

TESTING THE RUGGEDNESS OF MINI DISC DATA STORAGE

OBJECTIVE:

The objective of this lab is to perform various experiments on Mini Discs in order to *qualitatively* determine the ruggedness of this form of data storage. This lab will specifically seek to answer the following questions (specific to the Mini Disc) :

- How does extreme temperature affect data integrity?
- How does excessive wear-and-tear affect data integrity?
- How does exposure to a magnetic field affect data integrity?
- How does water damage affect data integrity?

EQUIPMENT/SOFTWARE USED:

Hardware:

- Six Mini Discs (4 TDK; 2 Maxell)
- Sony Mini Disc Player

Software:

- None used

PROCEDURES:

Brief History of Mini Disc Data Storage

The Mini Disc was first announced by Sony in 1991 and quickly became a popular method for storing audio files in many areas of the world. Although the Mini Disc never grew to great popularity in the United States of America, Mini Disc products can still be purchased within the US. As the Mini Disc grew in popularity, Sony also came out with a PC Mini Disc drive so that the Mini Disc could be used for computer storage as well. The primary reason the Mini Disc format was created was to provide an extremely rugged, portable, rewriteable, and convenient storage device. The Mini Disc is also relatively inexpensive when compared to other forms of data storage, although prices within the US are slightly higher than in many other countries. The official 1991 release from Sony makes the following feature statement about the Mini Disc:

(NEW YORK, May 16, 1991)

- o A 2.5-inch diameter disc that can store up to 74 minutes of digital audio sound;
- o Disc housed in a protective caddy; disc/caddy weights 0.6 oz.;
- o MD System employs different media for playback and recording:
 - CD-type Optical media for pre-recorded software;
 - Magneto-optical (MO) media for recording;
- o Direct access to any musical selection in less than a second;
- o Resistant to shock and vibration;
- o Prerecorded software manufacturing process similar to today's CDs.

Introduction to this Lab

This lab will test some of the physical limits of the Mini Disc in an attempt to qualitatively determine the ruggedness of this form of data storage. This lab will focus only on the Magneto-Optical Mini Disc and not the pre-recorded Optical discs. The magneto-optical discs use a special type of material that can change magnetic states only when a curie temperature is reached. Therefore, when writing data, an optical laser heats the specified “bit” to the Curie temperature, and sets the magnetization for that bit. In this manner, the re-writeable Mini Disc is an interesting cross between an optical storage device and a magnetic storage device. Even in appearance, they resemble a very small cross between a floppy disc and a CD.

In order to test the ruggedness of the Mini Disc, this lab will utilize six different Mini Discs, all with pre-recorded data (audio files). Each disc was verified before performing any tests, in order to ensure that the audio files were playable by an ordinary Mini Disc player. Only one disc was used in each experiment, and only one experiment was performed on any single disc. This was done in order to remove bias from one test to another, and to eliminate possible relationships between various tests. This lab is not comprehensive in an attempt to discover the limits of the Mini Disc, and results are measured qualitatively due to a lack of sufficient hardware and software necessary to verify the devices bit by bit. The remainder of this document will be divided into sections according to the various tests performed on the Mini Discs. Those tests are as follows: *Extreme Temperature, Wear-and-Tear, Magnetic Interference, and Water Damage.*

Extreme Temperature

In order to test the affect of extreme temperature on Mini Discs, two discs were used for this experiment. The first disc was labeled and placed in an average household

freezer overnight. The following day, the disc was removed from the freezer and was tested with the Mini Disc player. The TOC (Table of Contents) was readable, and showed that each audio file was still on the disc. Each of the audio files was tested to ensure that the data appeared in-tact. It appeared as though extreme cold did not affect the data integrity of the disc.

The second disc was labeled and then placed directly beneath a blow dryer set to the highest level. The disc was kept directly beneath the blow dryer for slightly over one minute. Once the dryer was removed, the disc was too hot to be handled and was thus allowed several minutes to cool before placing the disc inside the player. Each audio file on the disc was tested and it appeared as though the data was in-tact.

Wear-and-Tear

Two discs were used to test the durability of the Mini Disc under excessive wear-and-tear conditions. The first disc was tested for durability under unusual handling circumstances. Each Mini Disc comes with a protective case in order to keep the magnetic surface from being handled. However, for the purposes of this test, the sliding cover for the case was removed and the magnetic surface was handled directly by human hands. The surface of the disc was touched and handled rather roughly by two different individuals. Once again, it should be noted that these tests are qualitative and thus no particular measurement for the “roughness” of the handling shall be determined. After performing the test, the disc was placed in the player and the TOC was read. Each audio file was verified and once again, it appeared as though all data was unaltered.

