
Information technology — Digitally recorded media for information interchange and storage — Data migration method for optical disks for long-term data storage

Technologies de l'information — Supports enregistrés numériquement pour échange et stockage d'information — Méthode de migration de données pour disques optiques pour le stockage à long terme

ISO/IEC 29121:2018

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ISO copyright office
CP 401 • Ch. de Blandonnet 8
CH-1214 Vernier, Geneva
Phone: +41 22 749 01 11
Fax: +41 22 749 09 47
Email: copyright@iso.org
Website: www.iso.org

Published in Switzerland

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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.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

For an explanation on the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT) see the following URL: www.iso.org/iso/foreword.html.

This document was prepared by Technical Committee ISO/IEC JTC 1, *Information technology*, Subcommittee SC 23, *Digitally Recorded Media for Information Interchange and Storage*.

This third edition cancels and replaces the second edition (ISO/IEC 29121:2013), which has been technically revised.

The main changes compared to the previous edition are as follows:

- CD-R, CD-RW, BD-Recordable and BD Rewritable disks have been added as the optical disks for long-term data storage applicable in this document, and accordingly, the title of this document has been changed.
- Terminologies have been harmonized with those used in ISO/IEC 16963 and relevant updates in the latest version of ISO/IEC 16963 have been reflected.
- ISO/IEC 16963 has been moved from the Normative references clause to the Bibliography at publication stage in order to conform to the requirements from the ISO/IEC Directives Part 2.
- Minor editorial changes have been made to conform to the latest version of ISO/IEC Directives Part 2.

Introduction

Many organizations now use optical disks for long-term storage of information. It is assumed that a disk selected for recording has already been qualified for that purpose. It is therefore important to be able to verify that data have been recorded correctly and remains readable for the required amount of time. Previous International Standards clearly defined requirements for interchange, but did not contain requirements for longevity.

Longevity is limited both by disk degradation and by technology obsolescence. Interchange is regularly verified to assure that information on existing recorded disks will continue to be recoverable. Users can have a maintenance policy that protects disks against unanticipated failure or use, such as by making one copy, another to function as a backup or master and another for routine access. Hardware-support life cycles typically vary between five to ten years, and technology life cycles usually end after 20 years. Consequently, recordings that require a longer life cycle may have to be transferred to upgraded platforms every 10 to 30 years.

Optical disks for long-term storage should be evaluated. Significant longevity differences can exist for disks from different manufacturers and even between disks from the same manufacturer. It is preferable that disks selected for long-term preservation should have a long estimated lifetime, which can be estimated according to ISO/IEC 16963.

Disks with initially poor quality do not offer sufficient headroom and can reach the unrecoverable-error threshold before the next scheduled inspection, which is to be avoided for long-term data storage. This means that a disk of high initial recorded quality that maintains this condition for life is expected to have superior longevity.

Because read data are corrected (by an error-correction decoder), it is impossible to detect degradation without detecting the raw error rate or raw error number. The raw error can be detected with a standard test drive. The quality of the disk can be specified as the number of erroneous inner-parity detections with DVD-R, DVD-RW, +R and +RW disks. The quality of a DVD-RAM disk is defined instead by its byte error rate. Deterioration can be monitored by checking the raw error numbers and continues to be monitored. Methods described in this document define a quality-control policy that can non-destructively identify degradation, and thereby support timely and effective corrective action.

DVD-R, DVD-RW, DVD-RAM, +R and +RW disks are based on the technology now widely known as DVD in the market. This entails the use of red laser diodes, two 0,6-mm thick substrates bonded together by an adhesive layer to protect the recording layer from dust, write-once (DVD-R, +R) or phase-change recording layers (DVD-RW, DVD-RAM, +RW) and a 0,60 or 0,65 NA objective lens to ensure good spatial margins required for a professional data preservation. Disks having dual recording layers with a spacer between them are used in addition to those with a conventional single recording layer.

After the issuance of the previous edition of this document, ISO/IEC standards for the physical format of BD Recordable and Rewritable disks were published in 2013. ISO/IEC 16963 was also updated to include testing of BD Recordable and Rewritable disks in 2015. Accordingly, ISO/IEC JTC 1/SC 23 started work to include BD Recordable and Rewritable disks in this document and held joint discussions with Ecma International TC31. The BD data migration part of this work was standardized separately by Ecma International as ECMA-413, along with contributions from the Japanese national committee of SC 23. CD-R and CD-RW disks included in ISO/IEC 16963 are also incorporated.

