Audio Archival Recording

"The process of death begins at birth." cm

Since the invention of the Phonograph by Thomas A. Edison at his Menlo Park, NJ laboratory in 1877, recordings have been made and stored for future use as a record of the words, wisdom, sounds and music of all peoples. The degradation of these recordings began the day that they were made. All of these recordings eventually succumb to the effects of time due to chemical reactions, which take place within their media and with external environmental elements. The chemical degradation of media generally follows the rule of the "Arrhenius Relationship" wherein the rate of chemical reactions increases with temperature.

R(T) = Ae ^-Ea/KxT

wherein:

R is the speed of reaction,

A is an unknown non-thermal constant,

Ea is the activation energy (eV),

K is the Boltzman's constant (8.617385 x 10^-5 {eVK^-1})

In simpler terms, this means that for every 10°C increase in media temperature, the rate of chemical reaction of the compounds within the media itself and also with the outside world doubles. This fact produces an exponential function of reaction vs. temperature. Other degradation factors are less influential, like relative humidity, altitude, contamination by improper handling, and the composition of the surrounding environment and light. In lab testing, media manufacturers often tout long life expectancies. These claims are created out of accelerated life testing in which temperature and other parameters are elevated and performance is measured after a much shorter test cycle. However, only the true test of life expectancy is time. The rest is conjecture, but accelerated testing is the best prediction tool that we have to work with today.

Our old audio recordings that have been made over the years take many forms including the following that are listed approximately in the chronological order of development:

1. Rotating Cylinder (all used Hill and Dale modulation techniques)

a. Tinfoil

b. White Wax

c. Brown Wax

d. Black Wax

e. Celluloid (Blue Amberol)

2. Rotating Disc

a. Single Sided 50 RPM Zinc (commercialized by Emile Berliner circa 1890)

b. Hard Rubber Based Laterals

c. Shellac Based Laterals

d. Edison Diamond Disc (Hill and Dale)

e. Electrically Recorded Discs (circa 1925)

f. Aluminum Transcription Discs

g. Pre-Grooved Vinyl Discs

h. Acetate Transcription Discs

i. 45 RPM Discs (1949)

j. Vinyl LP (circa 1950)

k. Hard Drive

l. Diskette

m. CD

n. CD/R

o. DVD

p. DVD/R

3. Linear Motion

   a. Moving Optical Film (Analog)

   b. Wire (Analog)

   c. Moving Paper Tape (Analog)

   d. Moving Acetate Tape (Analog)

   e. Moving Mylar Tape (Analog)

   f. Cassette Tape (Analog)

   g. Micro-Cassette Tape (Analog)

   h. Beta Tape (Analog FM Azimuth Recording)

   i. Beta Tape (Digital Audio)

   j. VHS Tape (Analog FM Azimuth Recording)

   k. VHS Tape (Digital Audio)

   l. DAT (Digital Audio)

4. Other

   a. ROM

   b. RAM

   c. EE-ROM / Flash Memory

   d. Etc.

One of the reasons for showing this fairly extensive (yet incomplete) list is to demonstrate the extent of the number of formats and media types that archivists are confronted with. Each recording type exhibits a different degradation rate related to its specific Activation Energy and the temperature profile at which it had been stored over time. Also, a stable temperature is preferable to a dramatically varying one in that temperature cycling will produce additional failure modes.

A complete audio archive laboratory would need to be capable of handling all of the mentioned formats, which is a daunting situation to say the least! Consider the following questions that an audio archivist is confronted with:

1. How does one find and maintain players for all of these various recording media?
2. What is the optimal storage environment for each type?
3. Will transferring these data to modern digital formats outlive the original source?
4. Will these data be extractable in the distant future?
5. What is the best method of transfer to a new media?
6. How can the information be transferred without damaging the original specimen?
7. Should two copies be made of the original material for redundancy?
8. Should these two copies be stored in the same location, or in a separate building in case of fire?
9. What data format should be used?
10. What error correction format should be used?
11. What medial should be used?
12. Is “Standard” better than technically better?
13. Etc.

Fortunately, for most amateur archivists, the problems are much more limited because all formats are not generally dealt with. Probably, most home audio archivists are limited to the following 6 formats:

1. 78 RPM Lateral Cut Records
2. 80 RPM Hill and Dale Diamond Discs
3. Vinyl LPs
4. 45s
5. Reel to Reel Tape
6. Cassette Tape

Fortunately, we have an organization to turn to for guidance if we want to look for archival standards for analog and digital transfers of important audio artifacts. The United States Library of Congress uses the following:

1. Analog Archiving: 10.5 inch Reel to Reel, ¼ inch, 1.5 mil Tape (2,500 feet), ½ Track Stereo @ 15 IPS.

2. Digital Archiving: 96 KHz Sampling Rate with 24-bit resolution. The media is the Archival Grade CD/R.

It is recommended that all digital archival recording be performed flat and with no signal processing. The concept is to capture what is on the record in its entirety, including all of the noise. The 96 KHz sampling rate produces a frequency response up to 48 KHz, which is well beyond the range of human hearing. The 24 bit resolution provides 138 dB of dynamic range The reason for maintaining this level of performance is to accurately capture the noise as well as the signal. This will allow de-noise routines to have an easier time discriminating between audio signal and noise. A flat pre-amplifier is available from us for this purpose and is compatible with balanced sound cards. Applying any equalization curves is somewhat risky because the accuracy of the EQ curve may be indeterminate whereas a flat response is quite determinate. The EQ curve and noise reduction can always be performed at a later date

In addition to the basic problems outlined with archiving audio is that of the longevity of the transfer. If that original recording transfer is onto analog tape, it will also degrade in time just like the original master source, but at a different rate (either faster or slower, depending on many variables). Given enough time, the archival tape binders will break down chemically and will no longer hold the oxide coating onto the tape backing. Therefore, every 30 years or so, a new transfer of the material is required with its attendant problem of generational loss. Since analog tape produces a certain amount of distortion and noise, each generation will become of lower audio quality compared to the previous generation, and, ultimately would result in nothing but noise in, say, 1000 years. Therefore, there is a large advantage to the digital technique. That is not to say that the digital media will not deteriorate; it in fact will and its degradation will follow the Arrhenius Relationship. However, if the archivist can re-transfer the data to a new media before the digital archival copy fails, a perfect replication without loss can be produced. So, theoretically, a perfect archival copy could still exist 10,000 years from the date of original transfer, so long as the archival institution is prudent in this regard.

