

Reliability of fibre optic interconnecting devices and passive components —

Part 2: Quantitative assessment of reliability based on accelerated ageing tests — Temperature and humidity; steady state

The European Standard EN 62005-2:2001 has the status of a British Standard

ICS 33.180.20; 33.180.99

National foreword

This British Standard is the official English language version of EN 62005-2:2001. It is identical with IEC 62005-2:2001.

The UK participation in its preparation was entrusted by Technical Committee GEL/86, Fibre optics, to Subcommittee GEL/86/2, Interconnecting devices and passive components, which has the responsibility to:

- aid enquirers to understand the text;
- present to the responsible international/European committee any enquiries on the interpretation, or proposals for change, and keep the UK interests informed;
- monitor related international and European developments and promulgate them in the UK.

A list of organizations represented on this committee can be obtained on request to its secretary.

From 1 January 1997, all IEC publications have the number 60000 added to the old number. For instance, IEC 27-1 has been renumbered as IEC 60027-1. For a period of time during the change over from one numbering system to the other, publications may contain identifiers from both systems.

Cross-references

The British Standards which implement international or European publications referred to in this document may be found in the BSI Standards Catalogue under the section entitled “International Standards Correspondence Index”, or by using the “Find” facility of the BSI Standards Electronic Catalogue.

A British Standard does not purport to include all the necessary provisions of a contract. Users of British Standards are responsible for their correct application.

Compliance with a British Standard does not of itself confer immunity from legal obligations.

This British Standard, having been prepared under the direction of the Electrotechnical Sector Committee, was published under the authority of the Standards Committee and comes into effect on 15 September 2001

Summary of pages

This document comprises a front cover, an inside front cover, the EN title page, pages 2 to 21 and a back cover.

The BSI copyright date displayed in this document indicates when the document was last issued.

Amendments issued since publication

Amd. No.	Date	Comments

Reliability of fibre optic interconnecting devices and passive components
Part 2: Quantitative assessment of reliability based on
accelerated ageing tests -
Temperature and humidity; steady state
(IEC 62005-2:2001)

Fiabilité des dispositifs d'interconnexion et
des composants passifs à fibres optiques
Partie 2: Evaluation quantitative de la
fiabilité en fonction d'essais de
vieillesse accélérés -
Température et humidité, régimes
continus
(CEI 62005-2:2001)

Zuverlässigkeit von LWL-
Verbindungselementen und passiven
Bauelementen
Teil 2: Quantitative Beurteilung der
Zuverlässigkeit auf der Basis von
beschleunigten Alterungsprüfungen -
Temperatur und Feuchte; konstant
(IEC 62005-2:2001)

This European Standard was approved by CENELEC on 2001-05-01. CENELEC members are bound to comply with the CEN/CENELEC Internal Regulations which stipulate the conditions for giving this European Standard the status of a national standard without any alteration.

Up-to-date lists and bibliographical references concerning such national standards may be obtained on application to the Central Secretariat or to any CENELEC member.

This European Standard exists in three official versions (English, French, German). A version in any other language made by translation under the responsibility of a CENELEC member into its own language and notified to the Central Secretariat has the same status as the official versions.

CENELEC members are the national electrotechnical committees of Austria, Belgium, Czech Republic, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Luxembourg, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland and United Kingdom.

CENELEC

European Committee for Electrotechnical Standardization
Comité Européen de Normalisation Electrotechnique
Europäisches Komitee für Elektrotechnische Normung

Central Secretariat: rue de Stassart 35, B - 1050 Brussels

Foreword

The text of document 86B/1438/FDIS, future edition 1 of IEC 62005-2, prepared by SC 86B, Fibre optic interconnecting devices and passive components, of IEC TC 86, Fibre optics, was submitted to the IEC-CENELEC parallel vote and was approved by CENELEC as EN 62005-2 on 2001-05-01.

The following dates were fixed:

- latest date by which the EN has to be implemented
at national level by publication of an identical
national standard or by endorsement (dop) 2002-02-01
- latest date by which the national standards conflicting
with the EN have to be withdrawn (dow) 2004-05-01

Annexes designated "normative" are part of the body of the standard.
In this standard, annex ZA is normative.
Annex ZA has been added by CENELEC.

