Technical Bulletin 25

Canadian Conservation Institute

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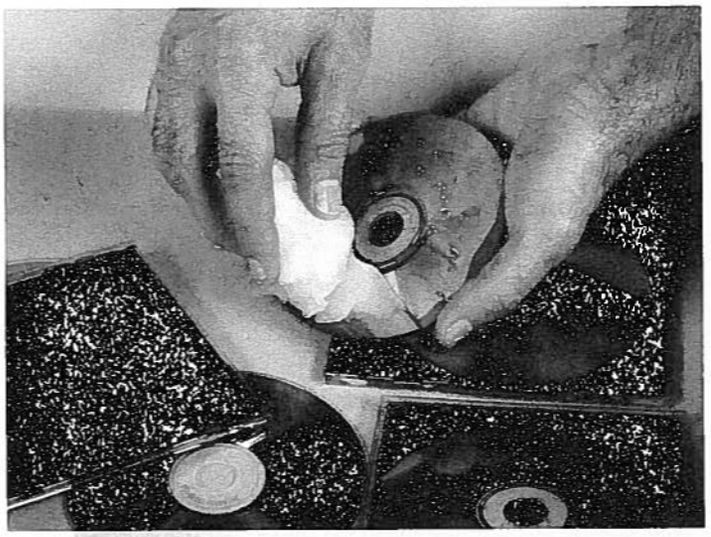
Disaster Recovery of Modern Information Carriers: Compact Discs, Magnetic Tapes, and Magnetic Disks



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Disaster Recovery of Modern Information Carriers: Compact Discs, Magnetic Tapes, and Magnetic Disks

by Joe Iraci

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Abstract

This bulletin summarizes some procedures for the disaster recovery of modern information carriers such as CDs, magnetic diskettes, and magnetic tapes following immersion in tap water, seawater, and dirty water. Procedures are also given for dealing with media that have hard-to-remove deposits on them or have been exposed to heat, dust/dirt, mould, and shock. These procedures are a compilation of information from the few case histories published, recommendations made by experts in the field, and research performed at the Canadian Conservation Institute. The information in this bulletin represents one piece of a comprehensive disaster plan; for disasters to be handled effectively, other key elements such as those dealing with disaster preparedness also need to be in place.

Author

Joe Iraci graduated from the University of Ottawa in 1987 with an Honours B.Sc. in Chemistry, and began working at the National Archives of Canada under the late Dr. Klaus Hendriks. In 1990, when the National Archives of Canada formed a Conservation Research Division, the emphasis of Joe's work shifted from photographic conservation and preservation to paper, namely paper stability studies, paper permanence, deacidification, and the accelerated aging of paper. In 1993, this Division was transferred to the Canadian Conservation Institute (CCI), where Joe currently works in the Conservation Processes and Materials Research Division. He was heavily involved in a joint study with the Pulp and Paper Research Institute of Canada that explored the effect of lignin on paper permanence. After the completion of this project, he began working in the field of electronic media, and has recently completed a research project sponsored jointly by CCI and the Canadian Council of Archives on the disaster recovery of optical discs and magnetic tapes and disks.

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Introduction

Modern information carriers (e.g. optical discs and magnetic tapes and diskettes) are machine-readable records, and the information they contain remains available only as long as the record can be read. Factors that could cause a record to become unreadable include:

- degradation of the materials of which it is made
- loss of the technology required to read it
- damage due to a disaster (e.g. exposure to water, fire, dust/dirt, mould, or shock)

Premature degradation can result from poor-quality materials, poor manufacturing techniques, or improper handling and/or storage.

The first consideration is to select good-quality materials. This is best accomplished by thoroughly testing all products before purchase. However, such test results can quickly become meaningless if manufacturers alter their formulations without informing consumers or have their products made by other companies. Therefore, unless testing can be conducted on a regular basis, the best option to obtain good-quality materials is to purchase brand name products from reputable manufacturers.

The manufacturing process also affects the longevity of modern information carriers. For example, in some of the earliest CDs produced the metal layer was not adequately protected from the environment. As a result, some of these CDs suffered from 'laser rot' (an oxidation reaction of the metal reflective layer in the CD), and could not be read within a couple of years of being produced.

Even properly manufactured products made of good-quality materials require proper storage conditions and correct handling procedures (International Organization for Standardization 2000; Michalski 2000) to ensure maximum longevity. However, because ideal storage conditions are not always possible, a monitoring program is also important. For example, magnetic tapes in storage should be examined frequently for problems such as binder hydrolysis (stickiness), flaking oxide, acetate base hydrolysis (vinegar syndrome), poor winds, physical distortion of tape or cassettes and reels, increases in error rates, etc.

The above precautions will ensure that the records themselves remain in good condition for as long as possible. However, even records in excellent condition cannot be read if the appropriate technology (hardware and software) is no longer available. The experience of the last few years has been that obsolescence of technology occurs approximately every 10–20 years, although the situation can be much worse. For example, of the approximately 50 videotape formats that were introduced between 1956 and 1995, 31 are now obsolete (Vidipax 1997). Therefore, in addition to preserving the information carrier itself, it is essential to copy the information to newer formats as major technological shifts occur.

Finally, it is important to be able to minimize the loss of information following a disaster. There are well-established procedures for disaster recovery of traditional media such as paper or photographic records (Buchanan 1994; Hendriks 1983), but the information for modern information carriers is limited to a few case histories (Atkins 1993; Van Bogart 1995a; Hendriks 1989) and recommendations (Walsh 1988; Van Bogart 1995b). Although a variety of techniques have been developed by various disaster recovery companies, these procedures are mostly proprietary and remain unavailable as general knowledge.

This bulletin summarizes a variety of procedures for the disaster recovery of CDs, magnetic diskettes, and magnetic tapes following immersion in tap water, seawater, and dirty water. Procedures are also given for dealing with media that have hard-to-remove deposits on them or have been exposed to heat, dust/dirt, mould, and shock. These procedures are a compilation of information from published case histories, recommendations made by experts in the field (Van Bogart 1995b), and research performed at the Canadian Conservation Institute (CCI) (Iraci 1999, 2000a, 2000b, 2001).

Note: When conducting any of the recovery procedures outlined in this bulletin, always wear latex or nitrile gloves to handle wet CDs, magnetic diskettes, and magnetic tapes. Once the materials have been cleaned and dried, use lint-free cotton gloves.

The information in this bulletin represents only one piece of an effective disaster plan. For disasters to be handled effectively other key elements such as those dealing with disaster preparedness also need to be in place.

Even when established procedures are available, successful recovery of media from a disaster is not always possible. Having a copy stored in a separate building or in another secure location is the best way to ensure the survival of all information.