Procedure for an Archival Audio Transfer:

1. Clean the Playback Equipment

   a. In the case of a mechanical recording, clean the stylus before each transfer.

   b. In the case of a magnetic recording, clean the heads and associated components with Isopropyl alcohol. Also, de-magnetize the heads and tape pathway components.

2. Verify the performance of the Equipment

a. Check the RPM of your turntable with a strobe disc if you are working with records.

b. Check the speed of your tape deck(s) with a reference tape if you are working with tape.

c. Check the head alignment (and record head bias if you are archiving on the analog reel-to- reel format) every few months. As the tape heads wear, these parameters change.

3. Clean a mechanical record using distilled water, preferable using a vacuum based record cleaning machine.

4. When playing a mechanical record, choose the appropriate stylus either by chart or by sound quality. A stylus chart by brand can be found in the back of the Diamond Cut Productions Users Guide.

5. Play the record in a dry-run to kick up any remaining dirt in its groove, and also adjust the gain of the recorder to produce a peak level of about –3 dB.

6. Re-clean the record as in step number 2.

7. Announce the Matrix Number, Title, and Artist of the recording onto the Archival Media

8. Transfer the Audio onto the Archival Media. Include the needle drop and the needle lift on this transfer recording. These artifacts can be removed later, but this methodology assures that there is an adequate lead-in groove recorded for noise print purposes later.

9. Replace the original recording back into acid free sleeve and store appropriately.

10. Record the item into your log book with the following information (a spread sheet or data base program works well for this application):

a. Brand Name and Record Matrix Number (found in the lead out groove {engraved in the wax master by hand}) Example: Edison Matrix # N-310B

b. Release number

c. Title of Audio Piece

d. Artist

e. Composer

f. Librettist

g. Recording Session Date

h. Recording Session Venue

i. Transfer Date

j. Name of Transfer Technician

k. Special Notes about the Transfer (half speed re-master, etc)

11. Proceed to the next recording to be transferred.

Important Note: Never apply any filtering or audio restoration processes to an archival recording. The objective is to record it as flat as possible with as much frequency response and dynamic range as is achievable. The restoration process is a completely separate and distinct activity having an entirely different objective.

Storage (Medium Term of 10 years)

Most media should be stored vertically to avoid media warpage. This rule applies to discs (CD, CD/R's or mechanical records) as well as reel to reel or cassette based magnetic tape (audio or video). All items should be stored in a clean place. Also, they should be stored in a stable cool and dry environment which is maintained in the range of 65°F to 70°F and between 45 to 50 % relative humidity (RH). (For long term storage, the temperature should be reduced to 45°F to 50°F.) It is also important to isolate these items from ultraviolet light sources such as the sun and fluorescent lamps. If there are windows in the storage area, a special UV filter film can be applied to the windows to prevent UV photonic penetration. If there are fluorescent lights in the room, they should be shielded with tubular UV shields. Ideally, all of these items should be stored in acid free boxes, which helps isolate them from dirt and light. Standard cardboard boxes can accelerate the degradation process because of the acidic nature of their composition. Cylinders should be stored vertically in their tubular containers and under the same conditions outlined above. Magnetic tapes (reel to reel or cassette) should never be stored after rewinding or fast forwarding. These tapes should be played to their end and then stored (tails out) which assures the proper wrap tension. When playing these tapes in the future, you will have to rewind them first. Do not store reel-to-reel tapes on slotted hubs as that can distort the geometry of the wrap.

Handling

In general, one should never touch the recording surfaces of any audio specimen. The acid and bacterial spores on ones fingers can initiate a chemical reaction which ultimately will degrade that section of the recording. However, just in case, one should wash ones hands before handling recordings or use acid free cloth gloves when dealing with one-of-a-kind rare items. Handle all items (tapes or discs) by their outer rim and inner label or flange. Never squeeze the flanges of a reel to reel tape together when picking it up as this will damage the edge of the recording. Cassette and Micro Cassette tapes should be handled by the outer shell only. Never touch anything in the tape pathway. To remove wax cylinders from their tube, two fingers should be inserted in the inner diameter of the cylinder and then "flexed" as removing. Never touch the

wax surface! This will cause mold to begin to grow on the cylinder shortly thereafter. Wax cylinders should be allowed to adjust to the room ambient temperature before installing them on the player mandrel. Otherwise, you run the risk of cracking the wax due to the thermal shock created.

Cleaning

We only recommend the use of distilled water for the cleaning of mechanical records. Any other solvent has the potential to leave behind a chemical residue which can cause damage to the item over time.

Summary

We have presented a guideline for dealing with archival audio materials in the best-case scenario. You will need to choose the exact methods based on your specific archival needs and financial means.

Note:

Much of the information in this article is derived from the experience that Rick Carlson and myself (Craig Maier) had in transferring the Unreleased Edison Lateral Test pressings into a digital format. We were involved in this project for a period of about seven years commencing in the late 1980s and received very instructive tutelage from a large number of individuals who were experts in this field at that time. The data used in this tutorial has been updated to be appropriate for today's technological environment.