ISO/IEC 16963 was initially listed as a normative reference in this document to introduce the lifetime estimation method. However, as the application of this method is strongly recommended as opposed to required, ISO/IEC 16963 was moved from the Normative references clause to the Bibliography for conformance with the ISO/IEC Directives Part 2.

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Information technology — Digitally recorded media for information interchange and storage — Data migration method for optical disks for long-term data storage

1 Scope

This document specifies the data migration method for DVD-R, DVD-RW, DVD-RAM, +R, +RW, CD-R, CD-RW, BD Recordable and BD Rewritable disks for long-term data storage. By applying this document for information storage, digital data can be migrated to a next new disk without loss from the present disk as long as data errors are completely corrected before and during the migration and provided copying of the data is allowed.

This document specifies:

- a data migration method for long-term data storage;
- test methods including test parameters, test area, test drive, disk preparation and test execution;
- an initial performance test and a periodic performance test that check a readability of the data recorded on the disks with categorized Maximum Data Error tables; and
- a necessity of precaution to reduce the possibility of deterioration in order to assure the integrity of the disks during their use, storage, handling or transportation.

This document offers guidelines to use disks with estimated lifetime of B_{mig} ($B_{0,000\ 1}$) Life which is introduced using B_5 Life and B_{50} Life specified in ISO/IEC 16963.

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 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 13170, *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)*

ISO/IEC 17341, *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)*

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

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 17592, *Information technology — 120 mm (4,7 Gbytes per side) and 80 mm (1,46 Gbytes per side) DVD rewritable disk (DVD-RAM)*

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)*

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ISO/IEC 26925, *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)*

ISO/IEC 29642, *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)*

ISO/IEC 30190:2016, *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 30191:2015, *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*

ISO/IEC 30192, *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 Rewritable disk*

ISO/IEC 30193, *Information technology — Digitally recorded media for information interchange and storage — 120 mm Triple Layer (100,0 Gbytes per disk) BD Rewritable disk*

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

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

3 Terms and definitions Teh STANDARD PREVIEW

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

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

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

3.1

B_{mig} Life

B_{mig}

lifetime (3.9) for use of *data migration* (3.5) and identical to $B_{0,000\ 1}$ Life which is 0,000 001 quantile of the lifetime distribution (i.e. 0,000 1 % failure time) or 99,999 9 % survival lifetime

Note 1 to entry: See [Annex E](#).

3.2

B_5 Life

5 percentile of the *lifetime* (3.9) distribution (i.e. 5 % failure time) or 95 % survival lifetime

[SOURCE: ISO/IEC 16963:2017, 3.4]

3.3

$(B_5 \text{ Life})_L$

95 % lower confidence bound of B_5 Life

[SOURCE: ISO/IEC 16963:2017, 3.5]

3.4

B_{50} Life

50 percentile of the *lifetime* (3.9) distribution (i.e. 50 % failure time) or 50 % survival lifetime

[SOURCE: ISO/IEC 16963:2017, 3.6]

3.5**data migration**

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

3.6**Error Correction Code****ECC**

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

Note 1 to entry: For DVD-R, DVD-RW, DVD-RAM, +R and +RW disks, the Reed-Solomon product code defined in ISO/IEC 16448 for DVD-ROM systems is applied. For BD Recordable and BD Rewritable disks, the Long Distance Code (LDC) + Burst-Indicating Subcode (BIS) defined in ISO/IEC 30190, ISO/IEC 30191, ISO/IEC 30192 and ISO/IEC 30193 is applied. For CD-R and CD-RW disks, the Cross Interleaved Reed-Solomon Code (CIRC) and the Reed-Solomon Product-like Code (RSPC) defined in ISO/IEC 10149 are applied.

3.7**error rate**

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

3.8**initial performance test**

test of the recording performance of data recorded on a disk before storing

3.9**lifetime**

time that information is retrievable in a system (3.18)

3.10**Max BER**

maximum byte *error rate* (3.7) at any consecutive 32 *ECC* (3.6) blocks on a disk as measured in the first pass of the decoder before correction ISO/IEC 29121:2018

Note 1 to entry: Max BER is applied to DVD-RAM disks. <https://standards.iteh.ai/catalog/standards/sist/39725ed5-7c70-4018-a185-d85ccc4906c2/iso-iec-29121-2018>

3.11**Max C1 Ave 10**

maximum number of C1 errors per second before error correction averaged over any 10 s

Note 1 to entry: See ISO/IEC 10149, ECMA-394 and ECMA-395.

