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DIN EN 61744:2006-10**Entwurf****Kalibrierung von Prüfaufbauten zur Bestimmung der chromatischen Dispersion
(IEC 86/569/CD:2020);
Text Englisch**Calibration of fibre optic chromatic dispersion test sets
(IEC 86/569/CD:2020);
Text in EnglishEtalonnage des ensembles d'essai de la dispersion chromatique des fibres optiques
(IEC 86/569/CD:2020);
Texte en anglais**Anwendungswarnvermerk**

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Gesamtumfang 32 Seiten

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Nationales Vorwort

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Änderungen

Gegenüber DIN EN 61744:2006-10 wurden folgende Änderungen vorgenommen:

- a) Aktualisierte Begriffe und Definitionen;
- b) die Verwendung eines Referenz-Fasernormals für die Kalibrierung ist jetzt erlaubt und auf dem gleichen Rang wie die andere Kalibriermethode;
- c) Anhang E und andere Verweise im Text auf die Verwendung der atmosphärischen Wellenlänge wurden entfernt, da diese im Faserbereich nicht verwendet wird;
- d) Anhang D und andere Verweise im Text auf die Kalibrierungskompensation wurden entfernt, um eine Angleichung an andere Kalibrierungsdokumente zu erreichen.

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Introduction

0.1 Chromatic dispersion in optical fibres

Chromatic dispersion is the variation with optical light wavelength of the light propagation delay time in a length of fibre. This variation can cause bandwidth limitation in the fibre when used to transmit communication signals. For a more detailed explanation, refer to Annex C and IEC 60793-1-1.

0.2 Chromatic dispersion (CD) test sets

CD test sets are used to measure the chromatic dispersion properties of optical fibres and typically comprise an optical source of known wavelength(s), a fibre light input coupling and output coupling means, optical detection means, and electronic or optical means of determining the optical delay or dispersion at the source wavelength. There are several variants each requiring slightly different calibration techniques. Refer to Annex C for further details.

In general, all CD test sets produce an output of fibre delay or dispersion versus the light wavelength, typically in graphical form.

In essence, all CD test sets operate with wavelength as a programmed (independent) variable, usually the ordinate (x-axis) and dispersion or time delay as the abscissa (y-axis) as a measured (dependent) variable. By their nature, fibre chromatic dispersion measurements require multiple wavelengths to be programmed. Even in the case of a single dispersion point obtained using the differential phase shift method, two separate wavelength values are used. It is also typical to expect a wide range of dispersion values over a range of wavelengths to be measured.

0.3 Overview of calibration procedures described in this standard

The requirement to calibrate the CD test set, traceable to known standards, is essential for quality control in fibre optic production, fibre research and similar activities. This standard describes the detailed procedures used to establish calibration of a CD test set.

Calibration of a CD test set is established by applying known artefacts or standards (themselves calibrated to reference standards) to the CD test set, and measuring its response.

Primarily the artefacts or standards used are as follows:

- e) wavelength artefact(s) or traceable wavelength measuring instruments used to calibrate the light source wavelength(s) used by the CD test set. This is to establish the correct excitation wavelength for the system (the „x-axis“);
- f) delay or dispersion artefact(s) used to calibrate the delay or dispersion response of the CD test set (the „y-axis“).
- g) Traceable chromatic dispersion reference fibre used to calibrate the CD test set. This method allows a simultaneous calibration of the whole CD test set, including the measurement of the delay or dispersion response of the CD test set as a function of wavelength and also the internal data processing part. A proper selection of the type of reference fibre is important, especially for an accurate calibration of the zero dispersion wavelength.

Calibration can only be carried out using these artefacts, including the use of a known standard fibre (reference fibre) whose chromatic dispersion is known. The fibre forms a stable source of known dispersion and may be used as a simple dispersion artefact.

If it is found that the CD test set measurement results have changed significantly compared to the user requirements (i.e. the test set has drifted), then adjustment should be carried out.

In this document, the reference medium for wavelength and the velocity of light is assumed to be in vacuum, and hence define the refractive index = 1,0000000.

Calibration of fibre optic chromatic dispersion test sets

1 Scope

This International Standard provides standard procedures for the calibration of optical fibre chromatic dispersion (CD) test sets.

