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Imaging materials — Optical discs — Care and handling for extended storage

Matériaux pour l'image — Disques optiques — Précautions et manipulation pour stockage étendu

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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 18938 was prepared by Technical Committee ISO/TC 42, *Photography*.

Introduction

In addition to storage conditions, the proper care and handling of optical discs[1)] is also vital to prolonged disc life. This is becoming increasingly important as optical discs are widely used for the recording and storage of information. This International Standard gives guidelines for their recommended care and handling and will be beneficial for all digital optical discs, regardless of their inherent stability.

Probably no form of data storage has been accepted and adopted as rapidly as the optical disc. It has become the medium of choice for numerous applications with ever increasing use for the recording and storage of information. Information is recorded in digital format that not only provides high storage density, but also allows duplication without information loss, ease of data manipulation and facilitates transmission. It is of tremendous benefit for audio usage since it permits uninterrupted playback for long periods of time. Information in a disc format can be accessed very quickly, unlike that in a roll format such as magnetic tape, which requires longer search time.

While the advantages are many, as with other media, there are nevertheless concerns about the life expectancy of recorded information on optical discs. This depends upon three independent components, namely the permanence of the disc itself, the disc drive and the software. Obsolescence of the disc drive and software, lack of playback device or inoperability of the playback device are all serious uncertainties. Another important issue is the quality of the initial data recorded onto the disc, which needs to be as high as possible. In addition, the very popularity of recordable optical discs has led to their wide availability, and wide variability in the quality of discs for long term preservation of information. Many discs may not be of sufficient quality for long term use.

The finite life of optical discs is well recognized and one approach to addressing this issue is by periodically transferring or reformatting the information. In addition, the ability to play back a disc in the future depends on the existence of functional playback equipment. As newer formats and equipment become popular, equipment manufacturers will probably discontinue production and support of the older, superseded equipment. Eventually, usable equipment to play obsolete optical disc formats will become difficult to find. Before this occurs, it is advisable that a migration plan be in place. However, these issues are outside the scope of this International Standard, which is only concerned with the stability of the optical disc itself. A primary objective of those involved with the preservation of information on this media is to ensure that the disc is not the weak link among the necessary components. To support this objective, it is advisable that steps be taken to maximize the optical disc's potential to be more stable than either the hardware or the software.

As with paper records, photographic film and magnetic tape, optical discs are subject to both damage and decay. They have a finite life. Predictions of the life expectancy of optical discs have involved extrapolations of property retention after high temperature and humidity incubations back to practical conditions. These extrapolations follow mathematical treatments that were developed for simpler chemical reactions, and therefore the results need to be interpreted with some caution. Predictions cover a very wide range, from 25 years to over 250 years, which vary with the manufacturer and the disc type. Their effective life can be increased or decreased significantly depending upon the conditions under which they are stored. Storage recommendations for optical discs are given in ISO 18925. Following these recommendations promotes the physical integrity of the media and increases their effective life.

1) It is recognized that both “optical discs” and “optical disks” are acceptable spellings. In this International Standard, the former spelling is used.

Imaging materials — Optical discs — Care and handling for extended storage

1 Scope

This International Standard establishes general principles for the care and handling of digital optical discs during use. It addresses the issues of physical integrity of the medium necessary to preserve access to the recorded data (information). This International Standard includes recommendations for handling procedures to maximize the effective life of optical discs. Faulty handling, packing and transporting techniques and methods often cause physical damage to the discs and to the content recorded thereon. Extending the longevity of optical discs requires the identification of appropriate handling methods, as well as well-developed and implemented training programs.

For the purposes of this International Standard, the term "optical disc" includes the families of compact disc (CD), digital versatile disc (DVD), high definition digital versatile disc (HD DVD) and Blu-ray disc (BD)[2)], and any hybrids of these families. The term "optical disc" also includes each type of disc within a family, including injection moulded [read-only memory (ROM)], dye-layer [recordable (R)] and phase change [rewriteable (RW), random access memory (RAM)] technologies.

While some of the recommendations in this International Standard (e.g. those for staff training) apply specifically to large-scale or long term usage, the basics of all recommendations in this International Standard are intended to be applied in circumstances where the desired result is long-term usage of the medium whether archival, commercial or personal.

This International Standard does not cover magneto-optical (MO) discs, laser discs (LD) or glass discs. At the time of writing, International Standards do not exist for HD DVD and Blu-ray discs. Nonetheless, it is believed that the recommendations in this International Standard for care and handling can equally apply to them. It is recognized that some of these requirements are not necessarily possible for the individual user to achieve.

The following are within the scope of this International Standard:

— use and handling environments, including pollutants, temperature and humidity and light exposure;

— contamination concerns;

— inspection;

— cleaning and maintenance, including cleaning methods and frequency;

— transportation;

— disasters, including water, fire, construction and post-disaster procedures;

— staff training.

The quality of the data written on the disc is outside the scope of this International Standard. However, a high quality result of the recording phase is important to the longevity of information. It is advisable that a rigorous program of data integrity testing be implemented, as this forms an obligatory part of all digital long-term storage. In addition, when keeping digital information for archival purposes, it is advisable that a multiple copy/multiple location strategy be in place.

2) Blu-ray disc and HD DVD are examples of suitable products available commercially. This information is given for the convenience of users of this International Standard and does not constitute an endorsement by ISO of these products.

