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Quality discrimination method for optical disks and operating method of storage systems for long-term data preservation

Standard

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Introduction

In 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, 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 Ecma standard 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 Ecma standard, recordable (write-once) 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 Ecma standard 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 Ecma standard 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 Ecma standard, the possibility of data restoration from the optical disk can be continuously monitored. Using this Ecma standard, 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 forward greater sophistication can be expected.

This 2nd edition introduces a few changes of editorial nature to be fully aligned with ISO/IEC 18630:2023.

This Ecma Standard was developed by Technical Committee 31 and was adopted by the General Assembly of June 2024.

Quality discrimination method for optical disks and operating method of storage systems for long-term data preservation

1 Scope

This Ecma standard 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 Ecma standard 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;

— 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 defect management.

2 Conformance

An optical disk applied to this document shall be in conformance with all the corresponding referenced document in **Clause 3** required to its format.

3 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.

ECMA-130, *Data interchange on read-only 120 mm optical data disks (CD-ROM)*

ECMA-267, *120 mm DVD - Read-only disk*

ECMA-268, *80 mm DVD - Read-only disk*

ECMA-349, *Data interchange on 120 mm and 80 mm optical disk using +R format - Capacity: 4,7 and 1,46 Gbytes per side (Recording speed up to 16X)*

ECMA-359, *80 mm (1,46 Gbytes per side) and 120 mm (4,70 Gbytes per side) DVD Recordable disk (DVD-R)*

ECMA-364, *Data interchange on 120 mm and 80 mm optical disk using +R DL format - Capacity: 8,55 and 2,66 Gbytes per side (Recording speed up to 16X)*

ECMA-382, *120 mm (8,54 Gbytes per side) and 80 mm (2,66 Gbytes per side) DVD recordable dsk for dual layer (DVD-R for DL)*

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

ECMA-396, *Test method for the estimation of lifetime of optical disks for long-term data storage*

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*

4 Terms and definitions

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

4.1
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 See ECMA-130, ECMA 394 and ECMA-396.

4.2
maximum PI SUM 8
Max PI SUM 8
maximum parity of inner code (PI) error count at any consecutive 8 *ECC* (4.7) blocks in one of the relevant areas on a DVD, measured at the first pass of the decoder before correction

NOTE See ECMA-267, ECMA-268, ECMA-349, ECMA-359, ECMA-364, and ECMA-382.

4.3
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 See ISO/IEC 30190, and ISO/IEC 30191.
NOTE 2 Maximum RSER shall be measured by averaging over any *N* consecutive LDC 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 Ecma standard, the number of *N* shall be 10 000 and when *defect management* (4.16) is applied, the number of *N* shall be 10 000 at maximum.

4.4
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 See ISO/IEC 30190, and ISO/IEC 30191.

NOTE 2 The number of burst errors is not covered in this Ecma standard.

4.5
error rate
rate of data errors on the recorded disk measured before error correction is applied

4.6
uncorrectable error
error in the read-out data that cannot be corrected by the error correction decoders

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

4.7
error correction code
ECC
mathematical computation yielding check bytes used for the detection and correction of errors in data

4.8
long distance code
LDC
error correction code (4.7) that increases the correction ability by increasing the code length and assigning more inspection symbols

NOTE 1 LDC is used in BD disks.
NOTE 2 See ISO/IEC 30190, and ISO/IEC 30191.

4.9
initial quality test
verification test of the data quality recorded on an optical disk before storing

4.10
periodic quality test
periodic test of the data quality recorded on an optical disk during preservation period

4.11
constant linear velocity
CLV
rotation control method of optical disk that keeps the linear velocity constant

4.12
data migration
process to copy data from one storage device or medium to another

4.13
lifetime
time that information is retrievable in a *system* (4.15)

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

4.14
preservation period
period during which an optical disk has been stored since data was recorded

4.15
system
combination of hardware, software, storage medium, and documentation used to record, retrieve, and reproduce information

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

4.16
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.]

4.17
defective cluster
cluster in a user-data area that has been registered in a defect list as unreliable or uncorrectable

NOTE See ISO/IEC 30190, and ISO/IEC 30191.

