



National Preservation Office

## Caring for CDs and DVDs

NPO Preservation Guidance  
Preservation in Practice Series



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### Introduction

Libraries, archives and museums hold a range of hand-held, portable media used to store photographs, text, audio and audiovisual material, games and software as digital data. CDs (Compact discs) and DVDs (Digital Versatile Discs/Digital Video Discs) are probably the most common types of optical disc found in collections. They may have been acquired as manufactured products (CD-ROMs, DVD-ROMs) or they may have been created by individuals or heritage institutions (CD-Rs and DVD-Rs). Sometimes they are attached to books or other printed material. The lifespan of data held on the discs is determined by the physical longevity of the discs and the redundancy of the machinery, hardware and/or software, needed to play them. The lifespan of discs is generally accepted to be less than that of traditional library and archive materials such as paper and parchment.

### Physical structure

All CDs and DVDs are made from polycarbonate plastic. All discs are read by a laser from the centre outwards; the laser follows a spiral datatrack, as the disc spins at high speed.

- A **CD-ROM** or **CD-R** has a thin protective lacquer layer on the top and sides that protects the data-reading layer and a label or printable surface is often applied on the top surface. The data-reading layer is located just below the top surface. It has a single data-reading layer and is read through the bottom surface only.
- A **DVD-ROM** or **DVD-R** has a recording structure and physical layering that provides a much higher data capacity than a **CD-ROM** or **CD-R**. It does not have a lacquer layer and the data-reading layers are located in the middle of the polycarbonate. A label or printable surface is often applied on the top surface. It can be single-sided or double-sided. Double-sided DVDs are read

through the top surface as well as the bottom. In addition each side can contain one or two data-reading layers. Secondary data layers are coated with a semi-reflective metal.

- The data-reading layer in a **CD-ROM** or **DVD-ROM** (read only memory disc) is impressed in the polycarbonate during manufacture as a series of pits and lands which are coated with a reflective metal layer.
- The data-reading layer in a **CD-R** or **DVD-R** (recordable write-once disc) consists of a photosensitive organic dye sandwiched between a polycarbonate and a reflective metal layer. A laser writes information into this layer by effecting a chemical change in the dye and an irreversible physical change in the polycarbonate layer, creating a pit pattern similar to that of a manufactured disc.
- The data-reading layer in a **CD-RW** or **DVD-RW** (rewritable disc) consists of a phase-changing metal between the polycarbonate and metal reflective layers. When heated the metal reverts to its original state to allow rewriting. Rewritable discs are not recommended for archival use.

## Physical risks

The following section considers issues that are important for both manufactured and created discs. If you are creating discs (CD-Rs and DVD-Rs) you will also need to consider the type of disc you should select, the writing equipment and the writing procedure. Please refer to the TASI publication, *Using optical media for digital preservation*.<sup>1</sup>

Incorrect environmental conditions can lead to delamination of discs and/or oxidation of the metal in the reflective layer. Dyes in CD-Rs/DVD-Rs will degrade over time; current research suggests that gold CDs with phthalocyanine dyes last longer than other types. If discs are not sealed properly during manufacture, the aluminium in the reflective layer may

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<sup>1</sup> *Using optical media for digital preservation*, Technical Advisory Service for Images, 2007  
[www.tasi.ac.uk/advice/delivering/cdr-dvdr.html](http://www.tasi.ac.uk/advice/delivering/cdr-dvdr.html)

oxidise, leading to disc failure. There have been isolated cases of so-called CD rot, that have been traceable to particular batches of CD-ROMs. Affected discs are discoloured with coffee coloured stains and when held up to a strong light pin-prick sized holes are visible. The stability of the bonding between the two sides and of the semi-reflective data layers of DVDs is unknown.<sup>2</sup> Loss of data or disc failure can occur if discs are marked or scratched. **Incorrect storage, handling and use can reduce the lifespan of all discs.**

### **Temperature**

A high temperature, a low temperature or a fluctuating temperature can cause damage to discs. The higher the temperature the faster the rate of chemical reactions and so the faster the rate of degradation. Discs should not be stored at a temperature exceeding 23°C. Temperatures below 0°C may lead to embrittlement and/or delamination. Fluctuating temperatures can cause discs to bend leading to microscopic cracks which may hinder the reading of the disc. The acceptable temperature ranges are either cold (0°C to 8°C), cool (8°C to 16°C) or room temperature (16°C to 23°C). Temperature should be set at a fixed point. At higher temperatures (room) the risk of chemical and mechanical deterioration increases, so cold and cool temperatures are considered more favourable. At lower temperatures (cold) it becomes more difficult and costly to control the relative humidity. Access copies of discs should be stored at a temperature similar to that of the environment in which they are used. If stored at a lower temperature the discs should be gradually acclimatised (within their enclosures) before use. This will reduce the risk of condensation.