The second disc used for this experiment was intended to be used to test the durability of the external case. It should be noted that a thorough experiment in this regard would include a variety of cases from different manufacturers. However, for the

purposes of this experiment, only a single Mini Disc (TDK) was used. For this particular experiment, the disc was dropped several times from a height of approximately seven feet onto a concrete surface. The disc was then stepped on several times by an individual weighing approximately 160 pounds. The disc was then placed beneath an office chair with the same individual as described previously sitting in the chair. The final test for this disc was to place the disc behind the driver-side rear wheel of a Saturn Relay minivan, and have the driver of the vehicle drive backwards over the disc, completely running over the top of the disc, and then to pull forwards once again, running over the disc a second time. Although there was obvious physical damage to the case, it appeared to be in-tact enough to attempt playback by the Mini Disc player. The disc was placed inside of the player, and almost immediately, the TOC was read and displayed by the device. Each of the audio files was tested and it appeared as though the data was unchanged.

Magnetic Interference

The recordable Mini Disc uses magnetic technology in order to store data, similar to a floppy disc or magnetic tape. The primary difference is that the material used is such that the magnetic field cannot be changed until the material has reached a curie temperature. For this reason, Mini Disc data storage is supposedly not susceptible to damage from an external magnetic field. Unlike the floppy disc, exposure to a decent-strength magnetic field should not alter the data on the disc. In order to test this claim, a magnet was forcefully removed from a 15" subwoofer using a closed magnetic circuit. These magnets are known to be fairly strong. Although an exact idea of the strength of this magnet was unknown, the magnet was able to easily hold a workman's hammer and electrical hand-held drill. The Mini Disc was centered onto the strongest section of the

magnet and was left in the same position for over 24 hours. The disc was then tested in the player and each audio file showed no sign of corruption. The disc appeared unaffected by the strong magnetic field.

Water Damage

The final test was to drop a Mini Disc into a pot of water and leave it there for slightly over one minute. The disc was then allowed to dry and was placed inside of the player (the disc was not inserted while still wet, to avoid damaging the player). The TOC was displayed and each of the audio files was tested and appeared to be in-tact.

REPORT:

There were a total of six tests each performed on a different Mini Disc. The tests were divided into four different categories. The following table shows the results of each test.

Table 1

Category	Test	Result (pass/fail)
Extreme Temperature	Heat	Pass
	Cold	Pass
Wear-and-Tear	Unusual Handling	Pass
	Case Durability	Pass
Magnetic Interference	Strong Magnet	Pass
Water Damage	Dropped in Water	Pass

As the table shows, each test was passed successfully. There was no noticeable loss of data to any of the discs used in the tests. It should be re-iterated that due to a lack of proper hardware and software, the discs could not be compared bit by bit, and thus there may have been some unnoticeable loss of data. However, none of the data was corrupted beyond a point where the player was unable to perform regularly.

CONCLUSIONS:

The results of this lab can be considered a success in light of the fact that each objective of the lab was met. Consider the following questions:

- How does extreme temperature affect data integrity?
 - The Mini Discs were able to withstand both extreme temperatures of hot and cold without any noticeable loss of

data. Due to the nature of how data is written to the Mini Disc, if the temperature were raised to the curie temperature of the magnetic material, then one can assume the data would become corrupted. Although little technical data could be found among available literature, one website indicates the curie temperature of Mini Disc material to be 180C (<http://www.dizone.net/pg/archives/0100/tech2.shtml>). Further research might include determining the actual temperature at which data becomes corrupted.

- How does excessive wear-and-tear affect data integrity?
 - Although it is very difficult to measure “wear-and-tear,” the Mini Disc did seem to withstand an abnormal amount of roughness. The fact that it could be dropped and even run over by a minivan indicates that the protective case does relatively well in protecting the storage disc from abuse.
- How does exposure to a magnetic field affect data integrity?
 - This question was particularly interesting due to the fact that the recordable Mini Disc is in fact a form of magnetic storage. However, due to the manner in which the Magneto-optical nature of the device, subjection to a strong magnetic field under normal room temperatures did not appear to affect the data integrity at all. Future research might include subjecting a Mini Disc to a strong magnetic field at a much higher temperature, in order to determine the mathematical

relationship between temperature and magnetic field and their effects on the Mini Disc's data integrity.

- How does water damage affect data integrity?
 - Placing the Mini Disc in a pot of water did not appear to affect the data on the disc. The storage material seemed to resist the water relatively well and dried rather quickly after the disc was removed from the water. One presumption was that the mineral deposits left from the water might affect the player's ability to read the data, however, because the material repelled the water so well, very few "water spots" were visible on the device. Even with these few spots, the player did not appear to have any difficulty reading the data from the disc.

Based on the results of this lab, the Mini Disc appears to be a very rugged form of data storage. The portability and the fact that data can be rewritten make it appealing for many different situations. Circumstances where data storage might be used in rough terrain or in a harsh environment would be served well by the Mini Disc. One drawback to the Mini Disc is the storage capacity. Although it is most commonly used for audio, where it can store up to 74 minutes (some can store 80 minutes) of compressed music, in data mode it only holds 140MB. For this reason, the Mini Disc was not commonly adopted for use in data storage other than for music. Overall this lab was successful in determining that the Mini Disc is truly a rugged form of data storage.