This standard is applicable to all types of CD test sets, with the exception that measurements on multimode optical fibres are excluded.

The purpose of this standard is to define a standard procedure for calibrating optical fibre chromatic dispersion (CD) test sets. The detailed calibration steps used vary according to the measurement technique used in the CD test set.

Whilst it is acknowledged that chromatic dispersion also occurs in multimode fibre and this fibre may be measured on many CD test sets, this standard will restrict discussion to single mode fibre measurements only.

The purpose of the procedures outlined in this standard is to focus manufacturers and users of CD test sets toward the reduction of measurement uncertainty in chromatic dispersion determination in optical fibres under all applicable conditions. The procedures apply to calibration laboratories and to the manufacturers or users of CD test sets for the purpose of

- a) calibrating CD test sets;
- b) setting specifications of CD test sets.

Use of the procedures also allows correct evaluation of CD test set uncertainty, relative and traceable to appropriate (for example, national) standards.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

IEC 60050-731, *International Electrotechnical Vocabulary (IEV) – Chapter 731: Optical fibre communication*

IEC 60825-1, *Safety of laser products – Part 1: Equipment classification, requirements and user's guide*

IEC 62129-1, *Calibration of optical spectrum analyzers*

ISO 9000 (all parts), *Quality management and quality assurance standards*

GUM: JCGM 100:2008, *Evaluation of measurement data – Guide to the expression of uncertainty in measurement*

ISO/IEC 17025, *General requirements for the competence of testing and calibration laboratories*

3 Terms and definitions

For the purposes of this document, the terms and definitions contained in IEC 60050(731) and the following definitions apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

- ISO Online browsing platform: available at <https://www.iso.org/obp>
- IEC Electropedia: available at <http://www.electropedia.org/>

3.1

accredited calibration laboratory

calibration laboratory authorized by the appropriate national standards laboratory to issue calibration certificates with a minimum specified uncertainty, which demonstrate traceability to national standards

3.2 adjustment

modifying the hardware or firmware of a CD test set with the intention of making the measurement result of the CD test set equal to that of a national standard or a similar calibrated CD test set. This has the effect of correcting all subsequent measurements on that CD test set

3.3 artefact

device, instrument or equipment used in the process of calibrating a CD test set, for wavelength, delay or chromatic dispersion

3.4 calibration

process by which the relationship between the values indicated by the infant CD test set and known values of the calibration standard is established under specified conditions

Note 1 to entry: The intention of calibration is to bring all CD test sets into substantial agreement with a suitable national standards laboratory. This may be performed by first comparing the relevant parameter of measurement artefact with that produced by the CD test set, followed by transfer of that result, either by adjustment of the CD test set or, by documentation of calibration factor(s) in a calibration certificate. The pertaining environmental conditions and instrument state are usually recorded. Calibration includes estimation of all uncertainties.

3.5 traceability chain

unbroken chain of standards and calibrations (see Figure 1)