### **Relative Humidity (RH)**

A high RH, a low RH or a fluctuating RH can cause damage to discs. The higher the RH the faster the rate of chemical deterioration. A high RH also increases the risk of mould which can interrupt playback. A low RH can cause embrittlement

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<sup>2</sup> See Schüller, D., Audio and video carriers: recording principles, storage and handling, maintenance of equipment, format and equipment obsolescence, Training for Audiovisual Preservation in Europe (TAPE), 2008 [www.tape-online.net/docs/audio\\_and\\_video\\_carriers.pdf](http://www.tape-online.net/docs/audio_and_video_carriers.pdf)

of materials leading to shrinkage and deformation. RH fluctuations can lead to layer separation, warping, cracking and pinholes in discs. Discs should be stored at a fixed point between 30% and 50% RH.

### **Air quality**

Air quality is reduced by particulate (small solids) and gaseous pollutants. Particulate pollutants can prevent the proper reading of carriers, cause surface abrasion and provide food for pests and moulds. Gaseous pollutants corrode the metallic reflective surface of CDs and DVDs. Particulate and gaseous pollutants come from external sources such as industrial facilities and traffic exhaust fumes and from internal sources such as deteriorating materials (including storage enclosures) and human activities such as photocopying, maintenance and building works. Air should be filtered to control particulate and gaseous pollutants, through an air handling system. If this is not practicable, the level of pollutants can be reduced by avoiding the use of materials which emit pollutants, such as photocopiers (ozone), certain paints and varnishes (solvents), new wood (acids), woollen carpets (gaseous sulphides) and sub-standard storage enclosures (acids) in areas where discs are stored and used. If building work or redecoration has taken place the level of pollutants should be allowed to fall to acceptable levels before reshelving discs. If particulate or gaseous pollutants are a problem, the level of contamination should be measured, its source determined and action taken to reduce or remove the pollutants.

### **Light**

Light, especially ultraviolet (UV), causes plastics to degrade. Light can also cause damage to the dye layers of CD-Rs and DVD-Rs. Discs should be protected from direct sunlight. Even if a disc is stored within a case the build up of heat can cause damage. Discs should be stored in the dark.

### **Handling**

Discs are easily damaged by poor handling. They can be scratched and marked. They may be dirtied by the deposition of foreign matter and fingerprints. Such damage can interrupt playback and provide food for

mould. Dust can also damage the playback equipment. The data-reading layer of CDs is located close to the top surface (label side) and can easily be damaged by poor handling.

- Archival copies should not be used for access purposes; access copies should be made and stored in a separate location from the original.<sup>3</sup>
- Ensure that hands are clean and dry before handling discs. When handling archival copies wear close-fitting vinyl or nitrile gloves. Cotton gloves are not suitable because they reduce dexterity, may leave fibre deposits on the discs and grease from the fingers gradually permeates through the cotton.
- Never touch the bottom (playing side) or top (label side) of discs. Handle them by the edge or centre hole.
- Do not bend or flex discs.
- Do not use adhesive tape or rubber bands on discs.
- Do not put any weight on top of a disc.
- Do not peel the label from a disc as this may delaminate the disc.
- Do not leave discs in playback equipment: there is a risk of damage caused by heat.
- Produce written handling guidelines for staff/users and ensure they are used.
- Provide handling training for staff/users.

### **Labelling**

Do not write on or apply labels to archive copies of discs. Labels can delaminate, warp and unbalance discs making them difficult to read. DVDs are more sensitive than CDs to any imbalance in the disc. This may also cause damage to playback equipment. Inks can cause damage to discs. If you need to mark a disc, use a xylene-free, soft felt-tipped pen with water-based ink and only write on the clear inner hub on the the label side of the disc.<sup>4</sup>

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<sup>3</sup> It is important to note that there is no legislation in the United Kingdom that permits preservation copying of copyright material held on discs, without permission.