2 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 14644-1, *Cleanrooms and associated controlled environments — Part 1: Classification of air cleanliness*

ISO 18925, *Imaging materials — Optical disc media — Storage practices*

3 Terms and definitions

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

3.1
Amaray case[3)]
case designed for DVD discs slightly larger than a jewel case

3.2
acclimatization
staging
process of conditioning material from one set of temperature-moisture conditions to another

3.3
balance
precision vertical position of the disc as it spins

3.4
blister
localized delamination that looks like a bubble

3.5
Blu-ray disc
BD
optical disc in which one or more information layers are located between two layers and the data can be read by an optical beam with a wave length of 405 nm

3.5.1
read only memory BD-ROM
optical disc to which information is transferred during manufacture to moulded areas in the Blu-ray disc format and can be read multiple times by an optical beam

3.5.2
recordable BD-R
recordable optical disc in which information can be recorded once to areas in the Blu-ray disc format and read many times

3.5.3
rewriteable BD-RE
recordable optical disc in which information can be recorded to areas in the Blu-ray disc format and can be erased, rerecorded and read many times

3) Amaray case is an example of a suitable product available commercially. This information is given for the convenience of users of this International Standard and does not constitute an endorsement by ISO of this product.

3.6
carton
box outer container that can hold one or more individual units and can be a fabrication of paper, card stock or plastic

3.7
compact disc
CD
optical disc in which the information layer is located near one surface of a substrate and the data can be read by an optical beam

NOTE Described in IEC 60908.

3.7.1
read only memory CD-ROM
optical disc to which information is transferred during manufacture to moulded areas in the compact disc format and can be read multiple times by an optical beam

NOTE Described in ISO/IEC 10149.

3.7.2
recordable CD-R
recordable optical disc in which information can be recorded once to areas in the compact disc format and read many times

3.7.3
rewritable CD-RW
recordable optical disc in which information can be recorded to areas in the compact disc format and can be erased, rerecorded and read many times

3.8
conditioning
exposure of a material to air at a given relative humidity and temperature until equilibrium is reached

3.9
container
box, can or carton used for storage and shipping of recording materials

EXAMPLE The box into which a reel, cassette, cartridge or shell is placed.

3.10
delamination
separation of a laminate into its constituent layers

3.11
digital versatile disc
DVD
optical disc in which one or more information layers are located between two substrates and the data can be read by an optical beam with a wave length of between 635 nm and 650 nm

NOTE Formerly called digital video disc.

3.11.1
read only memory DVD-ROM
optical disc in which information is transferred during manufacture to certain areas in the DVD format and can be read multiple times by an optical beam

NOTE Described in ISO/IEC 16448 and ISO/IEC 16449.

3.11.2
recordable DVD-R, +R
recordable optical disc in which information can be recorded once to areas in the DVD disc format and read many times

NOTE Described in ISO/IEC 23912, ISO/IEC 17344 and ISO/IEC 25434.

3.11.3
rewriteable DVD-RAM, DVD-RW, +RW
DVD optical discs that can be written, read and overwritten many times using phase change technology

NOTE 1 See Annex A.

NOTE 2 Described in ISO/IEC 17592, ISO/IEC 17341 and ISO/IEC 26925.

3.12
enclosure
case, cartridge, folder, envelope, sleeve or clam shell that is intended for physical protection against mechanical damage

3.13
extended-term storage conditions
storage conditions suitable for the preservation of recorded information having permanent value

3.14
high definition digital versatile disc
HD DVD
optical disc in which one or more information layers are located between two substrates and the data can be read by an optical beam with a wave length of 405 nm

NOTE Sometimes called high density digital versatile disc.

3.14.1
read only memory HD DVD-ROM
optical disc in which information is transferred during manufacture to certain areas in the HD DVD format and can be read multiple times by an optical beam

3.14.2
recordable HD DVD-R
recordable optical disc in which information can be recorded once to areas in the HD DVD disc format and read many times

3.14.3
rewriteable HD DVD-RW
DVD optical discs that can be written, read and overwritten many times using phase change technology

3.15
information
data recorded using the system

3.16
insulated record container
storage box designed to provide an environmental buffer against temperature and humidity fluctuations

3.17
jewel case
plastic enclosure featuring a hinged lid and one or more trays, each containing a hub clamp to secure and protect the disc surface

3.18
macroenvironment
atmospheric conditions in a large area in which records are kept

NOTE Atmospheric conditions are temperature, relative humidity and pollutants.

3.19
medium
material on which information is recorded

3.20
microenvironment
atmospheric conditions inside a storage enclosure in which records are kept

NOTE Atmospheric conditions are temperature, relative humidity and pollutants.

3.21
optical disc
disc that will accept and retain information from light modulation changes in a recording or reflective layer that can be read with an optical beam

3.22
optical disc cartridge
ODC
optical disc enclosure required for the operation of the disc

3.23
recording layer
layer of an optical disc on which data is written either during manufacture or in use

3.24
relative humidity
RH
ratio, defined as a percentage, of the existing partial vapour pressure of water to the vapour pressure at saturation

NOTE It is usually, but not always, equal to the percentage of the amount of moisture in the air to that at saturation.

3.25
replicated disc
disc made by an injection moulding process where the land and pits that make up the data are physically pressed into the polycarbonate

3.26
retrievability
ability to access information as recorded

3.27
slimline case
slimmer version of the jewel case

3.28
snapper case
alternative to the Amaray case with a cardboard cover

3.29
storage environment
conditions for storing materials

NOTE The conditions are temperature, relative humidity, cleanliness of facilities and atmospheric pollutants.

3.30

storage housing

physical structure supporting materials and their enclosures

NOTE It can consist of drawers, racks, shelves or cabinets.