Endorsement notice

The text of the International Standard IEC 62005-2:2001 was approved by CENELEC as a European Standard without any modification.

CONTENTS

	Page
INTRODUCTION	4
Clause	
1 Scope	5
2 Normative references	5
3 Guidance on testing for wear out failures	5
3.1 Failure distribution	5
3.2 Median time to failure (MTF)	6
4 Life test matrix	7
5 Worked example	9
5.1 Test condition matrix	9
5.2 Analysis of results	9
5.3 Calculating median time to failure	11
5.4 Calculation of temperature acceleration factor	14
5.5 Calculation of humidity acceleration factor	15
5.6 Extrapolation to service conditions	16
5.7 Calculation of failure rate	17
6 Random failure rate calculations	19
7 Implications for system reliability	20
Figure 1 – Extrapolation of results to determine time to failure	10
Figure 2 – Log-normal plot for devices in test condition C	13
Figure 3 – Log-normal plot for devices in test condition E	13
Figure 4 – Exponential curve fit for MTF versus $1/T$	15
Figure 5 – Exponential curve fit for MTF versus H_R^2	16
Figure 6 – Component reliability in service	18
Table 1 – Relative humidity (%) at various temperature and absolute humidity conditions	8
Table 2 – Matrix of test conditions	9
Table 3 – Times to failure (TTF) for devices in two life test conditions	12
Table 4 – Median times to failure for three temperatures at 85 % H_R	14
Table 5 – Median times to failure for three humidity levels at 85 °C	15
Table 6 – Median times to failure in different conditions based on worked example data	17
Table 7 – Calculated failure rates at 25 °C/85 % H_R	18

INTRODUCTION

Investigations carried out on optical passive devices such as splitters indicate that their failure mechanisms accelerate with both temperature and humidity. In many of the proposed applications, particularly in the telecommunications local loop, devices are located in environments that are subject to both high temperature and potentially high humidity. Information about the accelerating effect of both temperature and humidity is therefore essential to ensure that the devices are fit for use.

A system designer has an overall target reliability for a system that can be divided into target reliabilities that cover all components in the system. The location of a particular component in a network will influence the target reliability. If a fault in a component does not cause loss of service, for example if the service switches to a back-up, the target reliability of that component may not be so stringent. There is however a second consideration, besides continuity of service provision, and that is the "maintenance burden". This is a measure of the time spent repairing a network and a service provider needs to ensure that this does not become economically non-viable. The allocation of target reliability to particular components is a process that requires experience of the behaviour of the components in particular environments. Failure of passive optical components appears to be dominated by wear out mechanisms; therefore, the failure rate is not constant with time. This means that information is required not only to provide the median time to failure (MTF) but also for the distribution of the failure rate with time.

A worked example which focuses on temperature and humidity is given but it should be remembered that other factors such as vibration or the presence of organic solvents may also reduce the time to failure. The choice of suitable life tests should be based on an understanding of the conditions in which the devices are deployed, together with knowledge of the potential failure mechanisms of the device. There may be some failure mechanisms that are not readily accelerated by typical stress conditions. In establishing standards, this part of IEC 62005 sets out the minimum requirements, while other standards to be published should be used to establish whether additional stress testing is required.

A further complication is random failure. These are failures that cannot be attributed to a wear-out mechanism. Random failures consequently occur at a constant rate in a population of devices and are often referred to as steady-state failures.

It should be noted that the life test programme defined by this standard has been found to be applicable to passive devices operating in conditions where the ambient temperature does not vary by more than ± 15 °C from the mean value. It is only applicable to devices that have been specified according to the appropriate performance specification for the intended service conditions.

Devices that have dematable components or components that contain parts that rely on mechanical movement to perform correctly need additional life testing to ensure that the mechanical operation of the components remains correct throughout the lifetime of the component. The life test programme defined in this part of IEC 62005 still represents a significant part of the reliability information required for these components.