<sup>4</sup> For example, the Optical Media Pen sold by the American Institute of Conservation Electronic Media Group <http://aic.stanford.edu/sg/emg/pen/>

## **Storage**

The manner in which discs are stored can cause damage. Do not stack horizontally as the top discs may fall, the bottom discs may be compressed and retrieval for access is difficult.

- Discs should not be stored unprotected. Where possible store CDs and DVDs in jewel cases.
- Discs should be stored vertically on the shelf with vertical supports at appropriate intervals that are at least as large as the item being supported or vertically in standard, ventilated archive boxes.
- Store on static or mobile shelving or metal storage cabinets.<sup>5</sup> Metal should be powder-coated or baked enamel. Wood/wood finishes should not off-gas acids.
- Shelving should be strong enough to take the load of the discs.
- Do not pack discs too tightly or loosely on shelves.
- Discs should be pushed back from the edge of the shelf.
- Archival copies and access copies should be stored in separate locations.
- Archival copies should be provided with the highest possible security and fire protection.

## **Storage enclosures**

Damage can be caused by storage enclosures which do not adequately protect the discs and by enclosures made of materials that are harmful. Where possible store discs in jewel cases. Although they may take up a greater volume of storage space, discs are held rigidly upright and the only point of physical contact between case and disc is the disc hub. Corrosive gases may be emitted from jewel cases or inserts made from polyvinyl chloride (PVC). In practice it is difficult to ascertain what kind of plastic a jewel case or insert is made from. If in doubt, consider using preservation quality jewel cases or anti-corrosion inserts for archival copies.<sup>6</sup> Storage materials made of polyester, polyethylene and polypropylene are recommended.

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<sup>5</sup> Static shelving is preferred to mobile shelving.

<sup>6</sup> For example, CD inserts from Conservation by Design Ltd or polypropylene CD cases from Preservation Equipment Ltd.

In general storage enclosures used for discs should:

- Protect the carrier from dust, dirt and mechanical damage.
- Fit properly, so that discs are not scratched.
- Support the weight of the material enclosed.
- Provide rigidity for safe handling.
- Be made of a material that has no adverse effect on discs.

In addition:

- Original card cases or sleeves are not appropriate for long-term storage. Card attracts moisture and may raise the RH of the immediate surroundings of the carrier which may increase the rate of chemical decay. Card also discards fibres and creates dust. If the original containers need to be retained they should be marked with the same reference as the contents and stored separately.
- Remove any paper/card inserts that are in direct contact with the disc. Paper inserts may be acidic and can stick to the label side of a disc.
- If possible remove the paper/card title inserts from the containers. There is a small risk that the disc will be damaged by the acidic products of paper degradation.
- If possible remove discs from books/magazines and store separately.
- If the disc cannot be removed from a book/magazine, ensure that the book is stored upright and does not sag or bend. If necessary place the magazine in an archival enclosure and support with acid-free card.

### **Housekeeping**

Regular housekeeping reduces the risk of damage caused by dirt, dust, pests and mould. It also provides an opportunity for visual inspection of the collection. You should:

- Introduce a regular housekeeping policy.
- Dust shelves and storage enclosures with a microfibre cloth.
- Vacuum the tops of shelves and the floor with a vacuum fitted with a High Efficiency Particulate Air (HEPA) filter.

- Check discs visually and by playback for signs of deterioration. If a disc contains errors or is slow opening up, try playing it in on another machine, as the error-checking efficiency of machines varies. If permitted copy to another disc.<sup>7</sup> If necessary, consider using some data-reclamation software<sup>8</sup> or if possible recreating the lost data (this may be easier).

### **Cleaning**

It may be necessary to clean discs before storing, recording or to enable playback. The removal of any material other than loose surface dirt or fingerprints should be referred to a specialist.

- Discs do not require routine cleaning.
- First try using an air puffer to blow off dust.
- Use a non-abrasive lens tissue or a non-abrasive lint-free cloth.
- Clean from the inside of the disc outwards as if following the spokes of a wheel. Do not clean in a circular pattern as this can make marks which resemble the data track which the laser will try to follow. If possible, avoid cleaning the label side of the disc.
- Try to avoid using water. If necessary clean gently with distilled water using a non-abrasive lint-free cloth. If possible, copy the disc after cleaning.<sup>9</sup>
- Try to avoid using solvents and lens cleaners.<sup>10</sup> If possible, copy the disc after cleaning.<sup>11</sup>

### **Playback equipment**

Dust can be transferred from discs to disc drives. If playback machinery is poorly maintained it can interfere with playback and can cause damage to the discs. You should:

- Keep all equipment clean and in good working order.

