
**Information technology — Digitally
recorded media for information
interchange and storage — Test method
for the estimation of lifetime of optical
media for long-term data storage**

*Technologies de l'information — Supports pour l'échange d'informations
et le stockage enregistrés numériquement — Méthode d'essai pour
l'estimation de la durée de vie de supports optiques pour le stockage à
long terme*

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Foreword

ISO (the International Organization for Standardization) and IEC (the International Electrotechnical Commission) form the specialized system for worldwide standardization. National bodies that are members of ISO or IEC participate in the development of International Standards through technical committees established by the respective organization to deal with particular fields of technical activity. ISO and IEC technical committees collaborate in fields of mutual interest. Other international organizations, governmental and non-governmental, in liaison with ISO and IEC, also take part in the work. In the field of information technology, ISO and IEC have established a joint technical committee, ISO/IEC JTC 1.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of the joint technical committee is to prepare International Standards. Draft International Standards adopted by the joint technical committee are circulated to national bodies for voting. Publication as an International Standard requires approval by at least 75 % of the national bodies casting a vote.

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

ISO/IEC 16963 was prepared by Ecma International (as ECMA-396) and was adopted, under a special "fast-track procedure", by Joint Technical Committee ISO/IEC JTC 1, *Information technology*, in parallel with its approval by national bodies of ISO and IEC.

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Introduction

Markets and industry have developed a common understanding that the property referred to as the lifetime of data recorded to optical media plays an increasingly important role for the intended applications. Disparate standardized test methodologies exist for Magneto Optical media and recordable compact disk and DVD systems. It was agreed that the project represented by this International Standard be undertaken in order to provide a common methodology, applicable for various purposes, that includes the testing of currently available writable CD and DVD optical media.

ISO/IEC JTC 1/SC 23/JWG 1, which is a Joint working group among ISO/TC 42, ISO/TC 171 and ISO/IEC JTC 1/SC 23, initiated work on this subject and developed the initial drafts with assistance from Ecma International TC31.

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Information technology — Digitally recorded media for information interchange and storage — Test method for the estimation of lifetime of optical media for long-term data storage

1 Scope

This International Standard specifies an accelerated aging test method for estimating the lifetime of the retrievability of information stored on recordable or rewritable optical disks.

This test includes details on the following formats: DVD-R/RW/RAM, +R/+RW and CD-R/RW. It may be applied to additional optical disk formats, with substitution of the appropriate specifications, and may also be updated by committee in the future as required.

This International Standard includes:

- stress conditions
 - Basic stress condition and Rigorous stress condition testing for use with the Eyring Method and testing for use with the Arrhenius Method.
- ambient storage conditions in which the lifetime of data stored on optical media is estimated
 - Controlled storage condition, e.g. 25 °C and 50 % RH, representing well-controlled storage conditions with full-time air conditioning. Eyring Method is used to estimate the lifetime under this storage condition.
 - Harsh storage condition, e.g. 30 °C and 80 % RH, representing the most severe conditions in which users handle and store the optical media. Arrhenius Method is used to estimate the lifetime under this storage condition.
- evaluation system description
- specimen preparation and data-acquisition procedure
- definition of and method for estimating lifetime of stored data on specified media
- data analysis for lifetime of stored data
- reporting format for estimated lifetime of stored data

The methodology includes only the effects of temperature (T) and relative humidity (RH). It does not attempt to model degradation due to complex failure-mechanism kinetics, nor does it test for exposure to light, corrosive gases, contaminants, handling, or variations in playback subsystems. Disks exposed to these additional sources of stress or higher levels of temperature and relative humidity are expected to experience shorter usable lifetimes.

2 Conformance

Media tested by this methodology shall conform to all normative references specific to that media format.

3 Normative references

The following referenced documents are indispensable for the application 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.