Recovery from Tap Water or Seawater Immersion

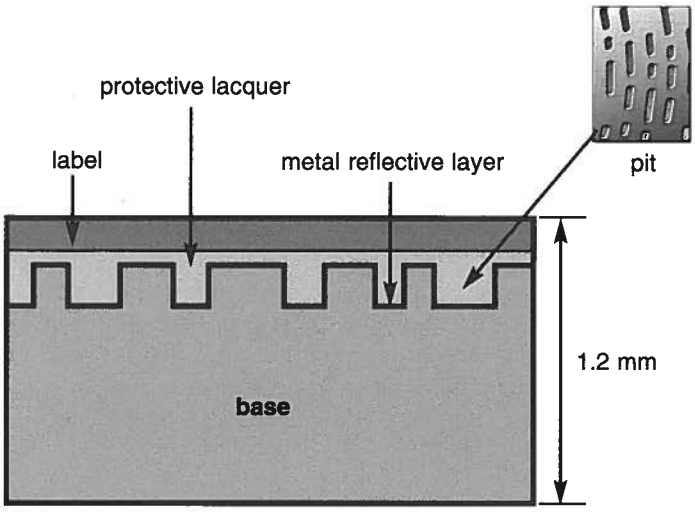
One of the most common threats to media is water — the source of which can range from pipe breaks to plumbing problems to extinguishing a fire. Exposure to seawater can also occur during natural disasters such as a hurricane or flooding in coastal areas.

Compact Discs

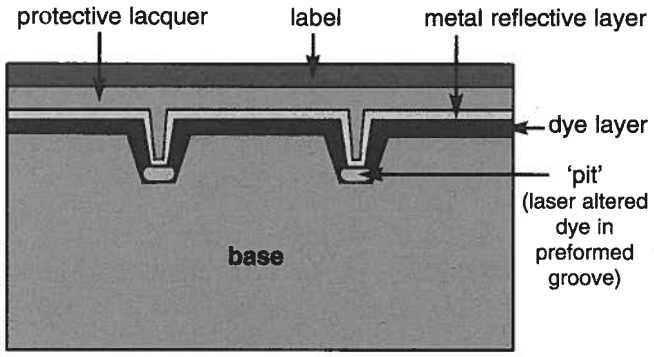
Note: Although this bulletin refers specifically to compact discs, the information can also be applied to most other formats of optical discs. For more detailed

instructions on the recovery of optical discs in the WORM format, see Van Bogart (1995a).

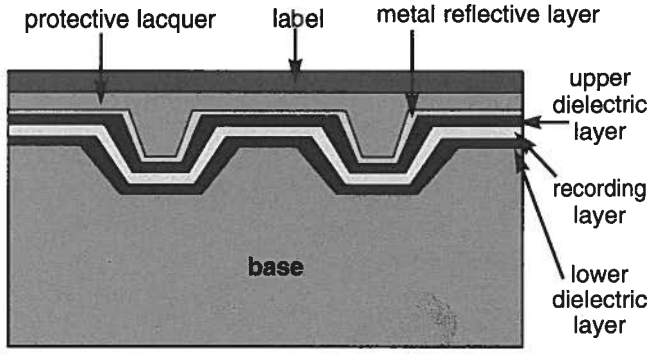
All types of compact discs [read-only (such as audio CDs, CD-ROMs, etc.), recordable (CD-R), and erasable (CD-RW)] are composed of several layers (see Figure 1). Of these, the metal reflective layer is probably the most important.



Read-only



Write-once



Erasable

Figure 1. Cross sections of the three types of CDs.

The purpose of the metal reflective layer is to reflect the reading laser light from the player back to the detector to create a signal. Therefore, any damage or deterioration to this layer will result in playability problems and the potential loss of the data contained on the disc. Unfortunately the metal reflective layer is an extremely thin metal deposit which is very vulnerable to physical damage. If a non-inert metal has been used it will also be subject to oxidation. This problem is compounded if the protective layer on top of the metal reflective layer is too thin or poorly resistant to chemical and physical damage.

Discs that are well manufactured (i.e. good-quality materials and properly assembled layers) are fairly impervious to water absorption because of the water resistance of the outer layers. The metal reflective layer in these discs will usually be unaffected by a reasonably short soaking in water. However, in the event of prolonged soaking (more than 1 week), some degree of water absorption is likely to occur with resultant damage to the disc (Iraci 1999; Iraci 2000a). Poorly manufactured discs may be more problematic. The lacquer coating might not uniformly cover the metal reflective layer or properly seal the edges of the disc, which could leave the metal layer exposed. In such cases the disc will be much less resistant to water soaking and damage could occur within 1 or 2 days. Examples of damage that might occur due to water soaking are shown in Figure 2.

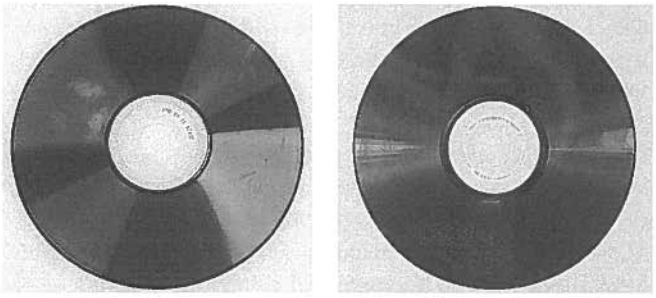


Figure 2. Left: *A recordable CD that was soaked for 8 days. The irregular blotches are a sign of damage to the dye layer in the disc. This disc cannot be read.* Right: *A read-only audio CD that was soaked for 28 days. The metal layer has been attacked (bottom middle portion) and light can be seen shining through it. This CD is also unusable.*

Procedure

Note: Conduct all recovery procedures cautiously as the surfaces of optical discs can easily be scratched.

If time and resources permit immediate salvaging:

1. Remove the disc from its case or cartridge. Cases or cartridges that are not damaged or deteriorated can be thoroughly cleaned with soap and water and re-used; damaged ones should be discarded.

2. Rinse the disc in clean room-temperature tap water and then in distilled water. If any residues remain, gently wipe the disc surfaces with a wet (distilled water) soft cotton tissue in a radial direction (see Figure 3) to remove them. Follow this wiping with another rinse in clean distilled water.