[SOURCE: ISO/IEC 30190:2021, 3.6, modified – NOTE has been added

5 Quality of optical disk

5.1 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 2	4.7 Gbytes 8.5 Gbytes	PI SUM 8[c]
	DVD-R	Write once			
	+R				
BD	BD-ROM	Read only	1 2 3	25 Gbytes 50 Gbytes / 66 Gbytes 100 Gbytes	RSER[d] and burst error[e]
	BD recordable disk	Write once	1 2 3 4 3, both sides	25 Gbytes 50 Gbytes 100 Gbytes 128 Gbytes 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 7.2.2 are used for the quality discrimination method for each type of optical disk.

[b] C1 error is the number of errors as defined in ECMA-130.

[c] PI SUM 8 is the PI error count as defined in ECMA-267.

[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.

5.2 Lifetime estimation of optical disks

The lifetime of an optical disk shall be estimated in accordance with the test method specified in ECMA-396, with the following conditions.

— Controlled storage-condition (temperature, T = 25 °C and relative humidity, R_H = 50 %) 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 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.

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

6.1 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.

6.2 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 5.2. It is also recommended that the disk be selected by screening inspection of defects at the shipment.

6.3 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.

6.4 Combination of recordable optical disk and drive

Adopt the combination of the recordable optical disk specified in 6.2 and the drive specified in 6.3 and confirm that the recording quality meets the criteria specified in 7.3. 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 7.3.

7 Quality discrimination method for recordable optical disk

7.1 General

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

7.2 Test method

7.2.1 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 10. Microscopic observation can reveal physical deterioration such as detachment of the protective coating and small holes.

7.2.2 Test parameters

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

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

b) For DVD-R specified by ECMA-359 or ECMA-382, and + R disk specified by ECMA-349 or ECMA-364, measure the maximum PI SUM 8 (Max PI SUM 8).

c) For BD recordable disks specified by ISO/IEC 30190 or ISO/IEC 30191, measure the maximum random symbol error rate (Max RSER) and the maximum burst error (Max BE). In the case that defect management is applied, measure the Max RSER and the Max BE after data replacement (see Annex A).

7.2.3 Recording method of optical disk for test

The optical disk used for the test shall be recorded by the drive for which combination quality is confirmed as shown in 6.3 and 6.4, using the optimum conditions determined by the optical disk manufacturer and the drive manufacturer.

It is recommended to record the entire user data area of the optical disk with arbitrary user data, but 3 zones may be specified for the inner radius, middle radius, and outer radius depending on the radial position of the optical disk (for example, 25 mm, 40 mm, and 55 mm, each 5 mm width etc.). For multi-layer optical disks, record all recording layers.

7.2.4 Playback evaluation drive

The recorded optical disk shall be tested with a reference drive conforming to the specifications of ECMA-394 for CD-R, of ECMA-359 or ECMA-382 for DVD-R, of ECMA-349 or ECMA-364 for +R and of ISO/IEC 30190 or ISO/IEC 30191 for BD recordable disks, or a playback evaluation drive with equivalent data error detection performance. In the evaluation, the test is performed by installing a reference drive or a playback evaluation drive under the following environmental conditions.

— temperature: 15 °C to 30 °C
— relative humidity: 20 % to 75 %

The playback evaluation drive is required to confirm a certain correlation with the playback characteristics of the reference drive, by using a reference disk or a calibration disk that conforms to the reference disk prepared by the manufacturer. The same applies to a playback evaluation drive that doubles as a recording drive.

7.3 Quality classification by data error testing

The quality grade of the optical disk in Table 2 is determined by combining the test results of data errors specified in 7.2.2 and the results of the lifetime estimation test specified in 5.2.

For the test of data errors, record data in accordance with 7.2.3 and use the playback evaluation drive specified in 7.2.4 as follows.

a) Test the entire area where the data is recorded. If recording zones are specified in 7.2.3, test the recording areas of those zones. For multi-layer optical disks, inspect all recorded layers.

b) The testing value shall be the maximum value in the test area(s).

