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Information technology — Digitally recorded media for information interchange and storage — Quality discrimination method for optical disks and operating method of storage systems for long-term data preservation

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ISO copyright office
CP 401 • Ch. de Blandonnet 8
CH-1214 Vernier, Geneva
Phone: +41 22 749 01 11
Email: copyright@iso.org
Website: www.iso.org

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Foreword

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Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html and www.iec.ch/national-committees.

Introduction

In the digital information society, there is no secure means for storing and accumulating rapidly growing digital information safely and on a permanent basis. There is therefore a concern that the world will face a critical situation and significant problem in the near future. Within this context, optical disks are increasingly being considered as a solution for archiving storage media with high capacity because of their unique features such as low cost, high compatibility and low energy consumption, and more specifically, their data storage capability without power consumption.

On the other hand, the data storage performance of an optical disk often depends on the initial recording quality and storage environment conditions. Therefore, when an optical disk is used for long-term data storage, it is desirable to check its estimated lifetime and initial recording quality by using a combination of a good quality optical disk and a good quality recording drive.

For this reason, this document specifies quality discrimination criteria using the initial quality of recordable optical disks as an index. It also specifies a quality judgement method for storage systems for long-term data preservation, including the consistency of the recordable optical disks and recording drives to ensure the quality of recorded digital data. In this document, recordable (write-once) disks among optical disks are adopted as long-term storage media to ensure the security of the stored digital data when giving greater importance to evidence, because physical overwriting and deletion by erroneous or intentional operation can be prevented.

This document is also applicable to read-only optical disks such as CD-ROM, DVD-ROM and BD-ROM, specifying the quality judgement method for long-term data preservation.

This document enables users to build data storage systems that use recordable and/or read-only optical disks for long-term data preservation. Optical disks with sufficient quality can be confirmed based on the results of the initial quality test. Through the periodic quality test described in this document, the possibility of data restoration from the optical disk can be continuously monitored. Using this document, manufacturers will be able to supply recordable and read-only optical disks incorporated with suitable recording and playback drives for building data storage systems for long-term data preservation.

In the future, it will be possible to build data storage systems using optical disks for storing and accumulating important digital information safely and on a permanent basis, for consumer use and professional use. The safe and secure progress of the digital information society towards greater sophistication can be expected.

Information technology — Digitally recorded media for information interchange and storage — Quality discrimination method for optical disks and operating method of storage systems for long-term data preservation

1 Scope

This document specifies a quality discrimination method for optical disks and the operating method of storage systems for long-term digital data preservation using optical disks and optical disk drives (hereinafter referred to as "drives").

It is applicable to recordable (write-once) optical disks which can prevent physical overwriting and deletion by erroneous or intentional operation in contexts where greater importance is given to evidence. It is also applicable to read-only (ROM) optical disks.

This document specifies:

- combinations of recordable optical disks and drives used for long-term data preservation;
- quality discrimination criteria for recordable optical disks and the operation method of long-term storage systems;
- a quality test for read-only optical disks and the operation method of long-term storage systems;
- quality discrimination criteria for BD recordable disks when adopting the defect management.

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.

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

ISO/IEC 12862, *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)*

ISO/IEC 16448, *Information technology — 120 mm DVD — Read-only disk*

ISO/IEC 16449, *Information technology — 80 mm DVD — Read-only disk*

ISO/IEC 16963, *Information technology — Digitally recorded media for information interchange and storage — Test method for the estimation of lifetime of optical disks for long-term data storage*

ISO/IEC 17344, *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)*

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

ISO/IEC 25434, *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)*

ISO/IEC 30190, *Information technology — Digitally recorded media for information interchange and storage — 120 mm Single Layer (25,0 Gbytes per disk) and Dual Layer (50,0 Gbytes per disk) BD Recordable disk*

ISO/IEC 30191, *Information technology — Digitally recorded media for information interchange and storage — 120 mm Triple Layer (100,0 Gbytes single sided disk and 200,0 Gbytes double sided disk) and Quadruple Layer (128,0 Gbytes single sided disk) BD Recordable disk*

ECMA-394, *Recordable Compact Disk Systems CD-R Multi-Speed*

3 Terms and definitions

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

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

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

3.1

maximum C1 error

Max C1

maximum number of C1 errors per second averaged over any 10 s in one of the relevant areas on a CD, measured at the input of error correction decoder under the standard data transfer rate

Note 1 to entry: See ISO/IEC 10149, ISO/IEC 16963, and ECMA 394.