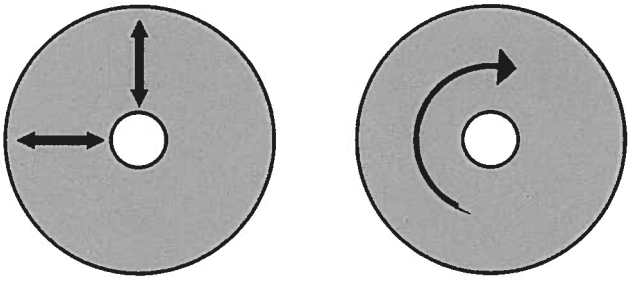


Figure 3. CDs should be wiped in a radial direction (left) *rather than a circular one* (right). *If scratches should occur during wiping, the error correction system is better able to correct radial scratches than circular ones.*

Wiping must be done carefully to avoid scratching the surfaces of the disc. This is especially true for discs that do not have tough topcoat layers (discs without these layers usually have a clear top layer and the metal reflective layer is visible underneath) or thick silk-screened labels. The top side of these discs can be very sensitive, and any scratches will likely lead to damage of the metal reflective layer (see Figure 4). This type of damage cannot be repaired, and if the error correction system cannot compensate for the presence of these scratches then some serious playability problems or data loss will occur. The base (non-label side) can also be scratched during wiping and, although scratching the base will not damage the sensitive metal reflective layer, it can lead to playability problems. If the error correction system cannot compensate for scratches to the base, they can sometimes be repaired with commercially available polishes or by disc repair services.

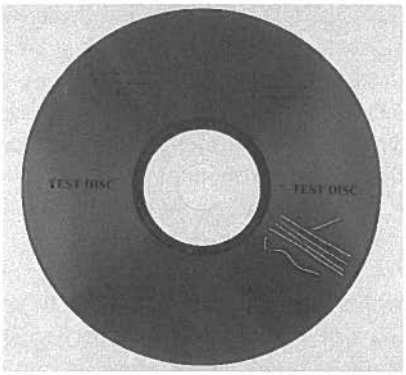


Figure 4. A read-only CD with scratches on the top side of the disc. When the laser light encounters this damage in the metal layer it will shine right through the disc rather than being reflected back to the detector. Therefore no signal will be created, and the disc will not play properly.

3. After rinsing the disc in distilled water, blot off any excess water with a clean soft lint-free tissue. This will prevent the formation of water spots during drying, especially on the base side of the disc. Do not use paper towels for drying as they can be abrasive.

4. When the excess water has been blotted off, lay the disc flat on tissue (label side down) and let it air-dry. Do not attempt to dry discs by freezing, vacuum freeze-drying, or exposing the discs to heat as these methods could cause delamination of the disc layers (see Figure 5).

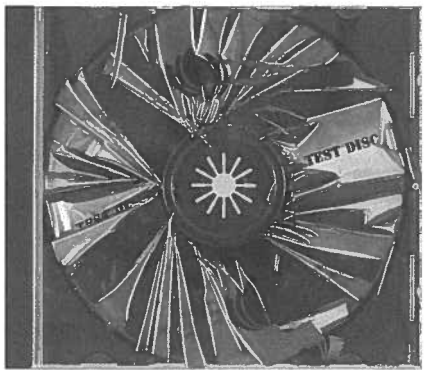


Figure 5. A recordable CD that was vacuum freeze-dried. The protective top layer and metal reflective layer have delaminated from the base of the disc.

5. Check the dry disc for the presence of spots. As optical discs are read through the base, spots on the label side will not affect their playability. Even spots on the base (non-label side) may not be problematic if the error correction system can compensate for them. Therefore it is important to play or analyse a disc to determine whether or not spot removal is necessary before attempting any aggressive removal procedures (which can cause scratching and serious playability problems).

   If it proves necessary to remove spots or residues, soak a Q-tip in distilled water and gently rub it in a radial direction over the area that needs to be cleaned (Van Bogart 1995a). Blot the disc dry and leave it to acclimatize to the use environment for a couple of days before attempting to play it.

The best chance of avoiding damage in a water-related disaster is to limit the length of time a disc is wet. The best scenario is therefore to salvage discs immediately. However, there will be times when resource limitations, the large volume of material that needs to be salvaged, and the priority of other materials will make immediate recovery impossible.

If immediate salvage is impossible, the following procedures will minimize damage to a disc that must remain wet:

1. Rinse the disc in clean distilled water and store it in cool water (about 5°C) until it can be recovered. Poor-quality

discs have shown problems after just 1 or 2 days of soaking in room temperature tap water, but no problems or less significant ones after even 28 days of soaking in cool water (Iraci 1999; Iraci 2000a). Rinsing before storage is especially important for discs that were immersed in seawater; however, if rinsing is not possible, simply store the discs in cool water.

Discs should be left in their cases when they are placed in cool water for storage; this will prevent damage that might occur if the discs rubbed or came in contact with each other.

2. As soon as time is available to recover the disc properly, follow the salvage procedures outlined previously.

Some discs may contain an adhesive label on the top surface, although the use of such labels is not generally recommended (International Organization for Standardization 2000).[1] If the label has rippled and developed small air pockets, it is likely to cause playability problems and errors. In such cases the label will have to be removed. Do not attempt to peel an adhesive label off as this could lead to delamination of the top layers of the disc (see Figure 6). Instead, remove the label with a suitable organic solvent (check with the manufacturer of the disc or perform some spot testing to ensure the solvent is compatible with the disc).

Figure 6. As the adhesive sticker is peeled off this CD the top layers of the disc (including the metal reflective layer) are being delaminated.

Discs may need to be copied onto new media after they have been recovered to guard against future problems, but this is not always necessary. Inspect the recovered discs (visually and with an optical disc analyser[2]); if there is no physical damage and only a small number of errors, then the discs can be kept. However, it would be a good idea to monitor recovered discs a little more frequently than the rest of the collection.

Magnetic Diskettes

Magnetic floppy disks are made of fairly water-resistant materials in a layered structure (see Figure 7), and are double-sided. The base provides the support for the disk; the binder holds the magnetic particles in place and also protects them; and the magnetic particles hold the recorded information. It is easy and relatively inexpensive to copy floppy disks, so it is always a good idea to make back-up disks and store them in a separate location.

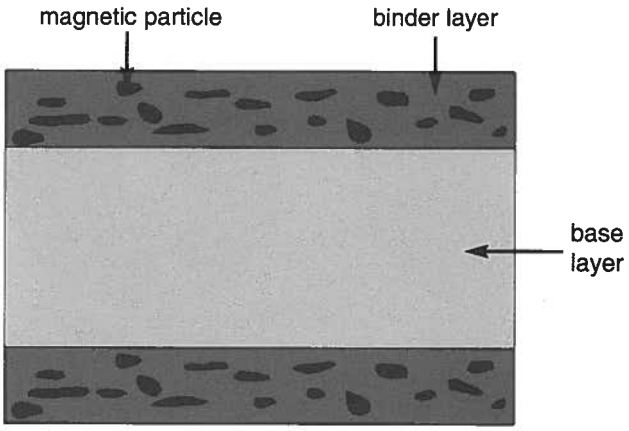


Figure 7. The structure of a magnetic floppy disk.