3.31

substrate

transparent layer of an optical disc which provides mechanical support of the recording layer

3.32

system

combination of media, hardware, software and documentation necessary for recording and/or retrieving information

3.33

WORM disc

optical disc in which the data in specified areas can be written only once and read multiple times by an optical beam

4 Composition of optical discs

4.1 General

Optical discs are composed of a series of layers made of different materials assembled like a sandwich. Typically, these layers include the polycarbonate substrate (plastic) layer(s), the data layer(s), the metal layers(s) or reflective layer, the metal protective layers, the adhesive layer and an optional extra layer for labelling or added protection. These layers are listed in Annex A.

4.2 Polycarbonate substrate (plastic) layer

The polycarbonate substrate makes up most of the disc. The polycarbonate is typically clear, but may be coloured for appearance or to prevent copyright infringement. The disc drive laser beam travels through this substrate. This substrate provides the disc depth necessary to maintain laser focus. It also gives the disc enough strength to remain flat.

A CD is one continuous 1,2 mm thick polycarbonate layer. Both DVDs and HD DVDs are made up of two 0,6 mm thick polycarbonate layers bonded together. BDs are made up of one 1,1 mm and one 0,1 mm polycarbonate layer bonded together. CDs are read from one side only. DVDs, HD DVDs and BDs are read from one or both sides.

4.3 Data layer

As its name implies, the data layer of optical discs is the layer that contains the encoded data. The encoded data appear as marks or pits that either transmit or alter light from the laser beam back to the laser photosensor by way of the metal reflective layer. Write-once (–R, +R) discs use organic dye material or phase change materials, whereas rewritable (–RW, +RW, –RAM, –RE) discs use phase change materials as the layer(s) for holding record data written by a disc drive. ROM discs do not use a separate layer, but the data has been pressed in the form of pits from injection moulding on the inner surface of the polycarbonate substrate during the disc manufacturing process.

4.4 Reflective layer

The metal layer in optical discs reflects the laser beam back to the laser photodiode in the optical pickup unit (OPU). Three main types of reflective metals typically are used for this layer:

a) aluminium or aluminium alloy,

b) gold, and

c) silver or silver alloy.

In “double-layer” DVDs, silicon is sometimes used as one of the semi-reflective layers. Some discs use a copper alloy for the purposes of appearance.

Aluminium is used in ROM, RW and RAM discs. Silver, silver alloy or gold are used in R discs, since aluminium is too active to use with dye. Aluminium is also prone to corrosion when exposed to moisture or other pollutants that penetrate into the disc. Oxidation of the aluminium diminishes its reflectivity, eventually making the disc unreadable by the laser. This is sometimes referred to as disc “rot”.

Silver can lose reflectivity due to corrosion on exposure to pollutants such as sulphur dioxide. Silver alloys are designed to inhibit corrosion.

In double-layer DVDs, the outer reflective layer (silicon, gold, silver or silver alloy) is only semi-reflective, i.e. it reflects back some of the laser beam and allows some of it to pass through to the fully reflective layer and then reflects back.

To summarize, the relative properties of the three main types of reflective metals are as follows:

— Cost: aluminium < silver < silver alloy < gold;

— Stability: aluminium < silver or silver alloy < gold.

4.5 Protective layers

A very thin lacquer layer is applied to the label side of CDs to protect the metal from exposure to the environment. Without this protective layer, the aluminium will oxidize within several days. The layer also gives some limited protection from writing on or labelling the disc. Some solvents used in markers (e.g. xylene, toluene) can also affect lacquer coatings and expose or react with the metal. Once the metal is damaged, the laser cannot read data in the damaged areas. DVDs have no such protective lacquer coating, due to the reflective layer location in the middle of the disc.

Sometimes a manufacturer will add an additional layer designed specifically to provide more resistance to fingerprints and scratches on the label side of CDs.

Protective layers also are available to place on the laser reading side of the disc. These are specifically designed for protection against scratches and other surface damage.

4.6 Adhesive layers

The discs of all DVD formats are formed by bonding two 0,6 mm discs together. Disc durability and reliability require excellent bonding. The bonding methods include hot-melt bonding and ultraviolet (UV) bonding. The bonding layer needs to be optically transparent for some double-layer DVDs.

The DVD bonding process mainly uses the following three methods:

— the spinning method, using a radical UV resin;

— the screen printing method, using a cationic UV resin;

— the sheet method, using a double-sided adhesive sheet.

It is essential that the adhesive layer be uniform within close tolerances, that it does not introduce tilt out of the range of the DVD specification, that no defects such as bubbles occur and that it is optically transparent in dual layer DVDs.

4.7 Additional layers

An optional layer may also be added to optical discs to provide a writable, printable or coloured surface. Such surfaces include thermal-printable, inkjet-printable and silkscreen-printable surfaces. These layers are applied over the lacquer layer on CDs, or over the polycarbonate substrate on other single-sided discs.

5 Failure mechanisms

5.1 General

Optical disc performance depends on the performance of the disc drive and the characteristics of the disc itself. This clause only discusses failure mechanisms due to the disc.

5.2 Physical stress

Optical discs are typically handled directly by users. They are subject to a variety of physical stresses, including mechanical impact and thermal shock. Mechanical impact can result in scratching, fracturing, breakage, warpage or delamination. Thermal shock is a rapid temperature change that can cause differential expansion or contraction resulting in warpage or delamination. Warping can be a temporary condition that returns to normal, but severe warping or repetitive warping can cause delamination and permanent damage.

