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Imaging materials — Information stored on magneto-optical (MO) discs — Method for estimating the life expectancy based on the effects of temperature and relative humidity

Matériaux pour l'image — Information stockée sur disques opto-magnétiques (MO) — Méthode d'estimation de l'espérance de vie basée sur les effets de la température et de l'humidité relative

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Contents

Page

Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

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

The main task of technical committees is to prepare International Standards. Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member 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 shall not be held responsible for identifying any or all such patent rights.

ISO 18926 was prepared by Technical Committee ISO/TC 42, *Photography*.

Introduction

This International Standard is one of a series of standards dealing with the physical properties and stability of imaging materials. To facilitate identification of these International Standards, they are assigned a number within the block from 18900 – 18999 (see Annex A).

Imaging materials — Information stored on magneto-optical (MO) discs — Method for estimating the life expectancy based on the effects of temperature and relative humidity

1 Scope

This International Standard specifies a test method for estimating the life expectancy (LE) of information stored on rewritable and write-once magneto-optical media. Only the effects of temperature and relative humidity on the media are considered.

2 Purpose and assumptions

2.1 Purpose

The purpose of this International Standard is to establish a methodology for estimating the life expectancy of information stored on magneto-optical discs. This methodology provides a technically and statistically sound procedure for obtaining and evaluating accelerated test data.

2.2 Assumptions

The validity of the procedure defined by this International Standard relies on five assumptions:

— the failure mechanisms acting at the usage conditions are the same as those at the accelerated conditions;

— the linearity of the byte error rate (BER) estimated over the accelerated and design conditions is valid;

— all failure mechanisms have been accounted for and appropriately modelled;

— failure caused by reversible effects such as surface dust is not included;

— failure from repairable parts such as external cartridge components is not included.

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 10089:1991, *Information technology — 130 mm rewritable optical disk cartridge for information interchange*

ISO/IEC 10090:1992, *Information technology — 90 mm optical disk cartridges, rewritable and read only, for data interchange*

ISO/IEC 11560:1992, *Information technology — Information interchange on 130 mm optical disk cartridges using the magneto-optical effect, for write once, read multiple functionality*

ISO/IEC 13549:1993, *Information technology — Data interchange on 130 mm optical disk cartridges — Capacity: 1,3 gigabytes per cartridge*

ISO/IEC 13963:1995, *Information technology — Data interchange on 90 mm optical disk cartridges — Capacity: 230 megabytes per cartridge*

ISO/IEC 14517:1996, *Information technology — 130 mm optical disk cartridges for information interchange — Capacity: 2,6 Gbytes per cartridge*

ISO/IEC 15041:1997, *Information technology — Data Interchange on 90 mm optical disk cartridges — Capacity: 640 Mbytes per cartridge*

ISO/IEC 15286:1999, *Information technology — 130 mm optical disk cartridges for information interchange — Capacity: 5,2 Gbytes per cartridge*

AITCHINSON, J. and BROWN, J.A.C. *The Lognormal Distribution*, Cambridge University Press, 1957

4 Terms and definitions

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

4.1
baseline
condition representing the disc at time of manufacture

NOTE This is customarily the initial parameter measurement taken prior to any application of stress. The designation is usually $t = 0$ for a stress time equal to zero hours.

4.2
byte error rate
BER
number of bytes in error divided by number of bytes tested

NOTE BER refers to the raw byte error rate, without benefit of any error correction or sector re-allocation.

4.3
censored data
time at which a specimen is removed from life testing due to any reason other than having reached end-of-life

4.4
end-of-life
occurrence of any loss of information

4.5
information
signal or image recorded using the system

4.6
$F(t)$
probability that a random unit drawn from the population fails by the time t, or the fraction of all units in the population which fail by time t

4.7
life expectancy
LE
length of time that information is predicted to be retrievable in a system under extended-term storage conditions

4.7.1
standardized life expectancy
SLE
minimum life span, predicted with 95 % confidence, of 95 % of the product stored at a temperature not exceeding 23 °C and a relative humidity (RH) not exceeding 50 %

4.8
magneto-optical disc
any disc conforming to the ISO/IEC standards contained in Clause 3

NOTE Double-sided media are considered to be composed of two discs, one per side. In general, a magneto-optical disc is one that uses thermo-magnetic properties for recording and opto-magnetic properties for reading.