Procedure
If time and resources permit immediate salvaging:

1. Remove the diskette from its jacket in order to clean it properly.

   A 5.25-in. diskette can be removed from its jacket by cutting carefully along the edge of the jacket with non-magnetic scissors [caution is necessary because there is only a very small gap between the diskette and the edge of the jacket]. Alternatively, the jackets of 5.25-in. and 3.50-in diskettes can be pried open (as shown in Figure 8) taking care not to damage the diskette inside. Carefully remove the diskette without rubbing it against any sharp edges of the enclosure. Do not re-use the jacket.

2. Rinse the diskette in clean distilled water at room temperature. If any dirt or residue remains, place the diskette on a smooth flat surface and gently wipe both sides in a circular fashion with a soft wet cotton tissue or cloth. Note that the recommended wiping direction is circular rather that radial (as was recommended for CDs); circular wiping is safer for magnetic disks because fewer files would be affected should a scratch occur. After wiping, rinse the diskette again in clean distilled water.

3. Gently blot off any excess water remaining on the diskette with a clean soft lint-free tissue to prevent the formation of water spots during drying. Do not use paper towels which can be abrasive.

4. Allow the diskette to air-dry. Do not freeze, vacuum freeze-dry, or expose the disk to heat to dry it (although the consequences of using these methods are much less severe than they would be for CDs).

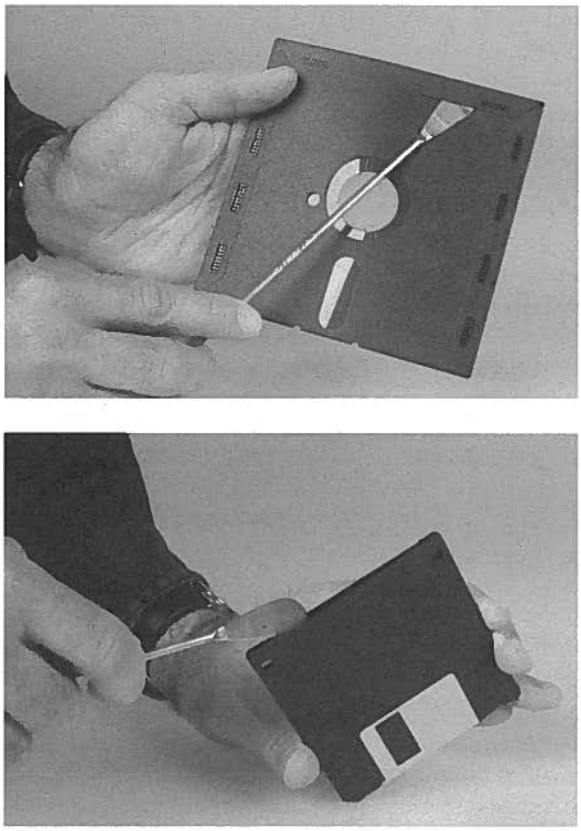


Figure 8. Prying open the jackets of (top) *a 5.25-in. diskette and* (bottom) *a 3.5-in. diskette.*

5. Inspect the diskette after it is dry and, if necessary, remove any spots or left-over residue by gently rubbing the area with a Q-tip soaked in distilled water. Blot the diskette dry again and leave it to condition to the use environment for a couple of days before attempting to use it. If any residue or debris remains on the dry diskette, remove it by rubbing gently with a soft dry cloth.

   It is very important to ensure that all residue is removed from the diskette before it is used, as any that remains will create a separation between the read heads and the diskette and result in read errors. Diskettes can tolerate a certain amount of rubbing without damage. However, any kinking of the diskette that occurs from poor handling and vigorous wiping, or any scratches on the diskette surfaces, will lead to permanent damage of the diskette, readability errors, and loss of data.

6. After the diskette has been conditioned to the use environment, remove any dust from the surface with compressed air.

7. Insert the cleaned diskette into a new jacket (taken from a new diskette) and make a copy of it.

If immediate salvage is impossible, the following procedures will minimize damage to a diskette that must remain wet:

1. Rinse the diskette thoroughly in clean distilled water and store it in cool water (about 5°C) until it can be recovered. Recovery procedures should be carried out as soon as possible, although tests have shown that several weeks of soaking will not cause additional read errors. The benefits of storing diskettes in cool water rather than room temperature water are not as marked as they are for optical discs (Iraci 1999). However, cool water storage is still recommended because it will prevent mould growth and retard any chemical reactions.

   Diskettes that are stored in cool water for a long period should be left in their jackets in order to protect them from contact abrasion.

2. As soon as time is available to recover the diskette properly, follow salvage procedures outlined previously.

Floppy diskettes that have been immersed in water may be stained on the surface (see Figure 9). However, such staining is <u>not</u> indicative of the presence of read errors so *do not assume that a stained diskette is no longer readable.*

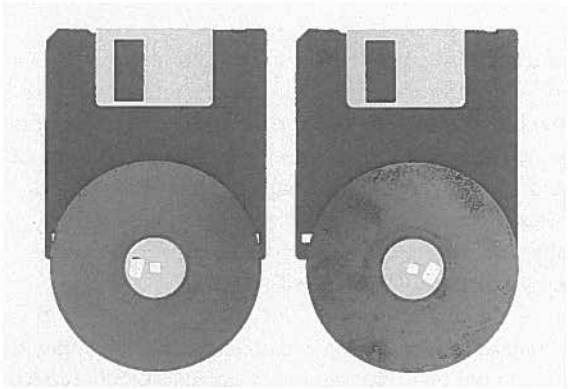


Figure 9. A stained floppy diskette (right) *versus an unstained diskette; neither one contains read errors.*

If diskettes do contain errors after recovery from water immersion (or after any of the other recovery procedures mentioned in this bulletin), the information may still by accessible through the use of recovery software such as Norton Utilities.

First, analyse the diskette for errors (Norton Utilities can read the entire diskette surface in a few minutes). If errors are found, analyse the diskette again in an attempt to reduce the number of errors. [The abrasive action of the read heads in contact with the diskette might remove dust or debris that is causing separation between the read head and the diskette surface; for this reason the read heads should be cleaned frequently when recovering diskettes.] When no more errors can be eliminated in this way, use error correction software to recover as much of the information as possible off of the diskette.

Magnetic Tapes

Tapes are constructed of layers of water-resistant materials (Figure 10 shows a cross section of a typical magnetic tape). Although exposure to water will not cause these layers to swell and break up (as would the layers in photographic materials), tapes can still be damaged.