5.3 Layer sensitivity

5.3.1 General

Proper care and handling of optical discs requires knowledge of the sensitivities of the various layers which make up optical discs. Various types of defects can be encountered because of the complex structure of these materials. Optical discs are laminates of very dissimilar layers and each layer can cause malfunctions. It is essential that the disc does not undergo any delamination. The primary layers and their susceptibilities to failure or damage sensitivities are as described in 5.3.2 to 5.3.6 below.

5.3.2 Polycarbonate substrate

The complete transmission of the laser beam to its focus point and back to the reading sensor shall go through the polycarbonate substrate. Eccentricity, manufacturing flaws, off-centring, lack of flatness or balance creates tracking and/or reading problems. This may be caused by physical stress, exposure to high or rapidly changing temperatures, humidity or manufacturing errors. Surface or penetrated containments can hinder or obstruct the laser beam.

5.3.3 Data layer

In ROM (replicated) discs, the data is moulded into the substrate and the data layer is not a separate layer as in R, RW and RAM discs. The recording layer in R, RW and RAM discs can be damaged by light, heat or moisture. The recorded signal therefore can be degraded by unwanted exposure to these factors or by chemical degradation due to aging. Physical damage that is deep enough to reach the data layer will also damage the data.

5.3.4 Reflective layer

This layer serves to reflect the modulated optical beam to the receiver. Any change in reflectivity caused by dents, abrasion or corrosion due to moisture or other contaminant penetration is very detrimental. Any change in flatness will change the laser beam angular reflection.

5.3.5 Protective (lacquer) layer

This layer exists on the label side and edge of CDs to protect the metal layer. Any removal, abrasion or chemical reaction can destroy the reflective layer and the information it contains.

5.3.6 Adhesive layer

In addition to maintaining the integrity of each layer, it is essential that the disc does not undergo any delamination. This may occur because of an inherent weakness of the disc, exposure to rapid changes and extremes in temperature and humidity, mechanical stresses, edge damage or the effect of external agents such as solvents and adhesives.

5.4 Scratches

5.4.1 Scratches on the laser-reading side of optical discs

Scratches that are deep, wide or bunched together are most likely to affect adversely the readability of the disc. These scratches can cause the laser to misread enough data to make error correction remedies ineffectual.

If scratches are deep enough to damage the data or reflective layer(s) on the reading side of a disc, the data cannot be read or repaired. Tangential and circular scratches can be more damaging than radial scratches because it is more difficult for error correction software to repair sequential errors.

5.4.2 Scratches on the non laser-reading side of optical discs

A scratch on the non laser-reading side of a CD can easily damage the reflective and data layers directly beneath the surface and therefore cause direct and severe damage. A surface scratch on the non-laser reading side of a DVD, HD DVD or BD only scratches the polycarbonate and does not impair laser reading/writing.

5.5 Effects of disc play

5.5.1 General

Optical discs do not wear from friction as vinyl records or magnetic tapes do. There is no mechanical contact between the disc and the optical pickup unit (OPU) of the player or the drive, which uses more than one photodiode to achieve correct mutual positioning between them. There is, however, the potential for wear on the hub from repeated insertion and removal of the disc from reading devices. Such wear may cause imbalance in the spinning disc and exacerbate manufacturing flaws.

5.5.2 ROM Discs

The laser light will have no effect on the data or reflective layer in ROM discs. It is possible for the disc to be read so many times that the cumulative effect of the laser light can eventually affect the polycarbonate. There is, however, no record of such discs having been played a sufficient number of times to incur damage from laser light. Accordingly, it is felt that any effects of laser light on ROM discs are negligible. The disc would likely fail much earlier from some other condition than from the effects of laser light.

5.5.3 R discs

Although R discs may have a limited number of read times, it is possible for the discs to be read more than 106 times. As with ROM discs, there is no recorded evidence of the ill effects of laser light. Accordingly, it is felt that any harmful effects of the laser light on R discs are negligible.

5.5.4 RW discs

In RW discs, unlike the other types, the recording layer can “wear-out”. However, these discs should be rewritable many hundreds of times. While the maximum number of possible read times after writing is unknown, it may decline after each successive writing.

5.5.5 RAM discs

In RAM discs, as in RW discs, the recording layer can “wear-out”. However, these discs should be rewritable several thousands of times. While the maximum number of possible read times after writing is unknown, it may decline after each successive writing.

6 Handling techniques

6.1 General

Proper handling techniques will help maximize the life of discs. Discs shall be handled by the edges.

6.2 Flexing

Flexing (bending) the disc by any means, such as removing it from a jewel case without releasing the hub clamp, may harm the disc by causing stresses. The disc should be stored in its case.

6.3 Contamination

Anything on an optical disc surface that impedes the ability of the laser to focus on the data layer can result in missing data as the disc is being read. Fingerprints, smudges, scratches, dirt, dust, solvents, moisture and any other foreign material can interfere with the ability of the laser to read or record data on the disc.

6.4 Disc enclosures

Optical discs shall be kept in chemically inert storage containers that are designed to hold one or more discs. Those designed to keep surfaces of the disc from contact with the inside of the case, thereby minimizing possible damage from surface contact, are recommended. Jewel cases and Amaray cases are examples that provide optimum storage. Polypropylene or other more stable cases are recommended.

For long-term disc storage, it is recommended to remove the label insert or booklet from inside the case and attach it to the outside. Paper can produce higher moisture content in the case, and may release harmful pollutants or in certain conditions adhere to the disc. These potentially harmful affects depend on relative humidity conditions and the insert material properties, as well as their proximity to the disc.

