Collection Condition Survey of Reel to Reel Tapes from the Larry Monroe Collection

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1 Introduction

Project Overview

In the Spring of 2018, a graduate student from the University of Texas at Austin, School of Information, performed a collection and condition survey on a group of reel to reel magnetic tapes. The goal of the survey was to review and document the condition of the magnetic tape in the Larry Monroe Papers collection at the Dolph Briscoe Center for American History. The scope of the project included an inventory of the reviewed reels and collection of condition information for the reels. Given the limitations of audio tape, there is no way to determine how it will truly react to playback until it is actually played, the condition of the tapes was determined visually. During the visual inspection, certain physical condition issues were noted, which can give a clue to the condition of the tape. Visibly noticeable issues, mold, cupping, stepping, blocking, curling, white powder, etc., can give the surveyor an idea of how the tapes were stored and how they might react to playback. The odor of the tapes can also give the surveyor an idea of the condition of the tapes, as certain scents are indicative of problems that can occur with the tapes.

Scope and Content

The scope of the project was originally larger and was to be a survey of all magnetic tape audio media in the Larry Monroe Collection, including reel to reel, cassettes, and any other magnetic tape that was a part of the collection. However, as the direction of the survey changed from being a sampling of items, randomly chosen from the collection, to needing to include a more detailed inventory of the collection, the scope was limited to the reel to reel magnetic tape. However, it should be noted that this was still approximately 600 reels and, given the allowed time to complete the survey, only a little under half of the reels were inventoried and inspected. A quick inspection of the boxes of reels not inventoried showed no reels that were either not

included the date range inspected, or showing any unusual condition issues that had not been noted previously.

Plan of Work and Project Goals

The proposed plan of work was based upon the desired inventory and collection condition survey desired by the Briscoe Center. The first step was to create an inventory that included condition issues for the survey. This was primarily based upon a condition survey created by Hannah Frost for the express purpose of surveying audio media[1]. Once the survey was completed, a copy containing only the inventory portion was given to the Briscoe. Using the condition survey, the surveyor was to determine what problems might occur once digitization of the reels begins and suggest methods to mitigate these issues, as well as give suggestions for future storage of the reels.

Larry Monroe

Larry Monroe was a beloved radio disk jockey in Austin, TX. He was known for his shows, Blue Monday, Texas Radio or Texas Music, Phil Music, which originally began as a short musical interlude in the middle of the Austin City Council meetings played live on KUT[2], and Segway City. Larry Monroe started in radio at age thirteen, announcing local basketball games in his home state of Indiana. After bouncing back and forth between radio stations in Ann Arbor and Detroit Michigan, he quit radio for a brief time before finding his way to Austin. He started at KOKE-FM just before they had a format change to country music, then ended moving around stations in Central Texas before finding his home for 29 years on KUT. After moving from KUT

[1] See Hannah Frost's chapter in Sound Savings, "Surveying Sound Recording Collections" for an example of the survey she created for collection condition surveys.
[2] See Michael Bertin's article "Phil Music" from The Austin Chronicle, for more information on the radio show Phil Music.

to KDRP in 2011, Larry continued with his popular radio shows until his death in 2014. His radio style was unusual in that it was a more free-form style. He chose music not based on its popularity or its style, but on how well it segued from one song to the next. He preferred to use themes in his shows, which would dictate which songs would be played and how they would be ordered. In an age of commercial radio where the most popular songs get played on a constant rotation, it was a different and very much appreciated radio style.

2 Collection Assessment and Survey

Inventory and Metadata

The inventory for the Briscoe Center consists of data collected from the box containing the reel, if existing, and information written on the reel flange, including any dates. Individual items are contained in either numbered boxes, following the Briscoe format of accession number-box number, or identifying information from a non-numbered box, so that individual reels can be located. Most the reels were located in numbered boxes, however as it was determined that not all the reels were going to be included in the survey, it was decided that a few non-numbered boxes should be included as well. All metadata was taken from the reel boxes and the reel flanges. Unfortunately, given the common habit of reusing both boxes and reels, until the reels are digitized, it is unknown if the metadata from the reel boxes and flanges will actually correlate to the information contained on the magnetic tape. Although only 259 reels have been inventoried, a review of all the boxes at the Briscoe, and an estimate of the number of reels taken by the Advanced Audio Preservation class for digitization, give the complete number of reels at approximately 600. Although not all of the reels are included in the inventory, it is hoped that having almost half of the reels inventoried will be a step in the right direction to knowing what the Briscoe Center has and what dates and shows might be missing from the collection. If time had permitted, the surveyor would have preferred to complete a full inventory of the boxes,

minus the condition survey. However, in order to get a better idea of the condition issues of the reels, it was decided that time would be better spent trying to gather as much information on the problems detected in the reels.