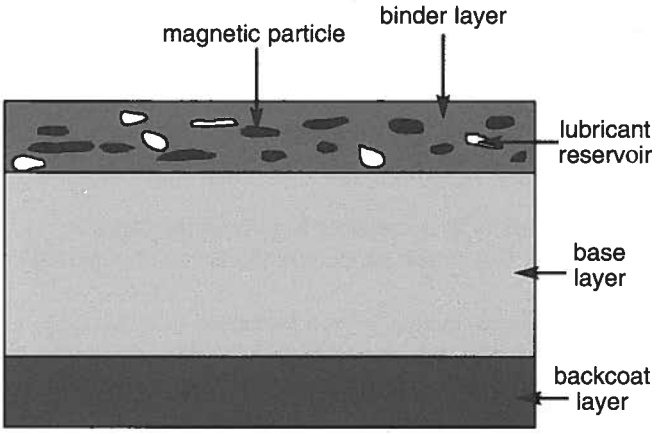


Figure 10. Cross section of a typical magnetic tape.

A variety of base materials can be used in magnetic tapes, and different base materials react differently to water immersion. Older tapes with paper as the base material are very susceptible to damage during water immersion and should be recovered immediately. Plastic-based tapes immersed in water can suffer chemical degradation or physical distortion (acetate-based tapes are more sensitive than polyester-based tapes).

The magnetic layer of tapes can also vary in composition, and some are more vulnerable to corrosion than others. Metal particulate (MP) and metal evaporate (ME) tapes, which are used for high-density recordings, high-grade video, and digital applications, do not withstand soaking in tap water as well as magnetic oxide tapes. In ME tapes, the magnetic material is deposited on the base material as a thin layer with no binder. Some protection from oxidation and damage is provided by additional top layers and lubricants. In MP tapes, the magnetic layer consists of iron particles coated with a passivating layer to protect them from oxidation. This protective layer is very sensitive to chlorine and comes apart when soaked in tap water (even cold tap water) which exposes the iron particles (which are highly susceptible to degradation via oxidation) to external influences (Brothers 1999).

The binder layer may also cause problems when tapes are immersed in water. The binder is typically a polyesterurethane polymer that is susceptible to degradation via hydrolysis (the polymer molecules react with water and break down). Although this reaction occurs slowly, degraded binder may be encountered in tapes that have been soaked for a long period — especially older tapes in which the binder is more likely to be in poor condition.

A brief summary of the recovery priority of the various types of magnetic tapes is provided in Table 1.

Table 1
Recovery priority of different tapes (Van Bogart 1995b)

	Recovery Priority
Base Material	Paper before Acetate before Polyester
Magnetic Material	Metal Evaporate before Metal Particulate before Iron Oxide before Barium Ferrite
Age	Older before Newer

Soaking in water could also lead to extraction of lubricant from a tape (Iraci 2001). This will leave hard-to-remove debris on the tape, the presence of which will cause numerous dropouts (momentary signal losses) when the tape is played. As it is impossible to predict which tapes may suffer this effect, it is best to store all tapes in suitable plastic cases (International Organization for Standardization 2000) in an effort to prevent them from getting wet.

Procedure

Water and debris cannot readily penetrate a properly wound tape. Therefore, the degree of effort required to recover tapes from an immersion in water, and the success of the effort, is largely determined by how well a tape is wound onto its reel. For a good-quality tape pack (for cassettes or reel-to-reel tapes), wound at the correct tension, an external cleaning of the tape pack may be all that is necessary. However, a poor-quality tape pack, one that is wound loosely (see Figure 11), or one that has popped strands (i.e. edges of the tape popping out of the tape pack; see "Recovery from Shock") will likely have water and debris between the tape layers. In such cases the individual tape layers will have to be cleaned.

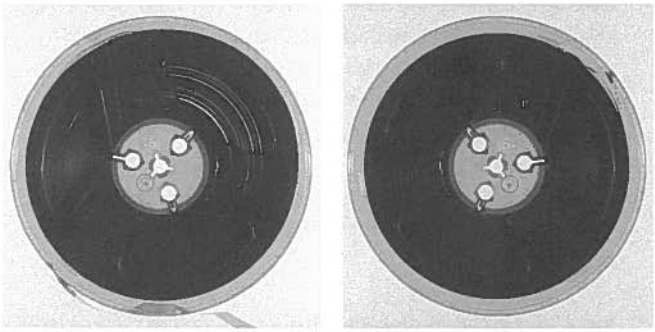


Figure 11. A loosely wound tape pack (left) *and one that is wound at a more acceptable tension* (right). *Notice the gaps ('windows') between the layers of tape in the loosely wound tape pack. Such gaps allow debris to penetrate the layers, which makes for a more involved recovery procedure.*

If time and resources permit immediate salvaging:

1. Drain any excess water out of the cassette or off the reel of tape.

2. Immerse the tape in distilled water (this should be done as soon as possible if tapes were soaked in seawater).

   For cassettes: Immerse the cassette in a bath of clean distilled water. Remove it from the bath and wipe the surfaces with a wet soft cloth. Then pour distilled water into the cassette housing to fill the tape compartments. The cassette gate (if present) may be flipped open to fill the housing more easily and for thorough cleaning of this area. Shake the water in the cassette for a few seconds and then pour it out. Repeat this procedure two more times.

   For reel-to-reel tapes: Place the reel of tape in a bath of clean distilled water and agitate it. Remove the tape from the water and repeat the procedure two more times using clean distilled water each time.

3. Hand-dry all external surfaces with a clean soft lint-free tissue, and allow the tapes to air-dry.

   For cassettes: Shake as much water as possible out of the cassette housing (the gate of the cassette housing can be opened to facilitate water removal). Stand the tape vertically with the empty hub on the bottom for air-drying.

   For reel-to-reel tapes: Carefully separate the flanges from the tape pack with inert spacers to promote water run-off and air flow. Stand the tape vertically for air-drying, but be sure to support the hub rather than allowing the tape to rest on the flanges (which could damage or distort the flanges and eventually damage the tape) (see Figure 12).

   Allow the dry tape to acclimatize to the use environment for 2 days before attempting to conduct further treatment. Never wind or play a tape that is wet.

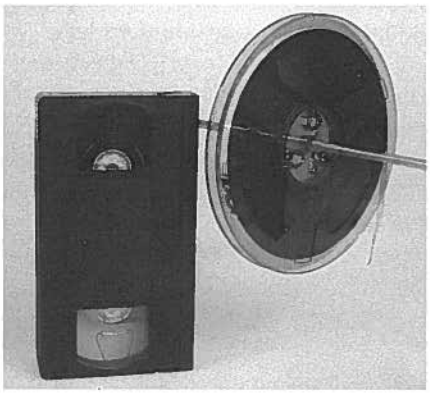


Figure 12. Drying position of cassette and reel-to-reel tapes after they have been cleaned.

The drying process can be accelerated by forcing room temperature air through the tape, but this must be done in a dust-free environment so as not to contaminate the tape with debris (see "Removal of Debris"). Dehumidification or vacuum drying at room temperature can also be used. Under hard vacuum, 0.5-in. (1.25-cm) tapes require 2–3 days for total dry-out; 1-in. (2.5-cm) tapes require 4–5 days. After vacuum dry-out, tapes should be exposed to use conditions for 24–48 h before further treatment. Do not unwind dried tapes prior to conditioning as they may be brittle and could break. These alternative drying methods may be preferable to simple air-drying as they speed up the drying process and reduce the risk of tape layers sticking together (Cuddihy 1994).

