INTERNATIONAL STANDARD

ISO/IEC 29121

Second edition
2013-11-01

Information technology — Digitally recorded media for information interchange and storage — Data migration method for DVD-R, DVD-RW, DVD-RAM, +R, and +RW disks

Technologies de l'information — Supports enregistrés numériquement pour échange et stockage d'information — Méthode de migration de données pour disques DVD-R, DVD-RW, DVD-RAM, +R, et +RW

Reference number
ISO/IEC 29121:2013(E)

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Published in Switzerland

Contents

Page

Foreword

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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 the identifying any or all such patent rights.

ISO/IEC 29121 was prepared by Joint Technical Committee ISO/IEC JTC 1, *Information technology*, Subcommittee SC 23, *Digitally recorded media for information interchange and storage*.

This second edition cancels and replaces the first edition (ISO/IEC 29121:2009), of which has been technically revised.

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 has 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 shall be 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 lifecycles usually end after 20 years. Consequently, recordings that require a longer lifecycle may have to be transferred to upgraded platforms every ten to thirty 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 shall continue to be monitored. Methods described in this International Standard 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.

Information technology — Digitally recorded media for information interchange and storage — Data migration method for DVD-R, DVD-RW, DVD-RAM, +R, and +RW disks

1 Scope

This International Standard specifies a data migration method for long-term data storage. According to the standard, manufacturers are able to construct storage systems that use DVD-R, DVD-RW, DVD-RAM, +R, or +RW disks for information storage. A user of the storage system can select disks with sufficient longevity potential, on the basis of an initial performance test, and can continuously monitor the potential for retrieving data from those disks on the basis of periodic performance test. These tests are to establish a practical estimate of the retrievability of the recorded data on a disk without producing uncorrectable errors, in response to time at controlled storage conditions to produce accelerated aging. 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.

The methodology for data migration is intended to be applied to disks with longer storage lifetime. It is recommended to use disks with estimated life time is given as a mean value and a standard deviation as specified in ISO/IEC 16963. If the estimated lifetime of the disks is known, users can determine a test interval according to the estimated lifetime. If the estimated lifetime is known as a mean value and a standard deviation, regardless of the test method for the estimation, it is recommended to carry out data migration based on this standard. If the estimated lifetime is unknown, the test interval should be three years or less. Considering the generational changeover of systems or applications, the user can determine a migration interval disregarding the estimated lifetime of the disks.

Disks with shorter estimated lifetimes have more rapid degradation and require more frequent periodic tests. In addition, degradation of recorded data occurs by complex failure mechanisms. Storage lifetime, therefore, varies depending not only on temperature and humidity but also on many other effects such as exposure to light, corrosive gases, contamination, handling, and variation in playback subsystems. Consequently, severe storage environments require more frequent periodic tests. The frequency of periodic testing also needs to be fixed based on the quality of the disks for storing data and the storage environment.

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO/IEC 16963, *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*

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

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)*

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)*

3 Terms and definitions

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

3.1
BER max
maximum byte error rate at any consecutive 32 ECC blocks on a disk as measured in the first pass of the decoder before correction

Note 1 to entry: BER max is applied to DVD-RAM disks.

3.2
B_{mig} Life
lifetime for use of data migration and same as $B_{0,000\,1}$ Life which is 0,000 001 quantile of the lifetime distribution (i.e. 0,000 1 % failure time) or 99,999 9 % survival lifetime (see Annex E)

3.3
B_5 Life
5 percentile of the lifetime distribution (i.e. 5 % failure time) or 95 % survival lifetime

3.4
$(B_5\ \text{Life})_L$
95 % lower confidence bound of B_5 Life

3.5
B_{50} Life
50 percentile of the lifetime distribution (i.e. 50 % failure time) or 50 % survival lifetime

3.6
data migration
process to copy data from one storage device or medium to another

3.7
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 16448:2002 for DVD-ROM systems is applied.

3.8
error rate
rate of errors on the recorded disk measured before error correction is applied

3.9
initial performance test
test of the recording performance of data recorded on a disk before storing

3.10
lifetime
time that information is retrievable in a system

3.11
PI SUM 8 max
maximum inner-parity (PI) error count at any consecutive 8 ECC 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.

