Remark: Adapters on which enough characteristics have been verified by the measurement shown in method 4 shall be used.