Drying at high or low temperatures can cause problems, and should generally be avoided. Do not freeze tapes for subsequent thawing and air-drying. Likewise, drying with heat, vacuum thermal-drying, and vacuum freeze-drying are not recommended. Heat can tighten the tape pack, distort the tape backing, and increase the amount of print-through (transfer of signal from one layer of wound tape to an adjacent layer of wound tape) for audio tapes. Low temperatures can loosen the tape pack making it more susceptible to slippage and tape edge damage. Any water that is trapped between tape layers will expand as it freezes and can distort the tape. Low temperatures can also cause migration of lubricant out of the tape to the surface which can affect the playability of the tape.

Note: Recent experiments on VHS tape (Iraci 2001) showed that vacuum freeze-drying or a freeze – thaw – air-dry sequence did not produce catastrophic results. In some cases, these drying methods were comparable to air-drying. However, overall the use of heat tended to result in more problems than air-drying.

4. Once dry and conditioned to the use environment, clean the tape thoroughly using tape cleaning equipment that includes a burnishing blade (for polishing the tape surface) and a special non-abrasive tissue (to wipe the tape surface clean). The tape should be run through the cleaner until little or no debris is visible on the burnishing blade. For tapes that do not have a lot of debris, two passes on the tape cleaner with tissue and blade should be sufficient. For tapes with a lot of debris, make four or five passes on the cleaner with just the tissue in place, then two passes with both the tissue and blade in place. This should avoid problems with the debris (see "Removal of Debris").

   This type of cleaning is suitable only for tapes in which the binder is in good condition. If the binder is in a weakened conditioned or has hydrolysed significantly (is suffering from 'sticky-shed syndrome' and is sticky), then a burnishing blade should not be used. Such tapes can be cleaned with tissue alone or other last resort

restoration method such as 'baking' (exposing the tape to elevated temperature in order to reduce the stickiness of the tape caused by hydrolysis) (De Lancie 1990; Fox 1990; Kent 1988). Another option for these tapes is to send them to a professional restoration facility.

5. Once the tape has been cleaned, it should be copied as a precaution. If the recovered tape is kept it should be inspected frequently to ensure that no problems (e.g. mould growth) develop as a result of the exposure to water and subsequent recovery procedure.

Cassettes/cartridges or reels showing damage or corrosion should be disassembled and replaced. In fact, it is advisable to routinely replace cassettes or cartridges that have been exposed to any trauma, even if obvious deterioration of the housing is not evident.

If immediate salvage is impossible, the following procedures will minimize damage to a tape that must remain wet:

1. Rinse the tape in distilled water (especially important if it was immersed in seawater).

2. Place the tape in cool distilled water (about 5°C) as soon as possible for storage until it can be handled; this will retard mould growth and binder hydrolysis. The amount of time that tapes can remain wet in cool water is difficult to determine and depends on factors such as tape quality and type of magnetic material used in the tape. Generally, it is best to limit the amount of time that the tapes remain wet bearing in mind that other materials such as paper documents, books, and photographs should be recovered first.

   Once wet, it is important that tapes remain wet until they can be properly cleaned. If they are allowed to dry out prematurely, it is likely that hard-to-remove deposits or spots will be created on the tape.

3. As soon as time is available to recover the tape properly, follow the salvage procedures outlined previously.

Recovery from Dirty Water Immersion

In disasters such as a flood the water may be very muddy, dirty, or tainted with sewage. This is a common occurrence in Canada where springtime flooding of basements is often routine. In this situation the salvage procedures vary slightly from those in clean water recovery. In all cases, it is important to clean the media as soon as possible.

Note: It is essential to take appropriate health and safety precautions, and use proper safety equipment (e.g. gloves, etc.), when dealing with materials that have been contaminated with polluted water.

Compact Discs

Procedure

1. Remove the disc from its case or cartridge. Soak a sponge in soapy (dishwashing liquid that is dye- and perfume-free) tap water and then squeeze the water onto the disc to rinse off the loose dirt. Do not rub or wipe the disc because loose grit could scratch the surfaces (Van Bogart 1995a).

2. Once the loose debris has been removed, gently wipe the surface with a soft cloth soaked in the soapy water to eliminate any residual or more tightly adhered debris. Be sure to wipe in a radial direction.

3. After wiping with the soapy water, rinse the disc in distilled water and then follow the salvage procedures described previously for tap water or seawater immersion.

4. The storage case can be cleaned and re-used if there is no sign of damage or deterioration; otherwise it is preferable to replace it.

Magnetic Diskettes

Procedure

Rinse the diskettes in clean tap water and remove them from their enclosures as previously described. Follow the initial recovery procedures outlined above for CDs, and then move on to the procedures described for recovering magnetic diskettes from tap water or seawater immersion. Remember that all wiping should be done in a circular direction.

Magnetic Tapes

Procedure

1. Clean the cassette or reel of tape as soon as possible by immersing it in a soapy (dishwashing liquid that is dye- and perfume-free) distilled water bath to remove dirt and oily or greasy debris.

2. Rinse the tape in distilled water to remove soapy residue.

   Inspect the tape visually to ensure it is clean. If the internal portion remains dirty, cassettes or cartridges must be disassembled in order to clean the tape properly. For reels, it may be necessary to remove the flanges (if they are removable) to clean the tape more thoroughly. If the cassettes or reels are not damaged or corroded, they can be cleaned with soap and water and re-used; however, it is preferable to replace them with new cassette shells or reels from the same type of tape.

3. Once the tape is clean, continue with the recovery procedures outlined previously for recovering magnetic tapes from tap water or seawater immersion.

Removal of Debris (Dust, Soot, etc.)

Compact Discs

Any type of debris (e.g. smoke particles, soot from a fire, dust, etc.) that is present on a CD could contaminate and damage the reading equipment if the CD is played. Debris on the non-label side of a CD could also interfere with the readability of the data. Such contaminants must be removed prior to playing the disc.

Procedure

1. Isolate the contaminated disc to avoid spreading the debris.

2. Remove minor debris with compressed air or nitrogen dusters, or gently wipe the disc surfaces with a soft non-abrasive tissue such as lens tissue or cloths specially designed for CD cleaning. Be sure to wipe in a radial direction.

3. For major contamination, remove loose debris with a soft-bristled brush or a vacuum cleaner with a HEPA filter taking care not to scratch the surface of the disc. Wipe off (radial direction) any remaining debris with a soft lint-free cloth dampened in distilled water. Blot off the excess water and air-dry the disc.

