

JIS

JAPANESE INDUSTRIAL STANDARD

**Test methods of fiber-optic
spectrum analyzer**

JIS C 6183—1992

Translated and Published

by

Japanese Standards Association

Printed in Japan

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

JAPANESE INDUSTRIAL STANDARD

J I S

Test methods of fiber-optic
spectrum analyzer

C 6183-1992

1. Scope This Japanese Industrial Standard specifies test methods of fiber-optic spectrum analyzer of dispersion spectroscopy type equipped with an input termination for optical fiber connectors to be used for measurement of power distribution of optical spectrum (hereafter referred to as "fiber-optic spectrum analyzer").

Remarks: The following Standards are cited in this Standard:

- JIS C 1003 Testing methods for digital voltmeters
- JIS C 6182 Test methods of optical power meters for laser beam
- JIS C 6830 Optical fiber cords
- JIS C 6831 Jacketed optical fibers
- JIS C 6835 Silica glass single-mode optical fibers
- JIS Z 8103 Glossary of terms used in instrumentation
- JIS Z 8120 Glossary of optical terms

2. Definitions For the purpose of this Standard, in addition to the definitions given in JIS Z 8103 and JIS Z 8120, the following definitions apply :

- (1) fiber-optic spectrum analyzer An optical measuring instrument which has an input termination for optical fiber connectors and the function to measure the power distribution relating to wavelength (frequency) averaged with time in the spectrum of the light incident to its input termination and to display the distribution on a picture plane.
- (2) measuring wavelength range The wavelength range of incident light in which the performances written in the specifications are satisfied.
- (3) wavelength sweeping width The range of wavelength indicated by the full scale on the displayed picture.
- (4) spectral resolving power The resolving power which resolves the light into monochromatic components. The indicated spectral half-width (wavelength interval between two points at which the intensity is 3 dB below the peak value) when a bright line spectrum is measured is considered as the resolving power.
- (5) power level The power level corresponding to the resolving power of a fiber-optic spectrum analyzer. On the fiber-optic spectrum analyzer the power level corresponding to the set resolving power is measured and indicated.
- (6) near dynamic range The maximum detectable power ratio when the power ratio of two adjacent optical spectrums is measured.

- (7) higher-rank (lower-rank) optical response The specific response which appears in a fiber-optic spectrum analyzer employing diffraction grating. This means the optical outputs observed as the signal light at wavelengths $m\lambda$ and $\frac{\lambda}{n}$ (m, n shall be integer), when the light of wavelength λ is measured. The optical outputs of $m \geq 2$ are called higher-rank rays and the optical outputs of $n \geq 2$ are called lower-rank rays relative to the primary ray (fundamental ray) of $m = 1$ and $n = 1$.
- (8) ghost and stray light level The leakage light components of a fiber-optic spectrum analyzer due to the incident light. That is the light with spectrums other than the spectrum of signal light and its higher-rank (lower-rank) rays when signal light is incident into the fiber-optical spectrum analyzer. The ghost and stray light level is expressed by the ratio of the level of spectrum of the signal light to the maximum value of spectrums including the signal light and its higher-rank (lower-rank) rays when monochromatic light is incident into a fiber-optic spectrum analyzer and the power distribution of spectrum is measured all over the measuring wavelength range.

3. Standard test conditions Unless otherwise specified the fiber-optic spectrum analyzer (hereafter referred to as the "specimen") shall be tested under the standard conditions given below. If it is difficult to carry out the tests under the standard test conditions, the conditions under which the tests are carried out and the influences on the test shall be recorded in the test report.

- (1) Temperature $23\text{ }^{\circ}\text{C} \pm 2\text{ }^{\circ}\text{C}$
- (2) Relative humidity $(65 \pm 10)\%$
- (3) Optical fiber The single-mode optical fiber specified in JIS C 6830, JIS C 6831 or JIS C 6835 shall be used and the length of fiber shall be 2 m or longer.

4. Outline of tests

4.1 Kind of test The performances of a fiber-optic spectrum analyzer are evaluated by tests carried out for the spectrum resolving power, near dynamic range, higher-rank (lower-rank) optical response, ghost and stray light level, overload and robustness, together with the tests for accuracy of wavelength and power level. The evaluation item in each test is different in the dimension therefore the error obtained by each test is used as the evaluation value for each item and is not used to obtain the overall error by adding these errors.