Potentially harmful enclosures, including cardboard, paper or highly plasticized materials, shall be replaced with a standard jewel case.

Plastic sleeves made of polypropylene or polyester will not harm discs, but offer no mechanical protection. Care shall be taken to avoid abrasion and surface contamination when inserting or removing discs from the sleeves. Discs shall not be placed in smooth surface plastic sleeves for extended periods; adhesion may develop and result in delamination when the disc is removed from the sleeve.

7 Identification

7.1 Basic concepts

When considering methods for applying identification onto an optical disc, two principle considerations shall receive attention, i.e. balance and interference with the metal or data layers of the disc. The risks associated with the latter include scratching the disc or utilizing solvents that may react negatively with the various disc layers. These issues are covered in 5.4 (Scratches), 8.3 (Organic solvents) and 7.7 (Marking).

Proper balance of the rotating disc affects the ability of a drive to accurately read the disc. Imbalance of a disc is often due to an offset in weight throughout the surface area of the disc. As the ability of the drive to accurately read the disc diminishes, error rates increase. The increase in error rates can manifest itself in several ways, including increased error correction, the appearance of audiovisual artefacts or total failure, all of which are detrimental to preservation of the content. In addition, error rates are a fundamental metric in the assessment of disc life expectancy and that of the data on the disc.

These factors shall receive consideration when choosing methods for identifying optical discs, regardless of the specific method or technology.

7.2 Adhesive labels

The application of adhesive labels poses a risk to the proper functioning of optical discs. The label can delaminate over time and interfere with disc drive operation. Applying or removing a label, or any portion thereof, from the surface of a disc can cause an imbalance in the spin of the disc in the disc drive, making the disc unreadable. To ensure the long-term availability of information on a disc that already has an adhesive label, the information on the disc shall be copied to, and stored on, a disc without such a label.

7.3 Printing on optical discs

Inkjet, thermal transfer, silk screen and offset printing are commonly used methods for print-labelling optical discs. Each method involves a different technology to place inks on the surface of the disc. Ink-jet-printable and thermal printable recordable discs are not normally interchangeable in respective printers. The silk screen and offset methods are typically used to label replicated discs.

The printable surface area depends on whether the disc is single- or double-sided. A label may be printed on the full surface on the top side of a single-sided disc. If a disc is double-sided (i.e. it has data on both sides), printing cannot be applied in the data area of the disc. Only the area of the mirror band and the hub area (between the mirror band and centre hole) may be printed on.

The performance of higher density discs is more sensitive to any imbalance of the disc than those of lower density. If printed ink is not uniformly distributed over the disc surface, the flatness and balance of the disc can be adversely affected, depending on the variation of ink application.

Laser-etched labelling, or “pit art” labelling, is an alternative to traditional printing and avoids potential flatness and balance issues. One method is to record a pattern in the unrecorded area of the data layer if a disc has not reached its full recording capacity. Another method is to write on a special layer that is similar to the data layer but on the label side of the disc. These two methods use different processes. The method used with the special layer is intended to give more visual impact.

7.4 Thermal printing

Thermal transfer printers use ink-coated films (ribbons) that are heated by a print head. The print head is in direct contact with the uncoated side of the ribbon, whereas the ink-coated side of the ribbon is in direct contact with the disc's surface. During print head and disc surface contact, the ink melts and adheres to the surface. Thermal transfer printing is applied to standard disc surfaces. Special printable-surface discs are not required. Only specially designed thermal printers, not thermal printers designed to print on paper, can be used to print directly on the surface of discs.

7.5 Inkjet printable surface

In inkjet printers, inks are sprayed, via droplets of an ink solution, onto a specially designed printable surface material on the disc. This surface is designed to hold the ink droplets in place while absorbing the liquid components of the ink.

7.6 Silk screening

Silk screening on optical discs uses a UV-curable ink to keep the ink colours from running together. This ink cannot contain any chemically active components that can affect the disc after the curing process, or abrasive particles in the ink pigments that can damage the protective layer on CDs. Silk screening typically is used for replicated discs.

7.7 Marking

For CDs, the proximity of the metal layer to the disc surface makes it particularly susceptible to damage from scratches, scrapes or denting caused by surface marking. A felt tip marker will minimize the risk of scratching or denting.

Of the three categories of markers (water-based, alcohol-based and solvent-based), solvent-based markers should be avoided because they will often contain xylene or toluene that may react with the lacquer on CDs.

Many vendors sell CD-safe markers, and these vary in ink solution. They should not contain any solvents harmful to optical discs, but should have a permanent quality. For risk-free labelling of any disc, the clear inner hub or the so-called mirror band of the disc shall be marked where there are no data. The same precautions taken in labelling CDs are advisable for DVDs, HD DVDs and BDs.

8 Contamination

8.1 Fingerprints, smudges, dirt, dust

Fingerprints, smudges, dirt or dust on the laser reading side of the disc can disrupt laser focus on the data. Dust can spin off into the disc drive and collect onto internal components.

8.2 Moisture

8.2.1 General

Prolonged exposure to moisture resulting from a spill, humid air, condensation or immersion allows water to become absorbed into the disc, where it may react with any of the layers.

8.2.2 Fungus

Extended exposure to humidity above 65 % RH will promote fungal growth. Fungus can cause two problems: it can impede proper laser focusing and it can cause disintegration of the disc components.

8.3 Organic solvents

Solvents such as acetone or benzene will dissolve the polycarbonate layer and thereby damage the disc beyond repair. Mild cleaning solvents (e.g. high purity isopropyl alcohol, methanol or hydro-fluoro-ether) may be used as these solvents evaporate quickly and will not dissolve the polycarbonate. They may, however, dissolve or damage labels or optional coatings and shall not be used on the label side of the disc.