ISO/IEC 10149:1995, *Information technology — Data interchange on read-only 120 mm optical data disks (CD-ROM)* (ECMA-130)

ISO/IEC 12862:2009, *Information technology — 120 mm (8,54 Gbytes per side) and 80 mm (2,66 Gbytes per side) DVD recordable disk for dual layer (DVD-R for DL)* (ECMA-382)

ISO/IEC 13170:2009, *Information technology — 120 mm (8,54 Gbytes per side) and 80 mm (2,66 Gbytes per side) DVD re-recordable disk for dual layer (DVD-RW for DL)* (ECMA-384)

ISO/IEC 16448:2002, *Information technology — 120 mm DVD — Read-only disk* (ECMA-267)

ISO/IEC 16449:2002, *Information technology — 80 mm DVD — Read-only disk* (ECMA-268)

ISO/IEC 17592:2004, *Information technology — 120 mm (4,7 Gbytes per side) and 80 mm (1,46 Gbytes per side) DVD rewritable disk (DVD-RAM)* (ECMA-330)

ISO/IEC 17341:2009, *Information technology — Data interchange on 120 mm and 80 mm optical disk using +RW format — Capacity: 4,7 Gbytes and 1,46 Gbytes per side (recording speed up to 4X)* (ECMA-337)

ISO/IEC 17342:2004, *Information technology — 80 mm (1,46 Gbytes per side) and 120 mm (4,70 Gbytes per side) DVD re-recordable disk (DVD-RW)* (ECMA-338)

ISO/IEC 17344:2009, *Information technology — Data interchange on 120 mm and 80 mm optical disk using +R format — Capacity: 4,7 Gbytes and 1,46 Gbytes per side (recording speed up to 16X)* (ECMA-349)

ISO/IEC 23912:2005, *Information technology — 80 mm (1,46 Gbytes per side) and 120 mm (4,70 Gbytes per side) DVD Recordable Disk (DVD-R)* (ECMA-359)

ISO/IEC 25434:2008, *Information technology — Data interchange on 120 mm and 80 mm optical disk using +R DL format — Capacity: 8,55 Gbytes and 2,66 Gbytes per side (recording speed up to 16X)* (ECMA-364)

ISO/IEC 26925:2009, *Information technology — Data interchange on 120 mm and 80 mm optical disk using +RW HS format — Capacity: 4,7 Gbytes and 1,46 Gbytes per side (recording speed 8X)* (ECMA-371)

ISO/IEC 29642:2009, *Information technology — Data interchange on 120 mm and 80 mm optical disk using +RW DL format — Capacity: 8,55 Gbytes and 2,66 Gbytes per side (recording speed 2,4X)* (ECMA-374)

ECMA-394, Recordable Compact Disc Systems CD-R Multi-Speed

ECMA-395, Recordable Compact Disc Systems CD-RW Ultra-Speed

4 Terms and definitions

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

4.1

Arrhenius method

accelerated aging model based on the effects of temperature only

4.2

baseline

initial test analysis measurements (e.g., initial data errors) after recording and before exposure to a stress condition, i.e. measurement at stress time $t=0$ hours

4.3

basic stress conditions

accelerated aging conditions for estimating the lifetime of data stored on optical media in a reasonable amount of time and labour

4.4

B_5 Life

5 percentile of the lifetime distribution (i.e. 5 % failure time) or 95 % survival lifetime

4.5

$(B_5 \text{ Life})_L$

95 % lower confidence bound of B_5 Life

4.6

B_{50} Life

50 percentile of the lifetime distribution (i.e. 50 % failure time) or 50 % survival lifetime

4.7

controlled storage condition

well-controlled storage conditions with full-time air conditioning (25 °C and 50 % RH) in which the lifetime of data stored on optical media may be extended

4.8

Eyring method

accelerated aging model based on the effects of temperature and relative humidity

4.9

data error

data error on the sample disk measured before error correction is applied

4.10

harsh storage condition

most severe conditions in which users handle and store the optical media (30 °C and 80 % RH) in which the lifetime of data stored on optical media may be shortened

4.11

incubation

process of enclosing and maintaining controlled test-sample environments

4.12

maximum data error

maximum data error measured anywhere in one of the relevant areas on the disk:

- for DVD-R/RW and +R/+RW, this is the Maximum PI Sum 8,
- for DVD-RAM, this is the Maximum BER, and
- for CD-R/RW, this is the Maximum C1 Ave 10.