3.12
periodic performance test
periodic test of the recording performance of data recorded on a disk during the storage

3.13
retrievability
ability to recover physical information as recorded

3.14
storage time
time that a disk is being stored since data is recorded on the disk

3.15
substrate
transparent layer of the disk, provided for mechanical support of the recording or recorded layer, through which the optical beam accesses the recordable/recorded layer

3.16
system
combination of hardware, software, storage medium, and documentation used to record, retrieve, and reproduce information

3.17
uncorrectable error
error in the playback data that could not be corrected by the error correcting decoders

3.18
X_{mig} Life
migration interval (year) which is determined by user

Note 1 to entry: See Annex F.

4 Test methods

4.1 Test parameters

For DVD-R disk defined in ISO/IEC 23912 and ISO/IEC 12862, DVD-RW disk defined in ISO/IEC 17342 and ISO/IEC 13170, +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 (PI SUM 8 max) in the first pass of the decoder before correction.

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

4.2 Test Drive

The test drive shall comply with ISO/IEC 16448 for DVD-R, DVD-RW, +R, and +R disks and ISO/IEC 17592 for DVD-RAM disks. It shall have the capability to measure PI SUM 8 max for DVD-R, DVD-RW, +R, and +RW disks and BER max for a DVD-RAM disk, respectively.

4.2.1 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.

4.2.2 Test preparation

Prior to conducting tests, the disks shall be visually examined to determine whether they contain dust, finger prints, or other contaminants. If appropriate, such contaminants shall be removed in accordance with the disk-manufacturer's recommendations. Certain options are contained in Annex A. Microscopic examination may reveal physical deterioration, such as delamination and porosity of the protective coating.

4.2.3 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.

Test results shall be judged by the PI SUM 8 max for DVD-R, DVD-RW, +R, and +RW disks or the BER max for a DVD-RAM disk.

4.3 Test area

The entire recorded area of all the disks should be tested in order to confirm the readability of the data (see Annex G).

5 Test result evaluation

5.1 Initial performance test result evaluation

When data is recorded on disks, the initial recording performance on the whole recorded area shall be checked. The initial recording performance is categorized as Level 1, 2 and 3 by PI SUM 8 max for DVD-R, DVD-RW, +R, and +RW disks and BER max for DVD-RAM as shown in Table 1 (see Annex C).

At least, the initial recording performance shall be within Level 1. Disks showing the initial recording performance of Level 2 should not be used for long-term data storage, and those 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 PI SUM 8 max and BER max depend 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
1	Recommended	< 140	$< 5{,}0 \times 10^{-4}$
2	Should not be used	140 to 280	$5{,}0 \times 10^{-4}$ to $1{,}0 \times 10^{-3}$
3	Shall not be used	> 280	$> 1{,}0 \times 10^{-3}$
Recording performance indicator		PI SUM 8 max	BER max

5.2 Periodic performance test result evaluation

Disks used for storing data should be periodically checked with the test interval described in Clause 6. The recording performance at the periodic performance test is categorized in Level 4, 5 and 6 by PI SUM 8 max for DVD-R, DVD-RW, +R, and +RW disks and BER max for DVD-RAM as shown in Table 2 (see Annex C).

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.

If the recording performance is in Level 6, the data stored on the disk shall be copied to another disk immediately, as far as the data can be retrieved. Please note that PI SUM 8 max and BER max are high enough in Level 6 to disable retrieval the data without uncorrectable errors.

Data migration flow for the initial performance test and periodic performance test is shown in Figure 1.

Table 2 — Category of recording performance at periodic performance test

Level	Status	DVD-R, DVD-RW, +R, +RW	DVD-RAM
4	Use as it is	< 200	$< 7{,}1 \times 10^{-4}$
5	Migrate data as soon as possible	200 to 280	$7{,}1 \times 10^{-4}$ to $1{,}0 \times 10^{-3}$
6	Migrate data immediately	> 280	$> 1{,}0 \times 10^{-3}$
Recording performance indicator		PI SUM 8 max.	BER max.