The inventory was also the first step in the condition survey. By knowing which items are at a greatest risk of deterioration or which items will need extra steps before being digitized, prioritization of the preservation of the reels can be done. The inventory allows the most damaged or deteriorated reels to be located and digitized or prepped for digitization. The inventory maintained the order of the tapes in the boxes, however as there appeared to be no order of the reels from the donor, this is primarily useful for the location of specific reels.

Survey

Originally, the survey was to be of all the magnetic media in the Larry Monroe Collection. If this had continued to be the case, then a random sample of reels, cassettes, and any other magnetic media, would have been surveyed to give an idea of conditions or issues that affected the media. Most magnetic media have similar problems, mold growth, sticky shed syndrome (or soft binder syndrome), blocking, oxide loss and introduction of dirt. Generally, the appearance of these issues is indicative of previous storage and of inherent vices in the media itself, which affect all of the items in a collection, and can give the surveyor an idea of issues that might appear throughout the collection. Random sampling is used in many types of surveying, as a correctly chosen small sample can show results that can be applied to a population as a whole. There are a few different types of random sampling that can be done: simple random sampling, systematic random sampling, stratified random sampling and cluster sampling[3].

[3] https://www.bcps.org/offices/lis/researchcourse/develop_data_sampling.html

Simple random sampling chooses samples based upon a few characteristics that you want to be represented in a whole, then a set number of samples that represent that characteristic is chosen. For instance, if you have 1000 items of magnetic media in a collection, split between cassettes and reels, first you would determine how many you have of each. Once you know how many cassettes and reels you have, you would use a random number generator to choose your sample. If you have 650 cassettes, you set the random number generator to generate a number between 1 and 650, then items that correspond to that number would be inspected. The generation of random numbers and inspection of the corresponding items would continue until there was a sample that was large enough to extrapolate to the population.

Systematic random sampling is similar, however instead of using a random number generator to choose the items, an item that falls at a certain interval is chosen for inspection. For example, if there are 650 items to survey, and a sample of 50 is desired, an inspection would be done of every 13^{th} item. However, it is generally best not to start from 1 and move through the items. Using a random number generator, a number from 1-13 would first be generated, and using that number as a starting place, every thirteenth item would be inspected.

Simple and Systematic random sampling only work for homogenous populations, making them useful for surveying a collection of cassettes or reels. However, if there are more than one homogenous group, say both cassettes and reels, two different samples representing both populations would be needed. This is stratified random sampling, where random samples are taken from each homogenous group, based upon how many objects are in each group.

Cluster sampling is similar, and used when the populations are extremely large. For instance, if there was to be a survey of all magnetic media in the United States, the population would too large to even try a simple or systematic random sample. Instead, a sample of a sample of a

sample would be taken. It would start with taking a sample of holders of magnetic media in the US. Perhaps there are 1000 institutions that have collections of magnetic media, it would start with a sample size of 20 institutions. Then from those institutions, a stratified random sample of the various types of media at each institution would be performed. Or instead of just starting with 20 random institutions, the institutions could be divided into categories like university, museum, private collection, etc. and the sampling could start with a stratified random sampling of types of institutions, from which a random sampling of items could be taken.

Since the sampling of a few randomly chosen items can be extrapolated to the whole of a collection, surveying only a small number of items is a common way to determine the conditions of the collection as a population. Had this continued to be a survey of randomly selected items, a stratified random sample of magnetic medic chosen using the systematic sampling method would have been inspected for various condition issues. However, since an inventory was also requested, a random sample of reels was not an option for this survey.

The survey contained the aspects of the inventory desired by the Briscoe Center, the box number, and data taken from the reel box and reel flange, as well as the size of the reels, the tape brand, the base material, the gauge, the oxide, the state of the housing, any noted contamination or odor, and condition issues such as step pack, flange pack, popped strands, cupping or curling, spoking, blocking, edge damage, objects in the wind, splicing, or white powder on the tape. If an item displayed a condition listed it was noted in the survey, as well as any other issues that were noticed during the inspection. See Appendix A for a sample of the survey.