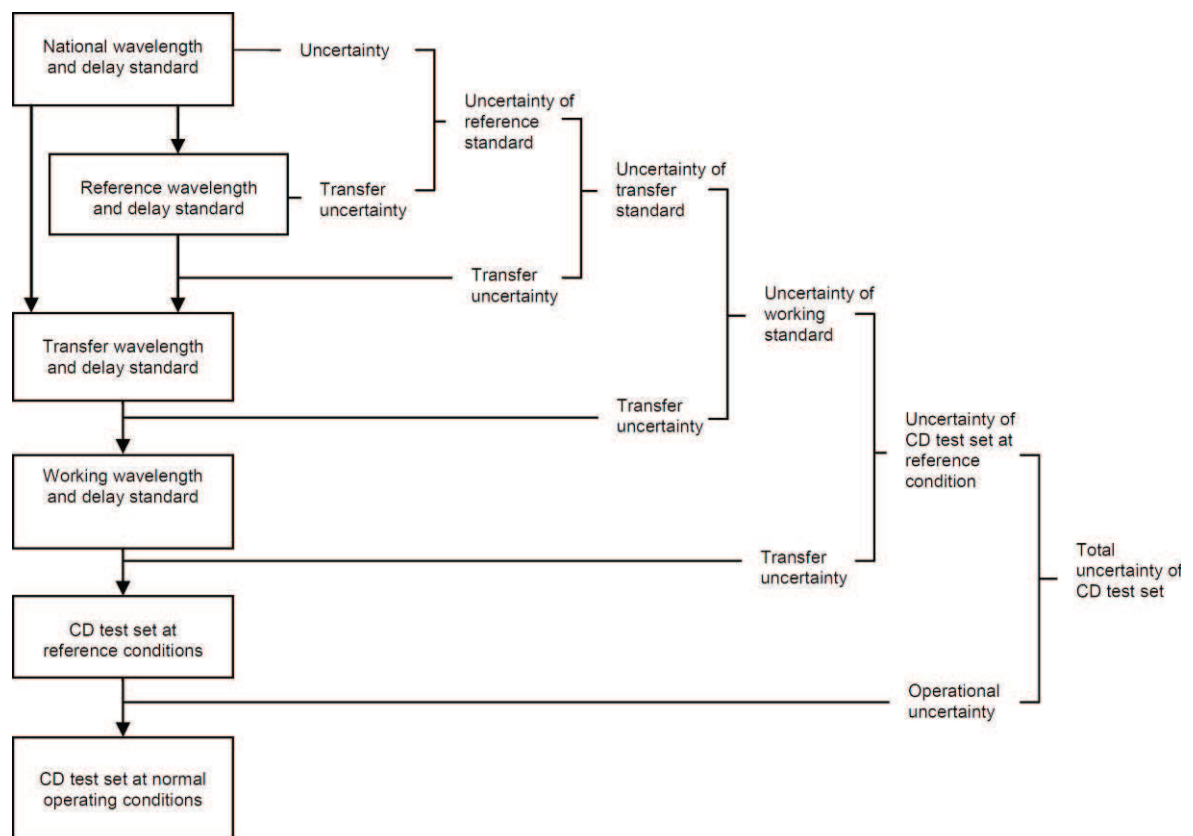


Figure 1 – Typical calibration chain for CD test sets

3.6

centroidal wavelength

power-weighted mean wavelength of a light source in vacuum, in units of nanometers (nm)

Note 1 to entry: For a continuous source spectrum, the centroidal wavelength λ_c in vacuum is defined by the following integral, where the integration limits enclose the entire spectrum of the source:

$$\lambda_c = (1/P_{\text{total}}) \times \left[\int p(\lambda) \times \lambda d\lambda \right] \quad (1)$$

where

$P_{\text{total}} = \int p(\lambda) d\lambda$ is the total optical source power.

For a spectrum consisting of i discrete lines, the centre wavelength in vacuum λ_c is defined as:

$$\lambda_c = (1/P_{\text{total}}) \times \left[\sum_i p_i \lambda_i \right] \quad (2)$$

where

$p(\lambda)$ is the spectral power density of the source in W/nm;

λ_c is the central wavelength in vacuum in nanometers;

λ_i is the i^{th} discrete line in nm;

p_i is the power levels at λ_i in W;

$P_{\text{total}} = \sum_i p_i$ is the total power in W.

3.7

chromatic dispersion (CD) test sets

instrument capable of measuring the chromatic dispersion of a single mode fibre at various wavelengths in the transmission windows of interest, typically the 1 310 nm and/or 1 550 nm wavebands

3.8

correction offset

CO

number that is added to or subtracted from the measurement result of a CD test set to correct for a known physical effect or systematic uncertainty

3.9

instrument state

complete description of the measurement conditions and state of the CD test set during the calibration process

Note 1 to entry: Typical parameters of the instrument state are the wavelength range in use, the data fit model (as applicable), warm-up time and other instrument settings.

3.10

measurement result

displayed or electrical output of any CD test set, in

- dispersion D in units of $\text{ps} \times \text{nm}^{-1} \times \text{km}^{-1}$,
- lambda zero λ_0 in units of nm, or
- zero dispersion slope S_0 in units of $\text{ps} \times \text{nm}^{-2} \times \text{km}^{-1}$,

after completing all actions suggested by the operating instructions, for example warm-up.

3.11

national standard

standard whose measurement is traceable to fundamental properties, such as the speed of light, which is recognized by an official national decision and used as the basis for fixing the value, in a country, of all other standards of the quantity concerned

3.12

national standards laboratory

body or laboratory that maintains and operates the national standard

3.13

operating range

all conditions of, for example, the dispersion, temperature and other influencing quantities, over which the CD test set is designed to perform within the stated expanded uncertainty

3.14

reference standard

artefact calibrated against a national standard and used to calibrate CD test sets.