8.4 Gaseous impurities

Gaseous pollutants (e.g. exhaust fumes and fumes from ammonia and chloride-based cleansers) cause chemical reactions that are harmful to optical discs. Positive air pressure shall be maintained in disc usage areas to reduce ingress of gaseous contaminants.

Ammonia and chloride-based cleaners shall not be used in optical disc storage, handling or usage areas. Polycarbonate substrates are sensitive to reactive gases, which cause crazing. Pollutants (chlorine and sulphide) can accelerate the degradation of the metal layer by acting or accelerating the oxidation process. Optical discs shall not be stored in the same storage vault as ink jet reflection prints, due to possible interactions.

8.5 Consumables

Optical disc use and handling areas shall be kept free of food, beverages and smoke. Food and drink pose a threat to optical discs, both because they contain destructive agents and because they can hold other pollutants. Many foods, especially those containing sugar, have adhesive characteristics that will cause discs to stick to each other or to other objects. Decaying food also can result in fungal growth or the presence of destructive vermin.

9 Use environment

9.1 General

Life expectancy increases when optical discs are stored in a cool, dry environment. Time out of the recommended storage environment shall be minimized, as this will maximize disc life. For acceptable storage environments, see ISO 18925.

During use and handling, many environmental factors affect the functioning and life expectancy of optical discs. Among the most critical factors are

— temperature,

— humidity,

— cleanliness, and

— the presence of potential contaminants.

9.2 Temperature and humidity

9.2.1 General

Optical disc life is influenced directly by temperature and humidity. Optical discs should perform satisfactorily when used under the following conditions, which are typical of non-air conditioned offices:

— temperature: +5 °C to +40 °C;

— relative humidity: 5 % to 80 %.

9.2.2 Equipment temperature

Inserting a disc in a playback machine constitutes a thermal shock for the disc. The disc endures a temperature variation of approximately 15 °C when the tray is closed. The temperature to which the disc can be exposed can exceed 40 °C. Therefore, it is vitally important not to leave discs in playback machines when the temperatures to which the discs are exposed inside are not provided by the manufacturers. This shall also be taken into account when determining the acclimatization time for a disc that will be immediately inserted into a playback machine.

9.3 Water avoidance

A major cause of chemical degradation of optical discs is the long-term interaction with water through absorption by the polycarbonate substrate. Precautions shall be taken to mitigate possible incursion of water due to condensation, floods, leaks and sprinklers, and to limit excess humidity. Walls and enclosures in use and handling areas shall be designed to prevent condensation of moisture on interior surfaces. Floors shall be provided with drains or other means of water removal. Drains shall have systems to prevent liquids or sewage from backing-up into the facility. All work and handling surfaces shall be elevated off the floor.

9.4 Air quality

9.4.1 General

Optical discs can develop an electrostatic charge, especially at low levels of humidity, and attract dust particles. For optimum performance, recording and playback operations shall be performed in a clean, dust-free environment. To achieve a dust-free environment, positive air pressure in use and handling areas shall be maintained relative to adjacent hallways, rooms and facility exteriors, in order to minimize contamination from outside sources.

9.4.2 Clean room specifications for large volume users

Record, playback and inspection usage of optical disc media shall be performed in a clean room environment to ISO Class 8 or better (see ISO 14644-1). A class 8 environment represents a typical dust-free office. The use of air filtration and a deionizer is recommended to clean the air and neutralize static charges.

9.5 Light exposure

9.5.1 Effect of light on replicated discs

Years of daily exposure to direct light may cause clouding of the polycarbonate.

9.5.2 Effect of light on recordable (R) discs

Direct sunlight or other sources of intense ultraviolet light will produce a photochemical reaction with the recordable dye layer, causing the ablated dye to fade and the unablated dye to become less transparent. Heat from sunlight or other broad-spectrum light sources can have a similar effect.

9.5.3 Effect of light on rewritable (RW, RAM) discs

Direct, or direct through windows, sunlight or other sources of intense broad-spectrum light will heat the disc, causing the phase-changing layer to lose the recorded optical characteristics. Indirect or filtered light, including sunlight, will have negligible effects on discs in a cool environment. Light has minimal, if any, effect on RW and RAM discs, for the phase-changing film used in such discs is not light sensitive, but heat sensitive.

9.6 Acclimatization

9.6.1 General

Acclimatization is the process of altering the temperature and moisture content of the optical disc recording so that it can be safely moved from one environment to another with a substantially different temperature and/or humidity level.

Optical discs appear fairly insensitive to the usual short periods of climate variations experienced in modern buildings and homes. Nevertheless, all necessary care shall be taken to avoid or minimize climate changes experienced by optical discs.

Under certain circumstances, sudden climate environment changes may occur, e.g. breakdown of air-conditioning, transfer to another room, shipping by truck, boat or plane. In such cases, physical reactions may occur that can affect the performance of the discs. These alterations of performance are caused by:

— the decay of the optical properties and of the reflection quality (condensation);

— the dimension variation (thermal expansion or shrinkage);

— bending that produces buckle or warp: tightening or loosening stress both for simple disc (CDs) or for discs made of two halves (DVDs).

9.6.2 Condensation

Water vapour contained in the surrounding air can, under certain conditions, condense. If condensation occurs on a solid surface, drops of water are formed on that surface. This interferes with the reading of the disc by the laser. A high level of water vapour can derive from natural climate conditions or from poor air-conditioning control of a room. Condensation depends on relative humidity and temperature.