Table 2 — Quality criteria of recordable optical disks

Quality grade	Type of optical disk			Estimate value of lifetime
	CD-R	DVD-R, +R	BD recordable disk	
	Test parameter			
	Max C1	Max PI SUM 8	Max RSER[a] and Max BE[b]	
Grade10	Less than 110	Less than 140	Less than $5{,}0\times10^{-4}$ and less than 800 bytes	10 years or more
Grade30	Less than 80	Less than 100	Less than $3{,}5\times10^{-4}$ and less than 800 bytes	30 years or more
Grade100	Less than 80	Less than 100	Less than $3{,}5\times10^{-4}$ and less than 800 bytes	100 years or more

[a] RSER = random symbol error rate
[b] BE = burst error

8 Quality test of recordable optical disk and operation of long-term storage systems

8.1 General

This clause specifies a quality test and operating method for storage systems for long-term data preservation using a recordable optical disk.

a) Users shall use optical disks and drives that satisfy the provisions of Clause 6 and a playback evaluation drive as specified in 7.2.4 to operate long-term storage systems.

b) Even if the quality grade of the optical disk has been confirmed, when the storage period of a blank disk exceeds the disk supplier's recommendation, the recording characteristics can have changed due to the influence of the environment, so it is recommended not to use it.

c) Before recording and playback, it is recommended to check that the recording surface of the optical disk is free of dirt and dust. If dirt or dust is present, it should be removed properly according to Clause 10.

d) When recording is intended in an environment that is a significantly different temperature and humidity from the environment in which the optical disk was stored, the angular deviation of the optical disk can change, so it is recommended to leave the optical disk for a sufficient time in the recording environment before recording.

8.2 Initial quality test

The recorded optical disk shall be measured for data errors specified in 7.2.2 using a playback evaluation drive as specified in 7.2.4 before storing. The initial quality is determined according to the quality grade from Table 2.

The initial quality test shall be as follows.

a) Test the entire area where the data was recorded. For multi-layer optical disks, test all recorded layers. The test result value shall be the maximum value within the test area of the optical disk.

b) Inspect all recorded optical disks.

c) If the test result does not meet the quality criteria specified in Table 2 or an uncorrectable error occurs in the data area, recreate it.

   If dirt, dust, etc. on the recording surface of the optical disk are properly removed according to Clause 10 and it is confirmed that the quality criteria are met by retesting, there is no need to recreate.

d) All test results (error distribution on optical disks, etc.), recording speed and inspection speed shall be recorded in the management ledger and used as judgment data for data migration during the preservation period.

8.3 Periodic quality test

The stored optical disk is periodically tested for data errors specified in 7.2.2 using a playback evaluation drive as specified in 7.2.4, and the quality shall be judged by Table 3 or Table 4 corresponding to the quality grade of the optical disk.

a) For the disk to be inspected, test the entire area where the data was recorded. For multi-layer optical disks, test all recorded layers. The test result value shall be the maximum value within the test area.

b) Perform a sampling test from the stored optical disks with the same recording conditions (lot). For lots whose sampling test results are Category 2 or Category 3, it is recommended to test all of them.

c) If Category 3 occurs, take immediate measures i.e, recreate it. In the case of Category 2, it will be recreated within one year.
   If dirt, dust, etc. on the recording surface of the optical disk are properly removed according to Clause10 and it is confirmed that Category 1 is satisfied by re-inspection, there is no need to recreate it.

d) The frequency of the periodic performance test should be approximately every 5 years, and should be determined according to the preservation plan of the data to be stored.

   The periodic performance test interval can be changed according to the quality grade of the optical disk used. Regarding changes, it is recommended to conform to ISO/IEC 29121.

NOTE There is a complicated failure mechanism in the deterioration of the data quality recorded on the optical disk. The lifetime of an optical disk depends not only on storage temperature and humidity, but also on many other factors such as light exposure, corrosive gases, dirt, handling, and drives for playback. As a result, when the storage environment is harsh, it is necessary to increase the frequency of periodic quality tests. In other words, the frequency of periodic quality tests depends on both the quality of the optical disk and the storage environment.

e) All test results (error distribution on optical disks, etc.), recording speed and inspection speed shall be recorded in the management ledger. When migrating data, record the work contents in the management ledger.