3.12**Maximum Data Error**

greatest level of data error measured anywhere in one of the relevant areas on the disk

[SOURCE: ISO/IEC 16963:2017, 3.13, modified — Note 1 to entry has been deleted.]

3.13**Max PI SUM 8**

maximum Parity of Inner (PI) code error count at any consecutive 8 *ECC* (3.6) blocks on a disk as measured in the first pass of the decoder before correction

Note 1 to entry: See ISO/IEC 16448, ISO/IEC 23912, ISO/IEC 17341, ISO/IEC 17342 and ISO/IEC 17344.

3.14**Max RSER**

maximum Random Symbol Error Rate before error correction, which excludes burst errors of length greater than or equal to 40 bytes

Note 1 to entry: See ISO/IEC 30190, ISO/IEC 30191, ISO/IEC 30192, ISO/IEC 30193 and ISO/IEC 16963.

3.15

periodic performance test

periodic test of the recording performance of data recorded on a disk during the storage

3.16

retrievability

ability to recover physical information as recorded

3.17

storage time

time that a disk is being stored since data are recorded on the disk

3.18

system

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

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

3.19

uncorrectable error

error in the playback data that could not be corrected by the error correcting decoders

3.20

X_{mig} Life

X_{mig}

migration interval (year) which is determined by the user

Note 1 to entry: See [Annex F](#).

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4 Test method

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4.1 Test parameters

For DVD-R disk defined in ISO/IEC 12862 and ISO/IEC 23912, DVD-RW disk defined in ISO/IEC 13170 and ISO/IEC 17342, +R disk defined in ISO/IEC 17344 and ISO/IEC 25434, and +RW disk defined in ISO/IEC 17341, ISO/IEC 26925 and ISO/IEC 29642, the maximum inner-parity error shall be measured at any consecutive 8 ECC blocks (Max PI SUM 8) in the first pass of the decoder before correction.

For a DVD-RAM disk defined in ISO/IEC 17592, the maximum Byte error rate (Max BER) shall be measured (see [Annex C](#)).

For CD-R disk defined in ECMA-394 and CD-RW disk defined in ECMA-395, the maximum C1 Ave 10 (Max C1 Ave 10) shall be measured.

For BD Recordable disk defined in ISO/IEC 30190 and ISO/IEC 30191 and BD Rewritable disk defined in ISO/IEC 30192 and ISO/IEC 30193, the maximum Random Symbol Error Rate (Max RSER) shall be measured (see [Annex H](#)).

4.2 Test area

The test area for the initial performance test shall be the whole recorded area of all disks.

The test area for the periodic performance test should be the whole recorded area of all disks (see [Annex G](#)).

4.3 Test drive

4.3.1 General

For DVD-R disks defined in ISO/IEC 12862 and ISO/IEC 23912, the test drive shall comply with each standard. For DVD-RW disks defined in ISO/IEC 13170 and ISO/IEC 17342, the test drive shall comply with each standard. For +R disks defined in ISO/IEC 17344 and ISO/IEC 25434, the test drive shall comply with each standard. For +RW disks defined in ISO/IEC 17341, ISO/IEC 26925 and ISO/IEC 29642, the test drive shall comply with each standard. The test drive shall have the capability to measure Max PI SUM 8.

For DVD-RAM disk, the test drive shall comply with ISO/IEC 17592. The test drive shall have the capability to measure Max BER.

For CD-R and CD-RW disks, the test drive shall comply with ECMA-394 and ECMA-395, respectively. The test drive shall have the capability to measure Max C1 Ave 10.

For BD Recordable disks defined in ISO/IEC 30190 and ISO/IEC 30191, the test drive shall comply with each standard. For BD Rewritable disks defined in ISO/IEC 30192 and ISO/IEC 30193, the test drive shall comply with each standard. The test drive shall have the capability to measure Max RSER.

NOTE The measuring circuit for RSER described in ISO/IEC 30191 and ISO/IEC 30193 is different from that of described in ISO/IEC 30190 and ISO/IEC 30192, especially in HF signal pre-processing circuit. See ISO/IEC 30190:2016, Annex H and ISO/IEC 30191:2015, Annex H.