9.6.3 Dew point

The dew point is the temperature at which moisture begins to condense on a surface, corresponding to saturation for a given absolute humidity, i.e. the more humid the air, the higher the dew point temperature.

9.7 Vibrations

While recording, the recording machine shall not be subjected to vibration or shock. In playback, vibration can cause an inability to read data that is evidenced by skipping, freezing, distortion or other interruption of the playback.

10 Transportation and shipping

10.1 Enclosures

Optical discs shall always be kept in protective enclosures (e.g. jewel cases) that hold the disc securely. These enclosures shall be packed in cartons or containers when shipped. To mitigate negative environmental factors, optical discs shall not be removed from the buffering effect provided by their protective cases when in packing, shipping or receiving areas. To further buffer optical discs from exterior environmental factors, they shall be packed in additional, non-dusting material for shipment. Protective packing also is required to avoid damage to jewel cases.

10.2 Cartons

Cartons and containers used for transporting optical discs shall be built solidly to protect the discs. Each carton shall be inspected to ensure that it is intact and capable of bearing the load. If the quantity of optical disc enclosures is not sufficient to completely fill the container, the free space shall contain packaging material so that there is no movement of the discs during transport. It is recommended that optical discs be packed in cartons with shock protection packing, e.g. bubble-pack or padding. Shipping packages shall be resistant to water and dust and shall be sealed to ensure that contaminants do not enter the package during transit.

10.3 Exposure

During shipping by public and commercial transit, the disc containers may be exposed to adverse environmental conditions. Common carriers will not guarantee against extremes or rapid changes in temperature and humidity.

EXAMPLE The cargo bay of any aircraft can have rapid environmental changes and extremes, from a hot, damp environment on a tarmac to a cold, dry environment when airborne.

These conditions can be detrimental to the physical integrity of the discs because of very different coefficients of humidity and temperature change between the various components of the disc laminate. To protect the discs from rapid environmental changes, the shipping container shall be well insulated and sealed.

10.4 Security

Discs which have permanent value (e.g. master discs, unique or original recordings) shall not be loaned or shipped without making sure that all criteria of this International Standard are met by both the shipper and the recipient. As a rule, duplicate or back-up copies should be shipped in the place of master discs. At no time shall the disc containers or the vehicles in which they are being moved be left unattended in open areas. This minimizes disc deterioration and reduces the possibility of theft and damage.

10.5 External fields

X-ray exposure, e.g. from airport baggage screening machines, will not harm optical discs. These discs can be exposed to magnetometers, such as hand-held security wands. The strong magnetic fields generated by these devises will not damage the recording.

10.6 Biological irradiation

Optical discs shall not be exposed to high power biological decontamination scanners. High levels of radiation can produce sufficient heat to melt or deform the discs or their plastic containers.

11 Inspection

11.1 General requirements

A visual inspection of the disc will help to detect any damage, abnormalities or contaminants on the surface, on the edges or within the disc. The visual inspection is performed best while holding the disc by the edge and optionally the inner hole. For more effective inspection, tilt the disc while viewing the disc surface in various angles of light reflected from a defused light source and/or indirect light. The varying light reflections highlight damage, abnormalities or contaminants that otherwise might not be detected by an initial inspection.

A visual inspection of the disc is recommended before recording or playback. Such an inspection is extremely important before recording on a disc. A small amount of dust or fingerprints can reduce the initial quality of the recording.

Many conditions impede proper disc performance. They may be broadly classified under three headings:

— types of damage, which include scratches, cracks, chips, peeling labels, warpage and breakage;

— abnormalities, which include bubbles within the disc, internal scratches or marks, clear areas within the reflective layer, off-centre adhesive labels and discoloration;

— contaminants, which include dust, dirt, fingerprints, food products, adhesives and liquids.

A slight difference of shading is normal between the recorded area and the non-recorded area of a recordable or rewritable disc. The shade closest to the centre of the disc is the recorded area. Problems in the disc outside this area that do not affect the spinning of the disc will not affect the readability of the recorded area in the disc.

During playback, any of the above-mentioned conditions that are severe enough to cause noticeable errors can have minor to catastrophic affects on disc performance.

Common indicators of discs that need immediate inspection include the following:

a) music that clicks, or video that skips, repeats, freezes or does not play at all or exhibits other artefacts;

b) computer program where one file or more does not load properly;

c) any form of data that is read partially or not at all;

d) abnormal sounds emitted from the drive.

11.2 Error rate monitoring

For those with access to necessary equipment, the periodic monitoring of error rates and other parameters (e.g. jitter, asymmetry, tracking) while discs are being stored is strongly recommended.

12 Cleaning and maintenance

12.1 General

Optical discs do not require routine cleaning. It is best to clean the disc only when contamination is visible or when readability is impaired, as any cleaning has the potential to cause damage.

12.2 Solvents and cleaning compounds

If cleaning with a flow of air or dry wiping fails to remove debris, water or water-based lens cleaners, detergents or surfactants formulated for cleaning optical discs shall be preferred to clean the optical disc surface. Isopropyl alcohol, methanol and hydro-fluoro-ether may also be used, as they will not dissolve the polycarbonate. Solvents (e.g. acetone, benzene and xylene) shall not be used, as they will dissolve the polycarbonate and damage the disc beyond repair. Some solvents may damage the identification label.