Components subjected to wider ranges of temperature variation or to other additional stresses such as vibration will also require additional life tests.

RELIABILITY OF FIBRE OPTIC INTERCONNECTING DEVICES AND PASSIVE COMPONENTS –

Part 2: Quantitative assessment of reliability based on accelerated ageing tests – Temperature and humidity; steady state

1 Scope

This part of IEC 62005 provides a basis for defining reliability tests for passive optical components. It provides advice on life testing procedures, the calculation of failure rates and the presentation of results. In addition to such general guidance, a worked example illustrates the method of calculating the instantaneous failure rate for a device during its service lifetime, based on accelerated life tests.

2 Normative references

The following normative documents contain provisions which, through reference in this text, constitute provisions of this part of IEC 62005. For dated references, subsequent amendments to, or revisions of, any of these publications do not apply. However, parties to agreements based on this part of IEC 62005 are encouraged to investigate the possibility of applying the most recent editions of the normative documents indicated below. For undated references, the latest edition of the normative document referred to applies. Members of IEC and ISO maintain registers of currently valid International Standards.

IEC 62005-4:1999, *Reliability of fibre optic interconnecting devices and passive components – Part 4: Product screening*

3 Guidance on testing for wear out failures

3.1 Failure distribution

Experience has shown that a log-normal distribution of times to failure can often be assumed to apply for wear-out failures of passive optical devices. That is to say that the log to the base e of the times to failure will have a normal (Gaussian) distribution. The dispersion parameter, σ , is the standard deviation of the logarithm to the base e of the times to failure. The log-normal distribution is the basis of the calculations shown in this standard.

The probability distribution function for a log-normal distribution is given by equation (1).

$$f(t) = \frac{1}{t\sigma\sqrt{2\pi}} \exp\left[-\frac{1}{2}\left\{\frac{\ln(t/t_m)}{\sigma}\right\}^2\right] \quad (1)$$

where

$t_m = t_{50}$ is the median time to failure (MTF), taken for 50 % of samples to fail;

σ is the standard deviation of $\ln(t)$.

In some cases, a Weibull distribution may provide a better representation of the failure distribution. The principles outlined in this clause are still valid, but the calculation involved in determining wear-out failure rates will be different. Where experimental results indicate that there is more than one significant failure mechanism, the median time to failure and dispersion should be reported in each case.

Information shall be provided to justify extrapolation models and activation energies used in reliability predictions. Field feedback shall be collated to support the basis for the accelerated ageing tests. Where feedback suggests that failure rates are very different to those predicted, failure analysis shall be carried out to allow the accelerated ageing programme to be modified appropriately.

Throughout this standard, failure rates are expressed in FITs, where one FIT is defined as one failure in 10^9 device-hours. This expression of failure rate is of more value in the assessment of system reliability than the MTF figure. From a system perspective, it is the early failures that are critical. The MTF refers to a time by which half of the components will have failed, which on its own is of no value in calculating the reliability of a system.

3.2 Median time to failure (MTF)

Accelerated testing is required to demonstrate the long-term reliability of optical passive devices. High temperature and humidity life testing is the most widely used method of providing reliability data in a test of reasonable duration.

For thermal over-stress, the association between lifetime and temperature is derived from the Arrhenius relationship:

$$t_{50} = R_0 \exp (-E_A / kT) \quad (2)$$

where

t_{50} is the median time to failure (MTF), taken for 50 % of samples to fail;

R_0 is the coefficient;

k is Boltzmann's constant ($8,6 \times 10^{-5}$ eV/K);

T is the temperature, in kelvins (K);

E_A is the activation energy, expressed in electronvolts (eV).

There is no universally accepted relationship between lifetime and humidity. Unless there is evidence to the contrary, the following expression may be used:

$$t_{50} = R_0 \exp [-\eta H_R^2] \quad (3)$$

where

η is the humidity activation parameter;

H_R is the relative humidity, in per cent (%).

When the acceleration rates are known, the median time to failure can be calculated at any operating temperature and humidity. The failure rate as a function of time may then be calculated provided that the standard deviation of the log-normal distribution is known.