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<sup>7</sup> It is important to note that there is no legislation in the United Kingdom that permits preservation copying of copyright material held on discs, without permission.

<sup>8</sup> For example BadCopy Pro [www.jufsoft.com/badcopy/](http://www.jufsoft.com/badcopy/) or Data Rescue [www.naltech.com/index.htm](http://www.naltech.com/index.htm)

<sup>9</sup> See footnote 7.

<sup>10</sup> In Care and Handling of CDs and DVDs (p25-26), Fred Byers details cleaning solutions that he considers harmless [www.clir.org/pubs/abstract/pub121abst.html](http://www.clir.org/pubs/abstract/pub121abst.html)

<sup>11</sup> See footnote 7.

- Ensure equipment is regularly maintained to professional standards.
- Carefully follow any instructions or manuals.
- Train operators and allow only those people to operate the equipment.
- Keep records of all working sessions in both the equipment's and the carrier's documentation.
- Avoid frequent on-off switching of working hard drives. Let the machine run throughout the session.
- Clean drives routinely to prevent damage to discs.
- Remove the disc from the playback machinery when finished.

### **Repair**

It is possible to recover data from discs that have suffered spillages, scratches and even breakages. If you cannot recover the data in readable form then you might, with the aid of special software, be able to recover the byte stream. Do not throw away unreadable discs – technological advances may enable the recovery of the data at a later date. Be aware that damaged discs may damage disc drives. If you do not hold the copyright to the content and you do not have permission to make a copy, you cannot recover the data by copying it.<sup>12</sup> If you hold the copyright or have permission to copy the discs then migrate data from damaged discs as soon as possible.

- Breakages – Keep the pieces. If the breakage is at the outer edge, there is more chance of recovering the data, as a disc is read from the centre outwards.
- Delamination – Error correcting software will correct some of the errors. If the delamination is at the outer edge, there is more chance of recovering the data, as a disc is read from the centre outwards.
- Scratches – radial scratches on the reading side of DVDs and CDs can usually be corrected by error correcting software in the playback system. Circular scratches are not easily corrected and can cause the laser to follow the scratch rather than the data track. Minor scratches may not

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<sup>12</sup> It is important to note that there is no legislation in the United Kingdom that permits preservation copying of copyright material held on discs, without permission.

affect reading at all. Scratches on the label side of CDs can damage the reflective metal layer. The removal of scratches should be undertaken by a specialist.

- Warping – Due to structural differences warping affects CDs more than DVDs. Warped discs may be unreadable and may damage playback equipment. Repairs should be undertaken by a specialist.
- Water damage – For minor spillages discs can be cleaned using a non-abrasive lint-free cloth. If necessary clean gently with distilled water or soak in distilled water, blot off excess water and air-dry. Good quality discs are fairly resistant to water damage, although a disc inundated for a long period will start to absorb water. Discs immersed in polluted water or seawater should be cleaned. If discs have been immersed in dirty water or seawater immerse the discs in cool (about 5°C), clean water until recovery procedures can be started. Discs should be slowly air dried. Freeze drying and vacuum drying are not recommended because they can cause discs to distort. Data recovery should be undertaken by a specialist.

## **Obsolescence**

Playback machinery (hardware) and software usually has a shorter lifespan than the disc itself. This is referred to as obsolescence. Obsolescence is frequently caused by discontinuation in the manufacture and support of the playback equipment as well as changes in software. Obsolescence can be mitigated by:

- Recording details of carriers, manufacturers and file formats.
- Technological watch of hardware, carriers and file formats.
- Maintenance of hardware.
- Migration of information from the original disc to another carrier or digital storage system.

## **Migration**

Migration may involve copying unchanged data from older carriers to newer carriers or to other storage systems in order to mitigate the risk of disc failure.