4.9
$R(t)$
probability that a unit drawn from the population will survive at least time t, or the fraction of units in the population that will survive at least time t

NOTE $R(t) = 1 - F(t)$

4.10
retrievability
ability to access information as recorded

4.11
stress
experimental variable to which the specimen is exposed for the duration of the test interval

NOTE In this International Standard, the stress variables are confined to temperature and relative humidity.

4.12
system
combination of recording medium, hardware, software and documentation necessary to retrieve information

4.13
test cell
device that controls the stress to which the specimen is exposed

4.14
test pattern
distribution of 1's and 0's within a sector

5 Measurements

5.1 Summary

A sampling of eighty discs is baseline tested for the byte error rate (BER) then divided into five groups according to a specified plan. Each group of discs is subjected to one of five combinations of temperature and relative humidity (stress). During the exposure to the stress condition, discs are periodically removed from the environmental test cell according to a set plan. These discs are then retested for BER and subsequently returned to the test cell for additional increments of exposure at the same stress.

For each disc, the time to reach end-of-life (loss of any information or BER 5×10^{-4}), is then determined or estimated. For each stress condition, the resulting service life data is fitted to a lognormal distribution for that stress. These five sets of parameters (lifetime, temperature and relative humidity) are regressed to fit an Eyring acceleration model. This model is then used to estimate the distribution of lifetimes at a standardized set of conditions.

5.2 Byte error rate (BER)

The objective of measuring the byte error rate (BER) is to establish a practical estimation of the system's ability to read previously written bits using a standard drive. This International Standard considers BER to be a reasonable estimate of the performance of the system. A change in the BER in response to the time at the accelerated temperature and humidity is the principal degradation parameter.

The true end-of-life for any data storage media is any loss of information. Ideally, each specimen is tested until actual failures occur. The first occurrence of any disc degradation that results in uncorrectable errors, is considered to signal the actual end-of-life.

Realistically, testing until all discs have failed is impractical. For the purposes of this International Standard, the maximum average BER shall be $5{,}0 \times 10^{-4}$ if actual failures do not occur during testing. This is very system dependent and its use here is an arbitrary level chosen as a conservative prediction of the onset of unacceptable errors and thereby the end of disc life. All BER measurements are made with the system error correction switched off.

5.3 Test equipment

5.3.1 General

Any disc drive system that conforms to ISO/IEC standards (see Clause 3) may be used. The tester shall be capable of reporting errors occurring prior to the implementation of error correction systems.

5.3.2 Calibration and repeatability

A control disc shall be maintained and measured before and after each data collection interval. For each test drive, a control chart shall be maintained for this control disc with plus or minus three sigma action limits. The mean and standard deviation of the control disc shall be established by collecting at least five measurements. If any individual BER reading lies outside the action limits, the problem shall be corrected and all data collected since the last valid control point shall be remeasured.

If it becomes necessary to replace the test drive, the new drive shall be calibrated using the control disc and compared to the replaced drive. If a statistical difference exists between the control disc BER means, subtract the new disc mean from the old disc mean and add this correction factor to all subsequent BER measurements made with the new drive.

5.4 Test specimen

A test specimen is any disc that conforms to ISO/IEC specifications referenced in Clause 3 and contains representative data written over 100 % of the user area. Representative data may be real data or random test data.

6 Accelerated stress test plan

6.1 General

A well manufactured magneto-optical disc should last several years or even decades. As such, it is not practical to conduct life studies under normal usage conditions. It is then necessary to conduct accelerated aging studies in order to determine the estimated potential for life of this medium. To be successful, these studies shall be planned ahead of time in order to be of sound design both technically and statistically.

Many accelerated life test plans follow a rather traditional approach in sampling, experimentation and data evaluation. These “traditional plans” share the following characteristics:

— the total number of specimens is evenly divided amongst all of the accelerated test cells;

— the specimen from each test cell is evaluated at the same increment of time;

- the Arrhenius relationship is used as the acceleration model;
- the Least Squares method is used for all regressions;
- the calculated life expectancy is for the mean or median life rather than for the first few failure percentiles.