3.2

maximum PI SUM 8

Max PI SUM 8

maximum parity of inner code (PI) error count at any consecutive 8 *error correction code* (3.7) blocks in one of the relevant areas on a DVD, measured at the first pass of the decoder before correction

Note 1 to entry: See ISO/IEC 12862, ISO/IEC 16448, ISO/IEC 16449, ISO/IEC 17344, ISO/IEC 23912, and ISO/IEC 25434.

3.3

maximum random symbol error rate

Max RSER

maximum value of random symbol error rate in one of the relevant areas on a BD excluding burst errors of 40 bytes or more, measured at the input of error-correction decoder

Note 1 to entry: See ISO/IEC 30190, and ISO/IEC 30191.

Note 2 to entry: Maximum random symbol error rate shall be measured by averaging over any N consecutive *long distance code* (3.8) blocks to reduce the impact of burst errors, with the condition that all blocks are recorded in a continuously written sequence, in a discontinuously written sequence excluding disk defects. In this document, the number of N shall be 10 000, and when *defect management* (3.17) is applied, the number of N shall be 10 000 at maximum.

3.4

maximum burst error

Max BE

maximum sum of the lengths of burst errors with length greater than or equal to 40 bytes in one recording-unit block in one of the relevant areas on a BD

Note 1 to entry: See ISO/IEC 30190 and ISO/IEC 30191.

Note 2 to entry: The number of burst errors is not covered in this document.

3.5**error rate**

rate of data errors on the recorded disk measured before error correction is applied

3.6**uncorrectable error**

error in the read-out data that cannot be corrected by the error-correction decoders

[SOURCE: ISO/IEC 29121:2021, 3.18]

3.7**error correction code****ECC**

mathematical computation yielding check bytes used for the detection and correction of errors in data

3.8**long distance code****LDC**

error correction code (3.7) that increases the correction ability by increasing the code length and assigning more inspection symbols

Note 1 to entry: Long distance code is used in BD disks.

Note 2 to entry: See ISO/IEC 30190, and ISO/IEC 30191.

3.9**initial quality test**

verification test of the data quality recorded on an optical disk before storing

3.10**periodic quality test**

periodic test of the data quality recorded on an optical disk during preservation period

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3.11**constant linear velocity****CLV**

rotation control method of optical disk that keeps the linear velocity constant

3.12**data migration**

process to copy data from one storage device or medium to another

3.13**lifetime**

time that information is retrievable in a *system* (3.15)

[SOURCE: ISO/IEC 29121:2021, 3.9]

3.14**preservation period**

period during which an optical disk has been stored since data was recorded

3.15**system**

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

[SOURCE: ISO/IEC 16963:2017, 3.20]

**3.16
defect management
DM**

method for handling the defective areas on the BD recordable disk

[SOURCE: ISO/IEC 17345:2006, 4.10, modified — disk type ("BD recordable") has been added.]

**3.17
defective cluster**

cluster in a user-data area that has been registered in a defect list as unreliable or uncorrectable

Note 1 to entry: See ISO/IEC 30190, and ISO/IEC 30191.

[SOURCE: ISO/IEC 30190:2021, 3.6, modified — Note 1 to entry has been added.]

4 Quality of optical disk

4.1 Types and quality indicators of optical disk (CD, DVD and BD)

The types and quality indicators of typical CD, DVD and BD disks are shown in [Table 1](#).