4.13

retrievability

ability to recover physically-recorded information as recorded

4.14

rigorous stress conditions

accelerated aging conditions for estimating the lifetime of data stored on optical media with higher confidence

4.15

stress

temperature and relative humidity variables to which the sample is exposed for the duration of test incubation intervals

4.16

system

combination of hardware, software, storage medium and documentation used to record, retrieve and reproduce information

5 Conventions and notations

5.1 Representation of numbers

A measured value is rounded off to the least significant digit of the corresponding specified value. For instance, it follows that a specified value of 1,26 with a positive tolerance of + 0,01 and a negative tolerance of - 0,02 allows a range of measured values from 1,235 to 1,275.

5.2 Names

The names of entities, e.g. specific tracks, fields, zones, etc. are capitalized

6 List of acronyms

BER byte error rate

BLER block error rate

PI parity (of the) inner (code)

Section 2 — Test and Evaluation

7 Measurements

7.1 Summary

7.1.1 Stress Incubation and Measuring

A sampling of disks will be measured at four stress conditions for the Basic stress condition testing or five stress conditions for the Rigorous stress condition testing for use with the Eyring Method, or three stress condition for the Basic stress condition testing or four stress conditions for the Rigorous stress condition testing for use with the Arrhenius Method.

Each stress condition's total time will be divided into sub-interval time periods. Each disk in each group of disks will have its initial data errors measured before their exposure to stress conditions. Thereafter, each disk will be measured for its data errors after each stress condition incubation sub-interval time period.

The control disk for monitoring of tester can also be measured following each incubation time interval.

7.1.2 Assumptions

This International Standard makes the following assumptions for applicability of media to be tested

specimen life distribution is appropriately modelled by a statistical distribution,

the Eyring Method can be used to model acceleration with the both stresses involved (temperature and relative humidity),

the dominant failure mechanism acting at the usage condition is the same as that at the accelerated conditions,

the compatibility of the disk and drive combination will affect the disk's initial recording quality and the resulting archival test outcome,

a hardware and software system needed to read the disk will be available at the time the retrieval of the information is attempted,

the recorded format will be recognizable and interpretable by the reading software.

7.1.3 Data Error

Of all specimen media, the data errors shall be measured in the disk testing locations as defined in 7.5. For each sample the Maximum Data Error shall be determined.

Each DVD-R/RW, +R/+RW disk will have its Maximum PI Sum 8 (Max PI Sum 8) determined.

Each DVD-RAM disk will have its Maximum Byte Error rate (Max BER) determined.

Each CD-R/RW disk will have its Maximum C1 Ave 10 (Max C1 Ave 10) determined.

Data collected at each time interval for each individual disk are then used to determine the predicted time to failure for that disk at that stress condition.

7.1.3.1 PI Sum 8

Per ISO/IEC 16448:2002, a row in an ECC block that has at least 1 byte in error constitutes a PI error. PI Sum 8 is measured over 8 ECC blocks in any 8 consecutive ECC blocks. The total number of PI errors, also called PI Sum 8, before error correction shall not exceed 280.

7.1.3.2 BER

The number of erroneous symbols shall be measured in any consecutive 32 ECC blocks in the first pass of the decoder before correction. The BER is the number of erroneous symbols divided by the total number of symbols included in the 32 consecutive ECC blocks. The maximum value of the BER measured over the area specified in 7.5 shall not exceed 10^{-3} .

7.1.3.3 C1 Ave 10

IEC 60908:1999 specifies that the BLER averaged over any 10 seconds shall be less than 3×10^{-2} . At the standard (1X) data transfer rate, the total number of blocks per second entering the C1-decoder is 7 350.