*For CD-Rs and DVD-Rs current best practice suggests this should be undertaken between 2 and 5 years.*<sup>13</sup> Migration may also involve the transfer of data to new file formats or platforms, to mitigate the risk of software/ hardware obsolescence. This will need to be undertaken as and when necessary. You must record information about fileformats and keep abreast of technological changes.<sup>14</sup> If possible this information should be recorded as preservation metadata within a recognised metadata schema, such as Dublin Core.<sup>15</sup>

### **A strategy for migration**

A strategy for migration should be drawn up. Prioritisation should ensure that those items selected for migration are those at greatest risk and/or of greatest value to institutions/owners and users. A strategy for migration should be based upon the following:

- The importance of the collection to the institution/owner and in a wider context.
- The use of the collection. Is it for access? Is it an archive?
- The content of the collection. Is it made up of originals or copies? Is the material unique or are copies/originals held in other institutions?
- The condition of the collection.
- Does the collection need to remain usable for 5, 10, 20, 50, 100 or 500 years? If only 5 years then migration may not be necessary.
- Identification of media type and file formats.
- Knowledge of which items should be migrated as a priority. Is it the most used, the most important, the most vulnerable, the most degraded or the most at risk of obsolescence?
- Knowledge of available resources including staff, time, skills and funding.
- Co-operation with institutions holding similar material. It will avoid duplication of effort and aid with prioritisation.

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<sup>13</sup> *Using optical media for digital preservation*, Technical Advisory Service for Images (TASI), 2007 [www.tasi.ac.uk/advice/delivering/cdr-dvdr.html](http://www.tasi.ac.uk/advice/delivering/cdr-dvdr.html)

<sup>14</sup> The National Archives supports a free online registry of file formats, software products and other technical components [www.nationalarchives.gov.uk/pronom/](http://www.nationalarchives.gov.uk/pronom/)

<sup>15</sup> See *Metadata overview*, Technical Advisory Service for Images (TASI), 2007 [www.tasi.ac.uk/advice/delivering/metadata.html](http://www.tasi.ac.uk/advice/delivering/metadata.html)

### **Practical advice for migration**

- Ensure that proper handling procedures are followed and that environmental conditions are appropriate.
- Ensure that proper environmental conditions are maintained.
- Consider any new risks to the originals that the migration process may create.
- Do not permit any migration procedure which could change or damage the original.
- Care for the copy in the same manner as the original.
- Use the best quality equipment and materials.
- Try to migrate the data while the disc and the information held on it are in good condition.
- Keep the use of originals to a minimum.
- The copy should be unmodified, without subjective alterations and improvements.
- Do not use digital formats which use data reduction based on lossy compression.
- The copy should have the full dynamic range and frequency response of the original.
- All procedures and parameters should be documented.
- Copies should be checked for data integrity. They must be free of uncorrectable errors and have the lowest possible number of correctable errors.
- Store copies in a separate location from the originals.

### **Digital mass storage systems**

Digital mass storage systems (DMSS) are seen as the answer to the problems posed by obsolescence and the physical deterioration of discs. DMSS store information on hard drives and automatically check data integrity, refresh and migrate the information as necessary to avoid future obsolescence. They require considerable investment in terms of funding, time and resources. Digital mass storage is a new technology: standards are not fully defined, methodologies have been identified but not implemented and good practice is being established. In the long term DMSS should be used. It is necessary

to maintain a good, up to date knowledge of the field in order to keep abreast of changes and to know when DMSS become the tool recommended for the preservation of the information held on discs.

### **Copyright and other legal issues**

Physical owners of discs are required to comply with the copyright legislation as applied to the carrier in question, as well as specific terms and conditions of use which are stipulated in association with the disc. They must also comply with any contractual arrangements made in relation to the donation or deposit of the material. It is important to note that there is no legislation in the United Kingdom that permits preservation copying of copyright material held on discs, without permission. Useful websites containing further information about copyright include [www.collectionslink.org.uk](http://www.collectionslink.org.uk) and TASI (Technical Advisory Service for Images) [www.tasi.ac.uk](http://www.tasi.ac.uk).

### **Technical protection measures**

CD-ROMs and DVD-ROMs may be copy protected, which will prevent migration of the data and copying for access purposes. These technical protection measures are commonly referred to as Digital Rights Management (DRM). Circumvention of technical protection measures used to protect content, without authorisation is not permitted under UK Legislation.

## **Additional reading**

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<http://www.tasi.ac.uk/advice/delivering/cdr-dvdr.html>



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