4.3.2 Test drive calibration

The test drive shall be calibrated by using a calibration disk prepared by the test drive manufacturer based on the calibration procedure defined by the manufacturer. The calibration shall be done at the intervals recommended by the manufacturer.

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4.4 Disk preparation

Prior to conducting tests, the disks shall be checked that no dust, fingerprints or other contaminants on them has been confirmed. If there are dust, fingerprints or other contaminants and appropriate, such contaminants shall be removed in accordance with the disk-manufacturer's recommendations. Certain options are contained in [Annex B](#). Microscopic examination can reveal physical deterioration, such as delamination and porosity of the protective coating.

4.5 Test execution

Before testing disks, the test drive shall be verified by checking the calibration disk supplied with the test drive or publicly verified. If the drive passes the calibration check, the disk to be checked shall be tested by the test drive.

On testing disks, care handling of the disks shall be taken in order to avoid introducing unexpected defects. See [Annex I](#).

Test results shall be judged by Maximum Data Error. Maximum Data Error is Max PI SUM 8 for DVD-R, DVD-RW, +R and +RW disks; Max BER for a DVD-RAM disk; Max C1 Ave 10 for CD-R and CD-RW disks and Max RSER for BD Recordable and BD Rewritable disks.

5 Test interval for periodic performance test

If estimated lifetime of the disks is known, the test interval may be determined according to the estimated lifetime; otherwise, the disks should be checked every three years or less.

In cases where the estimated lifetime is provided in accordance with ISO/IEC 16963, the disks should be checked according to [Annex E](#) and [Annex F](#).

Disks having well-defined characteristics that are stored under conditions described in [Annex B](#) are carefully handled and are read infrequently may require testing only every few years. A history of satisfactory longevity with similar disks would encourage longer intervals between testing.

The occurrence of retrievability problems or long read times may indicate a need for immediate testing.

When tests indicate deterioration of one disk, additional tests may be performed on other disks of the same type, age or lot to ascertain their condition. Replacement of all similarly affected disks should be considered if such additional tests indicate significant problems.

6 Test result evaluation

6.1 General

The readability of the data recorded on the disks is checked by the initial performance test and the periodic performance test. When data are recorded on disks, the initial recording performance shall be checked by the initial recording performance test. Depending on the test result of the initial recording test, disks are selected to be used for the long-term data storage. The performance of the recorded data on those disks should be periodically checked in the storage duration with the periodic performance test. Depending on the test result of the periodic performance test, the necessity of the data migration is judged.

6.2 Initial performance test

The initial recording performance is categorized as Level 1, 2 and 3 by Maximum Data Error as shown in [Table 1](#).

At least, the initial recording performance shall be within Level 1. Disks showing the initial recording performance of Level 2 should not be used. Disks showing the initial recording performance of Level 3 are out of the specification and shall not be used.

If the initial recording performance is worse than Level 1, the performance of the disk and drive used for recording the data should be verified because Maximum Data Error depends on the performance of both disks and drives. If the drive is not good, the drive should be replaced. If the disk is not good, another lot of disks should be used.

Table 1 — Category of initial recording performance

| Level | Status | DVD_R, DVD-RW, +R, +RW | DVD-RAM | CD-R, CD-RW | BD Recordable, BD Rewritable |
|--------------------|--------------------|------------------------|--|--------------|--|
| 1 | Recommended | <140 | $<5,0 \times 10^{-4}$ | <110 | $<5,0 \times 10^{-4}$ |
| 2 | Should not be used | 140 to 280 | $5,0 \times 10^{-4}$ to $1,0 \times 10^{-3}$ | 110 to 220 | $5,0 \times 10^{-4}$ to $1,0 \times 10^{-3}$ |
| 3 | Shall not be used | >280 | $>1,0 \times 10^{-3}$ | >220 | $>1,0 \times 10^{-3}$ |
| Maximum Data Error | | Max PI SUM 8 | Max BER | Max C1 Ave10 | Max RSER |

6.3 Periodic performance test

The recording performance at the periodic performance test is categorized in Level 4, 5 and 6 by Maximum Data Error as shown in [Table 2](#).

If the recording performance is within Level 4, the disk is good enough to continue to be used.

If the recording performance is within Level 5, the data stored on the disk shall be migrated to another disk as soon as possible.