

Imaging materials — Recordable compact disc systems — Method for estimating the life expectancy based on the effects of temperature and relative humidity

ICS 37.040.99; 37.080

National foreword

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The UK participation in its preparation was entrusted to Technical Committee CPW/42, Photography, which has the responsibility to:

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Imaging materials — Recordable compact disc systems — Method for estimating the life expectancy based on the effects of temperature and relative humidity

*Matériaux pour image — CD enregistrables — Méthode d'estimation de
l'espérance de vie basée sur les effets de la température et de l'humidité
relative*



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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 3.

Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

Attention is drawn to the possibility that some of the elements of this International Standard may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

International Standard ISO 18927 was prepared by Technical Committee ISO/TC 42, *Photography*.

This International Standard is one of a series of standards dealing with the physical properties and stability of imaging materials. To facilitate identification of these documents, they are assigned a number within the block from 18900-18999 (see annex A).

Annexes A, B and C of this International Standard are for information only.

Imaging materials — Recordable compact disc systems — Method for estimating the life expectancy based on the effects of temperature and relative humidity

1 Scope

This International Standard specifies a test method for estimating the life expectancy of information stored on recordable compact disc systems. Only the effects of temperature and relative humidity on the media are considered.

This International Standard does not cover the effects of light, air pollution, or time-dependent flow phenomena.

2 Normative references

The following normative documents contain provisions which, through reference in this text, constitute provisions of this International Standard. For dated references, subsequent amendments to, or revisions of, any of these publications do not apply. However, parties to agreements based on this International Standard 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 ISO and IEC maintain registers of currently valid International Standards.

ISO/IEC 10149:1995, *Information technology — Data interchange on read-only 120 mm optical data disks (CD-ROM)*

IEC 60908:1999, *Audio recording — Compact disc digital audio system*

Experimental statistics, US National Bureau of Standards Handbook 91, 1963

3 Terms and definitions

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

3.1

baseline

condition representing the disc at time of manufacture

NOTE This is customarily the initial parameter measurement taken prior to any application of stress. The designation is usually $t = 0$ for a stress time equal to zero hours.

3.2

block error rate

BLER

ratio of erroneous blocks to total blocks measured at the input of the first (C1) decoder (before any error correction is applied)

[IEC 60908:1999]

NOTE The more commonly reported value for BLER is the number of erroneous blocks per second measured at the input of the C1-decoder during playback at the standard (1X) data rate.

3.2.1

maximum block error rate

max BLER

maximum BLER measured anywhere on a disc

3.3

compact disc-recordable

CD-R

recordable optical disc in which information can be recorded to certain areas in compact disc format

NOTE 1 Information can be recorded one time and read many times.

NOTE 2 The term “compact disc-write once” (CD-WO) has also been used to describe this type of disc.

3.4

cumulative distribution function

$F(t)$

probability that a random unit drawn from the population fails by time, t , or the fraction of all units in the population which fail by time, t

3.4.1

lognormal cumulative distribution function

$F(t)$

cumulative distribution function in which the logarithm of the relevant parameter, in this International Standard the disc lifetime, has a normal distribution and is defined by the following equation:

$$F(t) = \frac{1}{\sqrt{2\pi}} \int_0^t \frac{1}{\sigma_1 x} e^{-\frac{1}{2} \left(\frac{\ln(x) - \mu_1}{\sigma_1} \right)^2} dx$$

where

- t is the time;
- x is a variable representing disc lifetime;
- σ_1 is the log standard deviation;
- μ_1 is the log mean;
- $\ln(x)$ is the natural logarithm of x .

NOTE When $t = e^{\mu_1}$, the lognormal cumulative distribution function evaluates to 0,5. In other words, the model predicts that half the samples have failed at that time.

3.5

disc-at-once recording

method of recording a CD-R disc whereby the entire CD is recorded in one pass without turning off the laser

3.6

end-of-life

occurrence of any loss of information

3.7

extended-term storage conditions

storage conditions suitable for the preservation of recorded information having permanent value

3.8**glass transition**

reversible change in an amorphous polymer from, or to, a viscous or rubber condition to, or from, a hard and relatively brittle one

3.8.1**glass transition temperature**
 T_g

approximate mid-point of the temperature range over which glass transition takes place

NOTE 1 T_g can be determined readily only by observing the temperature at which a significant change takes place in a specific electrical, mechanical, or other physical property.

NOTE 2 T_g can also be sensitive to the moisture content of the polymer.

3.9**information**

signal or image recorded using the system

3.10**life expectancy**
LE

length of time that information is predicted to be acceptable in a system after dark storage at 21 °C and 50 % RH

3.10.1**standardized life expectancy**
SLE

minimum life span, predicted with 95 % confidence, of 95 % of the product stored at a temperature not exceeding 25 °C and a relative humidity (RH) not exceeding 50 % RH

3.11**retrievability**

ability to access information as recorded

3.12**stress**

experimental variable to which the specimen is exposed for the duration of the test interval

NOTE In this International Standard, the stress variables are confined to temperature and relative humidity.