Table 1 — Types and quality indicators of typical optical disks

Type of optical disk		Recording layer	Number of layers	Capacity	Typical quality indicator ^a
CD	CD-ROM	Read-only	1	640 MB / 700 MB	C1 error ^b
	CD-R	Write-once			
DVD	DVD-ROM	Read-only	1	4,7 Gbytes	PI SUM 8 ^c
	DVD-R	Write-once	2	8,5 Gbytes	
	DVD+R				
BD	BD-ROM	Read-only	1	25 Gbytes	RSER ^d and burst error ^e
			2	50 Gbytes / 66 Gbytes	
			3	100 Gbytes	
	BD recordable disk	Write-once	1	25 Gbytes	
			2	50 Gbytes	
			3	100 Gbytes	
		4	128 Gbytes		
		3, both sides	200 Gbytes		

NOTE JIS Z 6017 is used as a method for long-term storage of digitized documents using writable CD, DVD and BD disks, and ISO/IEC 29121 is used for data migration methods.

^a The test parameters specified in [6.2.2](#) are used for the quality discrimination method for each type of optical disk.

^b C1 error is the number of errors as defined in ISO/IEC 10149.

^c PI SUM 8 is the PI error count as defined in ISO/IEC 16448.

^d RSER is the random symbol error rate as defined in ISO/IEC 30190.

^e Burst error is the sum of the lengths of burst errors as defined in ISO/IEC 30190.

4.2 Lifetime estimation of optical disks

The lifetime of an optical disk shall be estimated in accordance with the test method specified in ISO/IEC 16963, with the following conditions.

- Controlled storage-condition (temperature, $T = 25 \text{ }^\circ\text{C}$ and relative humidity, $R_H = 50 \text{ \%}$) as the ambient storage-condition for the lifetime estimation.

- 95 % lower confidence bound of B_5 Life [= $(B_5 \text{ Life})_L$] for the maximum-likelihood method with the least squares method, or the point estimates of the 5th percentile with variation (= B_{5V} Life) for the acceleration-factor method, as the lifetime estimation.

5 Recordable optical disk and drive used for long-term data preservation

5.1 General

This clause specifies the requirements for long-term data preservation using optical disks with regard to recordable optical disks and drives used for recording. By adopting a combination of high quality recordable optical disks and drives dedicated to long-term storage, deterioration of recorded data quality can be reduced during long-term data preservation.

5.2 Recordable optical disk used for long-term data preservation

Use the recordable optical disk which is designed for long-term data preservation, the lifetime of which is estimated by the test method specified in [4.2](#). It is also recommended that the disk be selected by screening inspection of defects at the shipment.

5.3 Drive used for long-term data preservation

Use the drive which is equipped with a control program that optimizes the recording characteristics according to the optical disk to be used.

The rotation control method of the optical disk during recording shall be a constant linear velocity (CLV), and the linear velocity shall be the speed specified or recommended by the combination of the recordable optical disk and the drive for recording.

5.4 Combination of recordable optical disk and drive

Adopt the combination of the recordable optical disk specified in [5.2](#) and the drive specified in [5.3](#) and confirm that the recording quality meets the criteria specified in [6.3](#). For when defect management is applied on a BD recordable disk specified by ISO/IEC 30190 or ISO/IEC 30191, the operating method and test parameters specified in [Annex A](#) shall be adopted to confirm the recording quality criteria in [6.3](#).

6 Quality discrimination method for recordable optical disk

6.1 General

This clause specifies the test method for quality discrimination and the quality criteria for recordable optical disks for long-term data preservation.

6.2 Test method

6.2.1 Preparation for test

Before conducting the test, the optical disk should be checked for dust, fingerprints and other stains. If there is dirt, remove it according to the handling method specified in [Clause 9](#). Microscopic observation can reveal physical deterioration such as detachment of the protective coating and small holes.

6.2.2 Test parameters

The data error parameters used in the test are as follows.

- For CD-R specified by ECMA-394, measure the maximum C1 error (Max C1).