4. If large amounts of debris are present, it may be necessary to immerse the disc in distilled or soapy water to clean it. Before proceeding, ensure the disc is intact (otherwise water could penetrate the layers and ruin the disc). If the disc is immersed in water, continue with the recovery procedures outlined previously for dirty water contamination.

   Note: Immersing the disc in water should be avoided whenever possible. It is not a routine procedure, but rather a method of last resort.

Magnetic Diskettes

Debris on magnetic diskettes will lead to read head separation from the diskette surface and read errors (see discussion below for magnetic tapes).

Procedure

1. Isolate the contaminated diskette to avoid spreading the debris.

2. Remove debris from the diskette enclosure. This can be done by blowing it off with compressed air or nitrogen dusters, gently wiping it off with a soft non-abrasive tissue or cloth or a soft-bristled brush, or vacuuming it off with a vacuum cleaner fitted with a HEPA filter.

3. Remove the diskette from its enclosure as previously described.

4. Follow the recovery procedure outlined above for CDs, except that wiping should be done in a circular direction.

Magnetic Tapes

The presence of debris on tape is very problematic. For tapes to be recorded or read, the reading/recording equipment heads must be in contact with the tape surface. The presence of debris leads to separation of these heads from the tape, which results in momentary losses of signal (dropouts). Higher density media are affected more than lower density media, as each speck of contaminant obscures more data. Debris can also contaminate and damage reading equipment, or scratch the tape. It may also get in between layers of wound tape leading to tape deformation. Any debris that is present must be removed before attempting to play a tape. Figure 13 illustrates the types of debris that can be found on magnetic tape, and their comparative sizes.

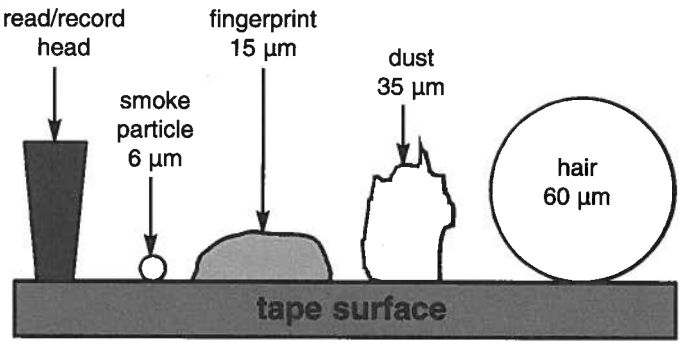


Figure 13. Common contaminants that may appear on the surface of magnetic tapes.

Procedure

1. Isolate the contaminated tape to avoid spreading the debris.

2. Remove debris from the container housing the tape with a vacuum cleaner equipped with a HEPA filter. Carefully open the tape. If debris has penetrated the container, vacuum the external portion of the cassette or tape pack itself (for reel-to-reel) being careful not to contact it.

   Note: Before applying the vacuum, check that the tape inside cassettes is not loose. Use only low suction power as strong air currents can cause the tape inside a cassette to vibrate, resulting in edge damage.

3. Remove remaining debris from the tape pack or the cassette shell with a soft brush.

4. If any debris still remains adhered to the cassette shell or reel hub and flanges, remove it by wiping the tape pack or cassette with a soft lint-free cloth dampened in distilled water.

Figure 15. Serious damage can result when CDs are subjected to extreme heat, e.g. from a fire.

Note: This is a last resort treatment to recover unplayable discs. It may cause delamination of the disc layers or embossing of the thin metal reflective layer (these effects are more likely above 120°C, but may also occur at lower temperatures). Use with caution.

Magnetic Diskettes

Exposure to heat can lead to melting or deformation. Diskettes damaged in this way are likely unrecoverable.

Magnetic Tapes

A properly wound tape pack is a poor heat conductor and thus provides some protection against exposure to heat.

Procedure
Exposure to intense heat (such as a fire) is likely to melt and fuse tape into a solid block. Tapes in this condition are not recoverable.

Exposure to moderate heat may distort tape or warp reels and cassettes. However, if warped reels or cassettes are replaced, the distorted tape may still play. Another consequence of exposure to moderate heat is an increase in the wind tension of the tape pack. This will result in distortion and stretching of the tape, leading to tracking problems and dropouts. To alleviate the increase in wind tension, let the tape condition to the use environment for 24–48 h and then carefully rewind it at a minimum tension. Before attempting to play the tape, inspect it for debris; if debris is seen, treat the tape as outlined previously in "Removal of Debris."

Recovery from Shock

Compact Discs

CDs can experience shock as a result of storage shelves falling over or the disc itself being dropped. Bending is also a form a shock. The usual consequence is that the disc breaks or the layers delaminate, resulting in an unrecoverable disc. However, CDs with pieces missing only on the outer portions may still be playable to some degree. [CDs begin playing from the inner portion of the disc and end at the outer portions; any imbalance of the disc is minimized in the middle because the position is still relatively near to the hub. Therefore, if the middle portion of the disc is still intact the disc may play well at least until the broken area is encountered.] Keeping this in mind may allow some information to be recovered from a broken or cracked disc.

Magnetic Diskettes

Magnetic diskettes suffer shock when they are bent, creased, or scratched as a result of the application of a physical force. Any such damage leads to an unrecoverable disk or one with many errors.

Magnetic Tapes

Tapes can suffer shock as a result of storage shelves falling over or the tape itself being dropped.

Procedure
Mild shock — The usual result of a mild shock is a loosening of the wind tension of the tape pack. This causes the tape pack to shift and results in popped tape strands or a flange tape pack (see Figure 16). If used in this condition, the edges of the tape are likely to be damaged by rubbing against the flange and the result will be tracking problems. A loosened tape pack also causes gaps to develop between strands of tape which can result in the tape creasing (cinching). Finally, a loose tape pack can allow debris to enter between the strands — leading to tape deformation and dropouts when the tape is played.

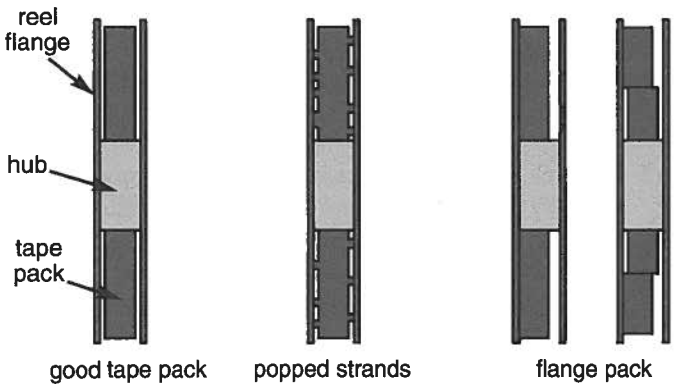


Figure 16. A good tape pack (left) *and others that are not ideal (Van Bogart 1995c).*

The remedy is to rewind the tape using the 'Play' mode. ['Play' mode provides the most constant tension and produces the best-quality wind; high-speed 'Rewind' or 'Fast Forward' produce uneven tension in the reel of tape

and the higher speed may damage the tape edges as they rub against the flange]. For cassettes, wind the tape all on one hub. For reel-to-reel tapes, wind the tape in the tails-out position (this is the already played position, i.e. the tape would have to be completely rewound in order to play it). Secure the tape ends (wraparound collars can be used for this) so that the wind does not loosen during storage. In addition, inspect reels and cassettes and replace those that are damaged or do not seem to be performing well.