4.2 Calculation method of accuracy As for the measuring accuracy of fiber-optic spectrum analyzer, evaluation shall be made on wavelength accuracy and power level accuracy. The evaluation procedure shall be such that the intrinsic error under the standard test conditions is obtained first in the intrinsic error test and then the partial errors of the specimen are obtained in the individual error test. Each error is obtained in percent (%), limits of operating error are obtained from formulae (1) and (2) and the value so obtained shall be taken as the accuracy of the specimen.

The evaluation equations specified in JIS C 6182 shall be used for formulae (1) and (2).

$$\varepsilon_{tu} = \sum_{i=1}^p \overline{\varepsilon_{ti}} + 2\sqrt{\varepsilon_{cx}^2 + \sum_{i=1}^p \varepsilon_{ti}^2 + \varepsilon_{te}^2} \dots\dots\dots (1)$$

$$\varepsilon_{tl} = \sum_{i=1}^p \overline{\varepsilon_{ti}} - 2\sqrt{\varepsilon_{cx}^2 + \sum_{i=1}^p \varepsilon_{ti}^2 + \varepsilon_{te}^2} \dots\dots\dots (2)$$

where,

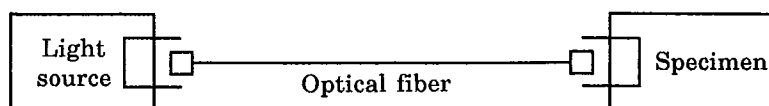
- ε_{tu} : upper limit of operating error
- ε_{tl} : lower limit of operating error
- $\overline{\varepsilon_{ti}}$: average value of upper limit and lower limit of partial error $\frac{\varepsilon_{tui} + \varepsilon_{tli}}{2}$
- ε_{cx} : intrinsic error of specimen (accuracy of specimen under standard test conditions)
- ε_{ti}^2 : dispersion of partial error $\frac{(\varepsilon_{tui} + \varepsilon_{tli})^2}{12}$
- ε_{tu} : upper limit of partial error
- ε_{tl} : lower limit of partial error
- i : subscript to each partial error
- p : number of partial errors
- ε_{te} : standard deviation of dispersion of measured values

5. Wavelength accuracy test

5.1 Outline of wavelength accuracy test The error factor which determines the wavelength accuracy consists of the intrinsic error of the specimen and the partial errors due to the wavelength dependent characteristic and temperature dependent characteristic in the individual error test. The overall accuracy of wavelength is obtained by introducing the intrinsic error and partial errors into formula (1) and formula (2).

5.2 Intrinsic error test The testing system for intrinsic error relating to wavelength accuracy is shown in Fig. 1. The test shall be carried out under the standard test conditions.

Fig. 1. Testing system for intrinsic error relating to wavelength accuracy



(1) Equipment

Light source: When calibration light source is specified in the specimen, the specified light source shall be used. If it is not specified, a light source whose spectral half-width is sufficiently narrower than the spectral resolving power of the specimen and whose wavelength stability is sufficiently better than the wavelength accuracy assigned to the specimen shall be used. Recommended light sources are shown in Table 1.

Table 1. Recommended light sources

Light source	Wavelength nm
Ar laser	487.9
	514.5
He-Ne laser	632.8
	1 152
	1 523

- (2) Test Use the measuring system of Fig. 1. Set the width of wavelength sweeping of the specimen so that it includes the wavelength of the light source. Set the resolving power of the specimen to satisfy formula (3).

$$R \geq \frac{S}{N} \dots\dots\dots (3)$$

where, R : set resolving power of fiber-optic spectrum analyzer
 S : width of wavelength sweeping
 N : number of indication points

Obtain the peak wavelength on the specimen using a light source of wavelength λ_0 and denote it λ_{li} . Repeat such measurement 10 times or more and obtain the dispersion of λ_{li} .

Obtain intrinsic error ε_{ex} of the specimen in wavelength under the standard test conditions from formula (4)

$$\varepsilon_{ex} = \sqrt{\varepsilon_{sx}^2 + \varepsilon_{ct}^2} \dots\dots\dots (4)$$

where, ε_{sx} : intrinsic error in light source wavelength
 ε_{ct} : standard deviation of measured wavelength at intrinsic error test, namely;

$$\varepsilon_{ct} (\%) = \sqrt{\frac{\sum_{i=1}^m (\lambda_{li} - \lambda_0)^2}{m} \times \frac{100}{\lambda_0}} \dots\dots\dots (5)$$

m is number of measurements.

If a gas laser with stable wavelength is used as the light source, and its performance is sufficiently better than the wavelength accuracy of specimen, the intrinsic error ε_{sx} of light source may be neglected.