Table 3 — Data error classification for periodic quality test (Grade10)

Category		Media type		
		CD-R	**DVD-R, +R**	**BD recordable disk**
		Test parameter		
		Max C1	**Max PI SUM 8**	**Max RSER[a]** and **Max BE[b]**
1	In good condition	Less than 160	Less than 200	Less than $7{,}1\times10^{-4}$ and less than 1 200 bytes
2	Measures within one year	160 or more and less than 220	200 or more and less than 280	$7{,}1\times10^{-4}$ or more and less than $1{,}0\times10^{-3}$ and/or 1 200 bytes or more and less than 1 900 bytes
3	Immediate measures	220 or more	280 or more	$1{,}0\times10^{-3}$ or more and/or 1 900 bytes or more

[a] RSER = random symbol error rate.
[b] BE = burst error.

Table 4 — Data error classification for periodic quality test (Grade30 and Grade100)

Category		Media type		
		CD-R	**DVD-R, +R**	**BD recordable disk**
		Test parameter		
		Max C1	**Max PI SUM 8**	**Max RSER[a]** and **Max BE[b]**
1	In good condition	Less than 110	Less than 140	Less than $5{,}0\times10^{-4}$ and less than 1 200 bytes
2	Measures within one year	110 or more and less than 220	140 or more and less than 280	$5{,}0\times10^{-4}$ or more and less than $1{,}0\times10^{-3}$ and/or 1 200 bytes or more and less than 1 900 bytes
3	Immediate measures	220 or more	280 or more	$1{,}0\times10^{-3}$ or more and/or 1 900 bytes or more

[a] RSER = random symbol error rate.
[b] BE = burst error.

9 Quality test of read-only optical disk and operation of long-term storage systems

9.1 General

This clause specifies a quality test and operating method for storage systems for long-term data preservation using a read-only optical disk.

9.2 Initial quality test

9.2.1 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 10.

9.2.2 Test parameters

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

a) For CD-ROM specified by ECMA-130, measure the maximum C1 error (Max C1).

b) For DVD-ROM specified by ECMA-267 or ECMA-268, measure the maximum PI SUM 8 (Max PI SUM 8).

c) For BD-ROM, measure the maximum random symbol error rate (Max RSER) and maximum burst error (Max BE) .

NOTE ISO/IEC 30190, ISO/IEC 30191 and Reference [6] contain further information on the random symbol error rate and burst error.

9.2.3 Playback evaluation drive

The optical disk shall be tested with a reference drive conforming to the specifications of ECMA-130 for CD-ROM, of ECMA-267 or ECMA-268 for DVD-ROM and of ISO/IEC 30190 or ISO/IEC 30191 for BD-ROM, or a playback evaluation drive with equivalent data error detection performance. In the evaluation, the test is performed by installing a reference drive or a playback evaluation drive under the following environmental conditions.

— temperature: 15 °C to 30 °C
— relative humidity: 20 % to 75 %

The playback evaluation drive is required to confirm that there is a certain correlation with the playback characteristics of the reference drive, by using a reference disk or a calibration disk that conforms to the reference disk prepared by the manufacturer. The same applies to a playback evaluation drive that doubles as a recording drive.

9.2.4 Test operation

Before storing, the optical disk shall be measured for data errors as specified in 9.2.2 using the playback evaluation drive as specified in 9.2.3 and the initial quality shall be determined using Table 5.

The initial quality test shall be as follows.

a) Test the entire area where the data exist. For multi-layer optical disks, test all layers. The test result value shall be the maximum value within the test area of the optical disk.

b) Inspect all optical disks to be stored.

c) If Category 3 conditions occur (see Table 5), take immediate measures i.e. obtain another copy of the same disk, or the data may be migrated to a recordable optical disk according to the means specified in Clause 6, 7 and 8 when the data can be retrieved. In the case of Category 2 conditions, take measures within one year.

If dirt, dust, etc. on the recording surface of the optical disk are properly removed according to Clause 10 and it is confirmed that Category 1 conditions are satisfied by re-testing, there is no need to take measures.

d) All test results (error distribution on optical disks, etc.) and inspection speed shall be recorded in the management ledger as judgment data for taking measures during the preservation period. When migrating data to recordable optical disks, record the work contents in the management ledger.