Severe shock — Tapes that suffer severe shock may fracture, wrinkle, or crease, and the cassette or reel may break. In this case, begin by cleaning off as much of the debris as possible (see "Removal of Debris").

A tape that is broken can be spliced together provided good-quality manufacturer-produced splices are used. Never use general-purpose adhesive tapes for splices as these will contaminate the magnetic tape with adhesive. Poor splices can also lead to deformation of the tape and possible damage to equipment used to play it.

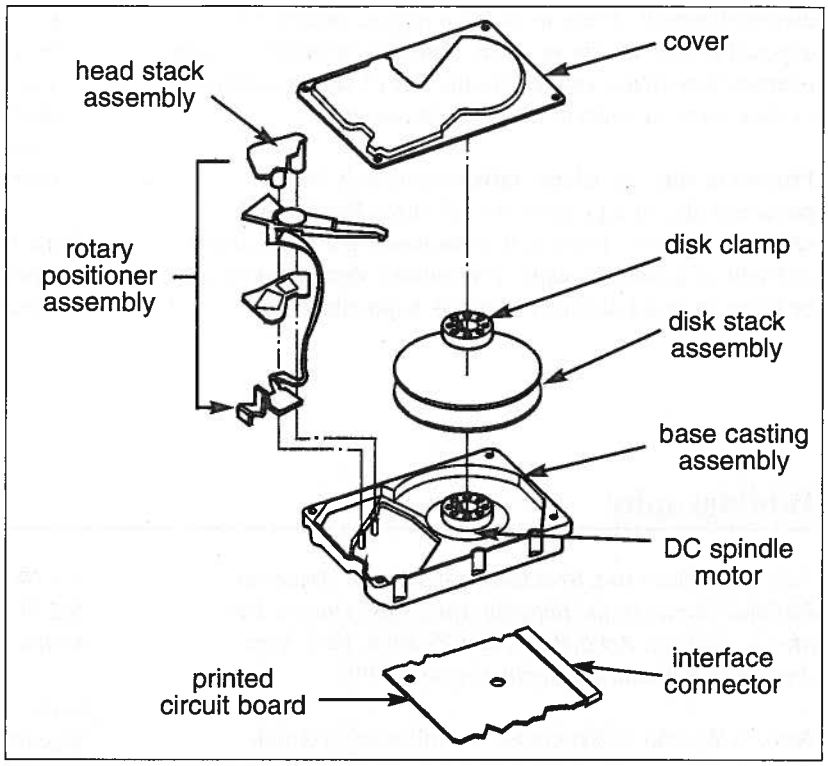


Figure 17. The structure of a magnetic hard disk. One or more disk platters are housed in a tightly sealed case (illustrated from an image from http://shell.rmi.net/~jimkw/fig1.htm).

A tape that is wrinkled or creased should be respooled and left in storage for several months. The sustained tension in the tape pack over this time period may relax the creases so that the tape can be played satisfactorily. A second option to smooth out the creases in the tape is thermal reconditioning. Unspool a 1- to 2-ft. (0.3- to 0.6-m) section of tape from the reel or cassette and lay it magnetic side down on a smooth Teflon sheet. Using an iron at a low setting, press down on the backing side of the tape. No back and forth ironing is required (Van Bogart 1995b).

Note: Thermal reconditioning produces quicker results but also has more potential for causing further damage. It should be reserved for more severely wrinkled tape and used with caution.

Magnetic Hard Disks

The surfaces of the actual disk platters of magnetic hard disks must be free from contamination in order for the hard disk to function properly. [The 'read-heads' in a hard disk assembly float on a very thin cushion of air when the disks are operating. The presence of any debris on the disk surfaces will disrupt the air gap and cause a 'head crash' (i.e. the heads will hit the disk surface and damage it).] For this reason magnetic hard disks in desktop computers are always sealed inside a casing (see Figure 17) that is resistant to debris and water. As hard disk assemblies are also housed in a computer case that provides additional protection, hard disks will usually not be contaminated in a disaster situation.

Note: Some hard disks have a small filtered hole in the case to allow equalization of environmental conditions. For these disks water will penetrate the case.

Although the hard disks are generally well protected, if any contamination does occur the end result is usually a lost disk. Cleaning requires opening the hard disk assembly which exposes the sensitive disk surfaces to further damage such as scratching. If a hard disk becomes contaminated, the best procedure is to consult the manufacturer or a company specializing in hard disk recovery. Frequent backing-up of hard disks will eliminate the need to recover this type of medium in the event of a disaster.

Conclusion

Traditional information carriers (e.g. paper documents, books, or photographic prints and films) are usually more vulnerable than modern media in the event of a disaster, and in most cases they must be recovered first. But this does not mean that modern materials can be ignored. Even though modern information carriers (e.g. optical discs and magnetic tapes and disks) are fairly impervious to the absorption of water, problems may still occur if they remain wet for

extended periods. These media also require attention when exposed to heat, debris, or shock. The lack of proper disaster recovery procedures can lead to the loss of large quantities of data stored on modern information carriers.

Product quality has a large influence on how well a particular disc or tape survives a disaster. For example, experiments have shown that some media are not as water resistant as initially thought. Precautions should therefore be taken to avoid disasters as much as possible:

- storage areas should be designed to protect media from potential disasters
- step-by-step recovery procedures should be readily available in case they are needed
- recovery procedures should not further endanger the media

These few simple recommendations will go a long way to securing the existence of information stored on modern information carriers.

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Endnotes

1. Adhesive labels are not generally recommended for use on optical discs because they can cause a variety of problems:
   - their application may cause the disc to become warped and unbalanced
   - the adhesives may react with the disc
   - they may lead to delamination of the disc layers if the disc is subjected to extreme changes in environmental conditions, or the label is repositioned or removed
   - they may loosen over time and create air pockets which will make the disc unbalanced
   - they may ripple and develop air pockets if they get wet

2. A variety of optical disc analysers are available — ranging in price from a couple of thousand dollars for basic models to more than $20,000 (prices in Canadian dollars) for sophisticated models. For the general analysis described in this bulletin, the basic models are sufficient. Alternatively, there are companies that offer disc analysis for a fee.

Notes