Statisticians, on the other hand, have devoted considerable attention to developing "optimum test plans" for an ideal situation. These plans have the following characteristics:

- two and only two acceleration levels for each stress;
- a large number of specimens distributed mostly amongst the lowest stress levels;
- the need to know the failure distribution, *a priori*, in order to develop the plan.

The maximum effectiveness of a plan can either be estimated before the test starts or determined after the results have been obtained. As each MO system will have different characteristics, a specific detailed optimum plan is impossible to forecast.

This test plan borrows from the optimum plan, the traditional plan, previous experience with the systems, test equipment and accelerated test stresses to put together a "compromise test plan". Modifications of this plan is required to design the best plan for other applications. The methodology shall be applicable to all MO media assessments.

6.2 Stress conditions

6.2.1 General

As mentioned in 6.1, an optimum test plan utilizes only two stress levels for each parameter evaluated, since in an ideal case the relationship between changes in the parameter investigated and changes in stress are known. The compromise test plan documented in this International Standard does not make such an assumption; therefore, three different stress levels per parameter shall be used so that the linearity of the parameter function versus the stress level may be demonstrated.

The test plan shall have the majority of test specimens placed at the lowest stress condition. This minimizes the estimation error at this condition and results in the best estimate of the degradation rate at a level close to the usage condition. The greater number of specimens at the lower stress also tends to equalize the number of failures observed by test completion.

For implementing the test plan documented in this International Standard, five stress conditions shall be used. The minimum distribution of specimens among the stress points that shall be used is shown in Table 1.

Table 1 — Summary of stress conditions

Test cell number	Test stress T_{inc}/RH$_{inc}$	Number of specimens	Interval duration h	Minimum total time h
1	80 °C/85 % RH	10	500	2 000
2	80 °C/70 % RH	10	500	2 000
3	80 °C/55 % RH	15	500	2 000
4	70 °C/85 % RH	15	750	3 000
5	60 °C/85 % RH	30	1 000	4 000

6.2.2 Temperature (T)

The temperature levels chosen for this test plan are based on the following.

— There shall be no change of phase within the test system over the test temperature range. This would restrict the temperature to greater than 0 °C and less than 100 °C.

— The level of temperature shall not be so high that either plastic deformation or excessive softening of thermoset adhesives occurs.

A common substrate material for magneto-optical discs is polycarbonate (glass transition temperature approximetely 150 °C). Experience with high temperature testing of MO discs indicates that an upper limit of 80 °C is practical for most applications.

6.2.3 Relative humidity (RH)

Practical experience shows that 85 % RH is the upper limit within most accelerated test cells. This is due to the tendency for condensation to occur on cool sections of the chamber (such as observation windows, cable ports, wiper handles, etc.). Droplets may become dislodged and entrained in the circulating air within the chamber. If these droplets fall on the test specimen, false error signals could be produced.

6.2.4 Rate of stress change

The process, described in this International Standard, requires that temperature and relative humidity be gradually changed (ramped) from permitted testing conditions to accelerated stress conditions and back again a number of times during the course of testing. The ramp duration and conditions shall be chosen to allow sufficient equilibration of absorbed substrate moisture.

Large departures from equilibrium conditions may result in the formation of liquid water droplets inside the substrate or at its interface with the thin film layers. Gradients in the water concentration through the thickness of the substrate shall also be limited. These gradients drive expansion gradients which can cause significant disc deflection.

In order to minimize moisture concentration gradients, the ramp profile specified in Table 2 shall be used. The objects of the profile are:

— to avoid any situation that may cause moisture condensation within the substrate;

— to minimize the time during which substantial moisture gradients exist in the substrate;

— to stay within specified rates of temperature and humidity change;

— to produce, at the end of the specified profile, a disc which is sufficiently equilibrated to proceed directly to testing without delay.

Discs bonded with thermoplastic adhesives may be close to, or above, their softening temperatures. By including a 2 h step at 50 °C/85 % RH, these adhesives have an opportunity to set before continuing the ramp to ambient conditions.