Table 5 — Data error classification for quality test of read-only optical disk

Category		Media type		
		CD-ROM	**DVD-ROM**	**BD-ROM**
		Test parameter		
		Max C1 error	**Max PI SUM 8**	**Max RSER[a]** and **Max BE[b]**
1	In good condition	Less than 110	Less than 140	Less than $5{,}0\times10^{-4}$ and less than 1 200 bytes
2	Measures within one year	110 or more and less than 220	140 or more and less than 280	$5{,}0\times10^{-4}$ or more and less than $1{,}0\times10^{-3}$ and/or 1 200 bytes or more and less than 1 900 bytes
3	Immediate measures	220 or more	280 or more	$1{,}0\times10^{-3}$ or more and/or 1 900 bytes or more

[a] RSER = random symbol error rate.
[b] BE = burst error.

9.3 Periodic quality test

The stored optical disk is periodically tested for data errors as specified in 9.2.2 using a playback evaluation drive as specified in 9.2.3. The disk quality is determined using Table 5.

a) For the disk to be inspected, test the entire area where the data exists. For multi-layer optical disks, test all layers. The test result value shall be the maximum value within the test area.

b) If Category 3 conditions occur, take immediate measures, i.e. obtain another copy of the same disk, or the data may be migrated to a recordable optical disk according to the means specified in Clause 6, 7 and 8 when the data can be retrieved. In the case of Category 2 conditions, take measures within one year.

If dirt, dust, etc. on the recording surface of the optical disk are properly removed according to Clause 10 and it is confirmed that Category 1 conditions are satisfied by re-testing, there is no need to take measures.

c) The frequency of the periodic quality test should be about every 5 years. The frequency should be determined according to the preservation plan of the optical disks.

NOTE There is a complicated failure mechanism in the deterioration of the data quality on the optical disk. The lifetime of an optical disk depends not only on storage temperature and humidity, but also on many other factors such as light exposure, corrosive gases, dirt, handling, and drives for playback. As a result, when the storage environment is harsh, it is necessary to increase the frequency of periodic quality tests. In other words, the frequency of periodic quality tests depends on both the quality of the optical disk and the storage environment.

d) All test results (error distribution on optical disks, etc.) and inspection speed shall be recorded in the management ledger as judgment data for taking measures during the preservation period. When migrating data to recordable optical disks, record the work contents in the management ledger.

10 Handling and storage of optical disks

Precautions regarding the handling method and storage of optical disks are as follows.

a) When holding an optical disk, hold your index finger in the centre hole and your thumb on the outer circumference to prevent fingerprints from sticking to the surface of the optical disk.

b) If the recording surface becomes dirty or dusty, wipe it gently with a soft cloth such as a cloth for eyeglasses so that it will not be scratched. When wiping, wipe straight from the inside to the outside (from the centre of the optical disk to the outer circumference).

c) When writing a title etc. on the label side with a pen, use a soft felt-tip pen.

d) Avoid sticking labels, stickers, etc. on the label side of an optical disk because there is a risk of causing playback troubles or equipment failure.

e) When printing a label using an inkjet printer, make sure that the ink used is sufficiently dry. Do not touch until the ink dries.

f) Do not allow condensation on the optical disk. If there is a risk of dew condensation, warm to room temperature before use.

g) Avoid direct sunlight and store in a dust-free environment as far as possible.

h) When storing an optical disk, put it in a case.

i) The storage environment for optical disks is as follows.

   1) In an office storage environment, it is recommended to store at a temperature of 5 °C to 30 °C and a relative humidity of 15% to 80%.

   2) In a long-term storage environment, it is recommended to store at a temperature of 10 °C to 25 °C and a relative humidity of 40% to 60%.

Annex A
(normative)

Defect management on BD recordable disk

A.1 General

This annex specifies an operating method and test parameters for when defect management (DM) is applied on a BD recordable disk specified by ISO/IEC 30190 or ISO/IEC 30191.

NOTE References [4] and [5] contain further technical information.

By adopting DM which replaces defective clusters with spare clusters, reliability improvement can be expected for long-term preservation usage, in terms of improving the initial recording quality and reducing the possibility of deterioration of recorded data quality due to defect growth during the preservation period.