12.3 Cleaning methods

The polycarbonate substrate is a relatively soft and transparent type of plastic. Each time the disc is wiped, rubbed, treated with a solution or otherwise manipulated for cleaning, the substrate, and thus the disc itself, are at risk of being scratched or contaminated. The use of anything abrasive (including paper products such as lens paper) to wipe the disc shall be avoided.

If the disc needs cleaning, the following practices described below shall be used.

a) First, use a gentle stream of air to blow or vacuum off dust and dry debris.

b) Debris that cannot be removed by an air stream should be removed by wiping the disc gently in a centre to edge direction with a non abrasive cloth. Discs shall never be wiped in a circular pattern following the circumference of the disc, as this can cause abrasion along the recording path of sufficient length to overcome the disc error correction system.

c) Debris that cannot be removed by gentle, dry wiping shall be removed by wiping the disc gently in a centre to edge direction with a non abrasive cloth that is dampened, not wet, with distilled water, isopropyl alcohol or methanol. Care shall be taken to avoid wetting the label side of an inkjet printable disc.

13 Disasters

13.1 General

Optical discs are highly susceptible to damage in environmental disasters. The four most common problems are:

— surface contamination,

— physical deformation,

— delamination, and

— recording layer oxidation or dye fade.

Surface contamination can both interfere with signal retrieval and result in serious abrasion of the disc surface during handling or playback. Significant surface contamination may prohibit disc spin, especially with discs that are encased in a cartridge. Any deformation of a disc that results in a departure from flatness can cause the servo system, which keeps the laser on the recorded track, to lose control. Even imperceptible deformations may cause tracking problems. Damage that penetrates to the recording layer may make the recording in that section unrecoverable. Delamination of the component layers of the disc prohibits playback and exposes recording layers to potential oxidizing or fading of the dye layer. Oxidation or serious dye fading of the recording layer destroys the recording.

13.2 Water

A common type of disaster is prolonged exposure to water. Discs are at risk from exposure to water, due to the tremendous variety of sources from which the contamination can originate. Water exposure can result from many sources, e.g. roof leaks, flooding, broken pipes, malfunctioning bathroom fixtures, municipal sewer problems, fire sprinkler systems and spilled drinks.

Exposure to water and various other liquids can seriously weaken or destroy the structural integrity of discs, resulting in layer separation and/or oxidation or dye fade of the recording layer. Water or moisture also can cause removal of the identification label. Water may contain contaminants that leave a residue on or in the disc, or which may interact with the disc.

13.3 Fire

In fire scenarios, discs may be exposed to heat, smoke, water, fire suppression chemicals and debris. Each of these contaminants has a different effect.

If exposed to sufficient heat, discs will deform, melt or burn. Deformation interferes with tracking on the disc or the ability of the disc to spin properly.

Damage during a fire is often caused by smoke. Smoke will affect most discs in the general vicinity, leaving an oily film on the surface that interferes with signal retrieval.

Fire also produces particulate debris that may be deposited on the disc surface.

13.4 Dry debris

Unless a disaster results in fire or flooding, the primary concern is exposure of the discs to dry particulate debris. Most dry debris will not interact chemically with optical discs, but disc surfaces are highly susceptible to abrasion by contact with dry debris. Debris that adheres to the disc may also interfere with signal retrieval during playback.

13.5 Impact from disasters

Discs are highly susceptible to damage from impact. Physical damage (e.g. abrasion, scratches, cracks and gouges) can be caused by falling or the impact of collapsed structures. Discs not contained in cartridges or jewel cases are particularly susceptible to these problems.

13.6 Repair

Devices and methods to repair optical discs include sanding, polishing and/or filling of flaws in the disc surface. Pastes applied by hand may provide improvement for very light scratches. Commercial quality disc repair machines can provide reliable repairing of light or heavy scratches. These machines sand and re-polish the disc surface. Non-commercial quality repair devices, including handheld devices or small drive-type devices, are not recommended. It is recommended that only qualified personnel and systems be used in attempting to repair optical discs.

14 Disaster response

14.1 General

Optical discs exposed to disasters may not be destroyed by the initial exposure, but may be damaged as a result of improper handling after a disaster or from delay in remedial work. As soon as a disaster site has been secured against possible injury to personnel, discs shall be treated to mitigate contamination and damage. While discs are fairly resistant to chemical decay over short periods of time, they are highly subject to physical damage. They also may be contaminated with chemicals that will react with the disc structure during extended exposure. If possible, both the handling and the decontamination shall be performed by specialists. Migration of data to a new disc may often be desirable.

14.2 Wet discs

Discs are particularly vulnerable to water damage. Biological contamination, oxidation, dye fade and delamination can occur within 24 h of exposure to water. Where liquid is present, discs shall be decontaminated and dried as soon as possible. Decontamination shall be performed as specified in Clause 12.

All wet paper and cardboard, excluding labels, shall be removed from the vicinity of the discs as quickly as possibly to reduce water retention and potential fungal growth. If fungal growth is detected, discs shall be treated only by trained personnel.

Discs shall not be returned to long-term storage before decontamination and drying. If discs fail immediately after initial drying, further air-drying for several days may improve playability.

14.3 Dry discs

Dry particulate debris can become airborne and spread easily to the surrounding environment. Contaminated discs shall be isolated until decontamination is completed. Dry particulat debris shall be cleaned as specified in Clause 12.

15 Staff training

15.1 General

While the handling of optical discs may appear simple in comparison to legacy formats, emphasis shall be placed on the proper handling of all media. Only trained personnel shall handle optical discs intended for extended-term usage. The preservation and effective use of information contained on optical discs is directly related to, and enhanced by, a regular staff training programme.