Note 1 to entry: The artefact may be a delay [dispersion] or wavelength standard artefact.

Note 2 to entry: Proper use of the calibration standard ensures traceability.

Note 3 to entry: The term includes the national standard, reference standard, the transfer standard and the working standard in descending order of metrological uncertainty.

3.15

scaling factor

SF

ratio of known standard values for a standard artefact to the values indicated by the CD test set when no correction offsets are applied

Note 1 to entry: The factors can apply to wavelength, delay [dispersion] calibration, as well as to recorded zero dispersion wavelength, slope and actual dispersion data values when using a calibrated reference fibre.

3.16

spectral bandwidth

full-width half-maximum (FWHM) spectral width of the source

Note 1 to entry: If the source exhibits a continuous spectrum, then the spectral bandwidth, B , shall be the full-width-half-maximum (FWHM) of the spectrum.

Note 2 to entry: If the source exhibits a spectrum consisting of i discrete line (for example, a laser diode with a multiple-longitudinal mode spectrum), then the FWHM spectral bandwidth B shall be the r.m.s. spectral bandwidth, multiplied by 2,35 (assuming the source has a Gaussian envelope):

$$B = 2,35 \times \left[\left(\frac{1}{P_{\text{total}}} \right) \times \left(\sum_i p_i \lambda_i^2 \right) - \lambda_c^2 \right]^{1/2} \quad (3)$$

where

λ_c is the centroidal wavelength (see 0) of the laser diode, in nm;

$P_{\text{total}} = \sum_i p_i$ is the total power, in W;

p_i is the power of i^{th} longitudinal mode, in W;

λ_i is the wavelength of i^{th} longitudinal mode, in nm.

3.17

traceability

ability to demonstrate, for a measurement result or a CD test set, an unbroken calibration chain originating from a national standard

Note 1 to entry: CD test sets calibrated by the procedures of this standard are traceable. In the sense of this standard, direct traceability of the measurement result to either a national standards laboratory or to an accredited calibration laboratory is demonstrated. Such traceability includes the detailed calculations of all (cumulative) transfer uncertainties in the calibration chain.

3.18 **transfer**

part of the calibration process where, following comparison of the relevant parameter of a calibrated artefact to that of a CD test set, the artefact result is applied to the CD test set

Note 1 to entry: Transfer may be performed either by adjustment of the CD test set, or by documentation of a calibration factor in a calibration certificate.

3.19 **transfer standard**

intermediary artefact, for example a delay [dispersion] or wavelength artefact used to calibrate new working standards of a corresponding type

3.20 **uncertainty limits**

limits of permissible error (of a measuring instrument)

bounds or extreme values of expanded uncertainty permitted by user requirements, manufacturer's specification, regulatory documentation, etc. (see ISO 10012)

3.21 **working standard**

standard which, usually calibrated against a reference standard or transfer standard, is used on a routine basis to calibrate CD test sets

4 Calibration

4.1 General

This clause summarizes the action of calibrating a chromatic dispersion (CD) test set and details the recommendations for the environmental requirements of the calibration facility.

4.2 Preparation for calibration

4.2.1 General advice and organization

The following recommendations apply:

Calibrations should be carried out where possible with facilities (refer to ISO/IEC 17025) that are independent of the other functions of the laboratory/ organization. This independence should include measurement equipment.

The environmental conditions shall be commensurate with the degree of uncertainty that is required for calibration:

- a) the environment shall be clean;
- b) temperature monitoring and control are required;
- c) humidity monitoring and control are required;
- d) all laser sources shall be safely operated (see IEC 60825-1).

All standards used in the calibration process shall be calibrated according to a documented programme with traceability to national standards laboratories or to accredited standards (see Figure 1). It is advisable to maintain more than one standard on each hierarchical level of the calibration chain so that the performance of standards can be verified by comparisons on the same level.

There shall be a documented measurement procedure for each type of calibration performed, giving step-by-step operating instructions and equipment to be used. There should be pro-forma result sheets, uncertainty budgets and calibration certificates.