A.2 DM operation

When DM is applied, the spare area shall be defined in the data zone at disk formatting. The spare area is composed of an additional temporary disk management area (ATDMA) and spare clusters as shown in Figure A.1. In this Ecma standard, the spare area should be allocated in accordance with Table A.1.

NOTE The values in Table A.1 are recommended by INF-TA-1010[4] as the default setting.

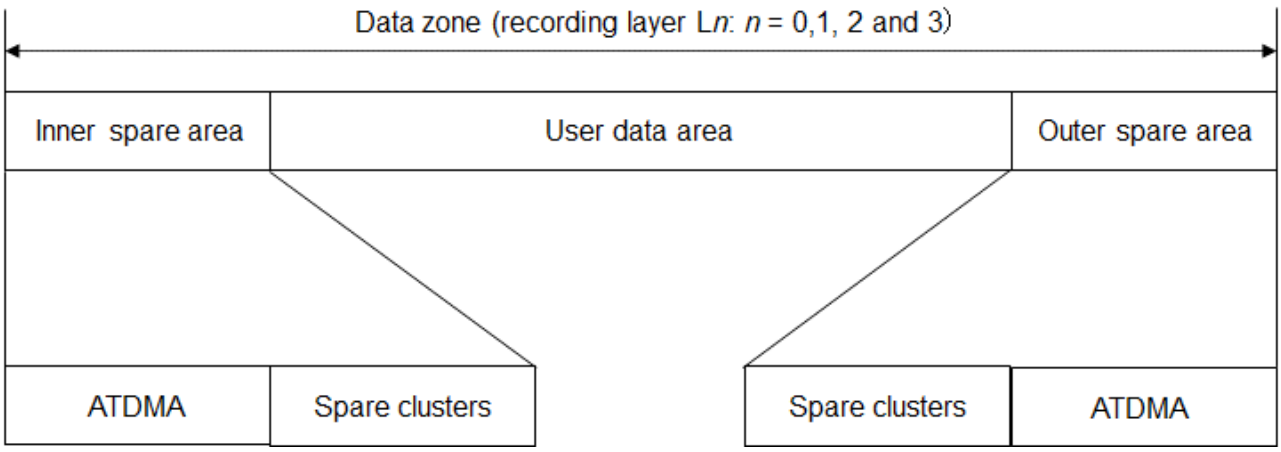

Figure A.1 — Spare area allocation on BD recordable disk

Table A.1 — Number of clusters in each spare area

Disk type	Spare area per recording layer			
	Area	**Spare cluster**	**ATDMA**	**Total**
Single layer	Inner spare area (L0)	2 048	2 048	4 096
	Outer spare area (L0)	4 096	4 096	8 192
Dual layer	Inner spare area (L0 and L1)	2 048	2 048	4 096
	Outer spare area (L0 and L1)	4 096	4 096	8 192
Triple layer	Inner spare area (L0, L1 and L2)	4 096	4 096	8 192
	Outer spare area (L0, L1 and L2)	4 096	4 096	8 192
Quadruple layer	Inner spare area (L0, L1, L2 and L3)	4 096	4 096	8 192
	Outer spare area (L0, L1, L2 and L3)	4 096	4 096	8 192
NOTE This table is adapted from Reference [4].				

A.3 Test parameters after DM adoption

After replacing defective clusters in the test area with spare clusters and combining them with the other non-defective clusters, measure the maximum random symbol error rate (Max RSER) and maximum burst error (Max BE) (see **7.2.2**).

Bibliography

[1] ISO/IEC 17345:2006, Information technology — Data Interchange on 130 mm Rewritable and Write Once Read Many Ultra Density Optical (UDO) Disk Cartridges — Capacity: 30 Gbytes per Cartridge — First Generation

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[3] JIS Z 6017, Document management — Long term preservation for electronic imaging document

[4] INF-TA-1010 Specification for Information Document for Mt. Fuji Commands for Multimedia Devices

[5] White Paper Blu-ray Disc™ Format 1. B Physical Format Specifications for BD-R 7th Edition, August 2015

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