3.13**survivor function**
 $R(t)$

probability that a random unit drawn from the population survives at least time, t , or the fraction of all units in the population which survive at least time, t

NOTE $R(t) = 1 - F(t)$

3.14**system**

combination of material, hardware, software and documentation necessary for recording and/or retrieving information

3.15**test cell**

device that controls the stress to which the specimen is exposed

3.16

track-at-once recording

method of recording a CD-R disc whereby each track is recorded individually with 150 empty sectors immediately preceding it and two run-out sectors immediately following

3.17

uncorrectable error

error in the playback data that is not correctable by the cross interleave Reed-Solomon code defined in IEC 60908:1999 as implemented in a system

4 Purpose and assumptions

4.1 Purpose

The purpose of this International Standard is to establish a methodology for estimating the life expectancy of information stored on recordable compact disc systems. This methodology provides a technically and statistically sound procedure for obtaining and evaluating accelerated test data.

The methodology deals only with the effects of temperature and humidity on the retrievability of stored information. For this reason, this International Standard is primarily directed to those storage applications, e.g. libraries and archives, in which exposure to other influences potentially detrimental to information life expectancy, such as chemical agents, intense light sources and improper handling, is controlled and minimized.

4.2 Assumptions

The validity of the procedure defined by this International Standard relies on three assumptions:

- specimen life distribution is appropriately modelled by the lognormal distribution;
- the kinetics of the dominant failure mechanism is appropriately modelled by an Eyring acceleration model;
- the dominant failure mechanism acting at the usage condition is the same as that at the accelerated conditions.

Publications by Hamada and Stinson provide data indicating that these assumptions are applicable to compact disc-recordable (CD-R) systems (see references [6] and [7] in the Bibliography).

5 Measurements

5.1 Summary

A sampling of eighty recorded discs shall be divided into five groups according to a specified plan. Each group of discs (test cell) shall be subjected to one of five test stresses, combinations of temperature and relative humidity. Periodically during the stress conditions, all discs from each stress group shall have their block error rate (BLER) measured. Data collected at each time interval for each individual disc are then used to determine a lifetime for that disc.

The disc lifetimes at each stress level are fitted to a lognormal distribution to determine a mean lifetime for the stress. The resulting five mean lifetimes are regressed against temperature and relative humidity according to an Eyring acceleration model. This model is then used to estimate the distribution of lifetimes at a usage condition.

5.2 BLER

End-of-life is the occurrence of any loss of information. Ideally, each specimen is tested until the first loss of information occurs. Realistically, this is impractical. This International Standard considers max BLER to be a high-level estimate of the performance of the system. The objective of measuring BLER is to establish a practical

estimation of the system's ability to read recorded data without uncorrectable errors. A change in max BLER in response to the time at an accelerated temperature and humidity is the principal quality parameter.

IEC 60908:1999 states that the BLER averaged over any 10 s shall be less than 3×10^{-2} . At the standard (1X) data rate, the total number of blocks per second entering the C1-decoder is 7 350. Thus, an equivalent limit on BLER is 220 block per second.

For the purpose of this International Standard, recorded data are considered to have reached end-of-life when the BLER, measured as erroneous blocks per second, exceeds 220 anywhere on the disc, i.e. when the max BLER exceeds 220. It is recognized that the correlation between actual loss of information and max BLER is very system dependent. A BLER of 220 is an arbitrary level chosen as a predictor of the onset of uncorrectable errors and thereby end-of-life.

5.3 Test equipment

5.3.1 General requirements

A compact disc player that conforms to ISO/IEC 10149 and software capable of producing a display of max BLER.

If it becomes necessary to replace the test equipment, the USA National Bureau of Standards Handbook 91 shall be followed for correlating test equipment outputs.

The make, model and version of the test equipment (including software) shall be reported with the test results.

5.3.2 Calibration and repeatability

A calibration, according to the tester manufacturer's procedure, shall be performed prior to any measurement data being collected. A calibration disc shall be available from an accredited source.

In addition to the calibration disc, one control disc shall be maintained at ambient conditions and its max BLER measured before and after each data collection interval. A control chart shall be maintained for this control disc.

The mean and standard deviation of the control disc shall be established by collecting at least five measurements. Should any individual max BLER reading differ from the mean by more than three times the standard deviation, the problem shall be corrected and all data collected since the last valid control point shall be remeasured.

5.4 Test specimen

5.4.1 General requirements

A test specimen is any disc that, after recording, meets ISO/IEC 10149 specifications and contains representative data extending to within 2 mm of the maximum recording diameter.

5.4.2 Specimen selection

All discs shall be nominally identical with regard to substrate groove structure, layer structure, coating composition, recording capacity, and age prior to test initiation. It is preferred that the CD-R media be chosen from different lots and production lines in order to be representative of normal process variations.

All discs shall be maintained in the manufacturer's transportation and storage conditions prior to recording.

The nominal disc capacity shall be reported with the test results.