Thus, the number of C1 errors per second before error correction which is averaged over any 10 seconds, called C1 Ave 10, shall not exceed 220.

7.1.4 Data Quality

Data quality is checked by plotting the median rank of the estimated time to failure values with a best-fit line for each stress condition. The lines are then checked for reasonable parallelism.

7.1.5 Regression

The log predicted time to failure values shall be calculated using linear regression.

Multiple linear regression is used for the Eyring Method and linear regression is used for the Arrhenius Method.

7.2 Test specimen

The disk sample set shall represent the construction, materials, manufacturing process, quality and variation of the final process output.

Consideration shall be made to shelf life. Disks with longer shelf time before recording and testing may impact test results. Shelf time shall be representative of normal usage.

7.3 Recording conditions

Before media are entered into accelerated aging tests, they shall be recorded as optimally as is practicable, according to the descriptions given in the related standard. OPC (optimum power control) during the writing process shall serve as the method to achieve minimum data errors. It is generally assumed that optimally-recorded media will yield the longest predicted lifetime. Media is deemed acceptable for entry into the aging tests when their data errors and all other media parametric specifications are found to be within their respective standard's specification limits.

The choice of recording hardware is at the discretion of the recording party. It may be either commercial drive-based or speciality recording tester based. It shall be capable of producing recordings that meet all specifications.

The recording speed used for testing shall be reported.

NOTE It is expected that lifetime of data on a disk may be affected by recording conditions including recording speed.

7.3.1 Recording test environment

When performing the recordings, the air immediately surrounding the media shall have the following properties:

temperature:	23 °C to 35 °C
relative humidity:	45 % to 55 %
atmospheric pressure:	60 kPa to 106 kPa

No condensation on the disk shall occur. Before testing, the disk shall be conditioned in this environment for 48 hrs minimum. It is recommended that, before testing, the entrance surface be cleaned according to the instructions of the manufacturer of the disk.

7.3.2 Recording method

Specimen disks shall be recorded in a single session and finalized.

7.4 Playback conditions

7.4.1 Playback tester

All media shall be read by the playback tester as specified in each of the medium's standard and at their specified test conditions.

Specimen media shall be read as described in the format standards identified in Clause 3.

7.4.2 Playback test environment

When measuring the data errors, the air immediately surrounding the disk shall have the following properties:

temperature: 23 °C to 35 °C

relative humidity: 45 % to 55 %

atmospheric pressure: 60 kPa to 106 kPa

Unless otherwise stated, all tests and measurements shall be made in this test environment.

7.4.3 Calibration

The test equipment should be calibrated as prescribed by its manufacturer using calibration disks approved by said manufacturer and as needed before disk testing. A control disk should be maintained at ambient conditions and its data error should be measured at the same time the stressed disks are measured, both initially and after each stress sub interval.

The mean and standard deviation of the control disk shall be established by collecting at least five measurements. Should any individual data error 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 re-measured.

7.5 Disk testing locations

7.5.1 Rigorous stress condition testing

All data areas on a disk shall be tested.

7.5.2 Basic stress condition testing

Testing locations shall be a minimum of three bands spaced evenly from the inner, middle and outer radius locations on the disk as indicated in Table 1. The total testing area shall represent a minimum of 5 % of the disk capacity. For DVDs and +R / +RW disks, each of the three test bands shall have more than 750 ECC blocks for 80 mm disks, and 2 400 ECC blocks for 120 mm disks. For CDs, each of the three test bands shall have more than 5900 sectors.

Table 1 — Nominal radii of the three test bands (Unit; mm)

	DVD- R / RW, +R / +RW disk (Single Layer / Dual Layer)		DVD- RAM disk		CD-R/RW disk
	80 mm	120 mm	80 mm	120 mm	120 mm
Band 1	25,0	25,0	24,1-25,0	24,1-25,0	25,0
Band 2	30,0	40,0	29,8-30,8	39,4-40,4	40,0
Band 3	35,0	55,0	34,6-35,6	54,9-55,8	55,0