3 Findings and Recommendations

Condition of Reels

All of the reels surveyed were ¼ inch reels, primarily made of polyester, with some acetate tape, either in entire reels or spliced into reels with polyester (Image 1). Although it is difficult to tell the difference between polyester and PVC tape, polyester was the most widely used base for magnetic tape, and after 1972 was the only base being used for magnetic media[4]. There is a possibility that the Larry Monroe Collections contains reels with a PVC base, however without intrusive and destructive testing, there was no way for the surveyor to determine this.

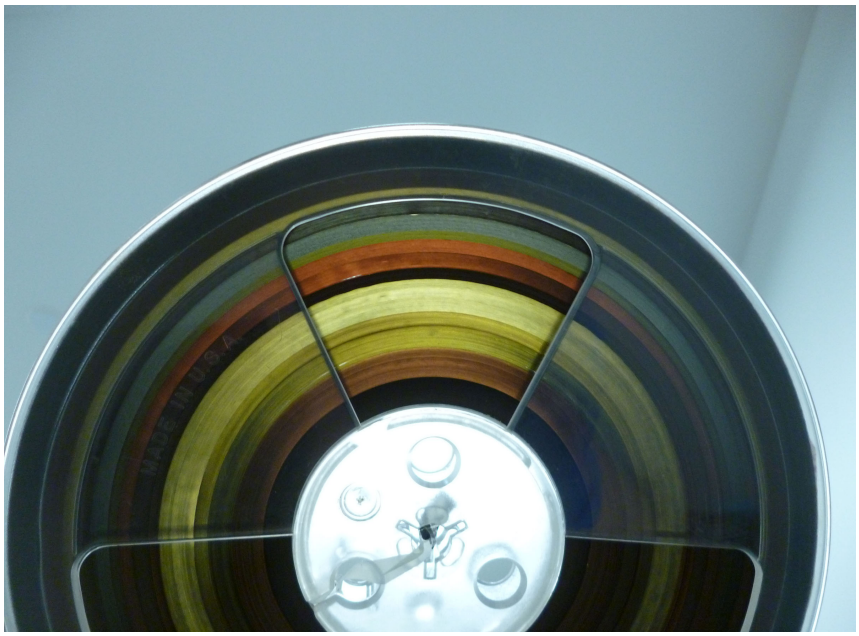

Image 1
Acetate tape spliced to polyester tape

Except in one instance, where a notation was made on the flange, the oxide of the tapes is unknown. Prior to 1983[5], Ferrous oxide was the magnetic material used in open reel tapes, however since the dates of the tapes are generally unknown and the dates of the recordings fall in a range of 1969 to 1999 with many undated recordings, there is no unobtrusive way to determine the oxide of the tape. The one tape with the oxide notation, CrO_2, indicates that the magnetic material is Chromium Oxide.

[4] See "2.2.1 Tape Base" from FACET: The Field Audio Collection Evaluation Tool for more information on other base types (pg. 3).
[5] According to "FACETS", BASF started using Chromium oxide in the pigment layer for some brands at this time (pg. 3).

The reels were split almost evenly between 7-inch and 10-inch (47% 7-inch and 53% 10-inch), with two 4-inch reels surveyed. Approximately 45% of the reels inventoried did not have a box, primarily the 10-inch reels. Out of the remaining reels at the Briscoe Center, less than 10% of the 7-inch reels had no box (probably lower if you take into account the reels taken by the Advanced Audio Preservation class), and about 42% of the 10-inch reels had no box. The reels with no box often showed an accumulation of dust and various other contaminants on the tape itself, generally on the edges and the first few feet.

Unfortunately, some data on the tapes was not able to be collected. The reel length is generally unknown, although most of the tapes filled the reel flanges. Nor was the surveyor able to determine the thickness, track format, whether was any noise reduction, whether it was recorded in stereo or mono, or the recording speed of the reels. Occasionally a recording speed or stereo/mono indication would be noted on the reel box or flange, however similarly to other information on boxes and flanges, it is unknown if it is representative of the recorded tape itself.

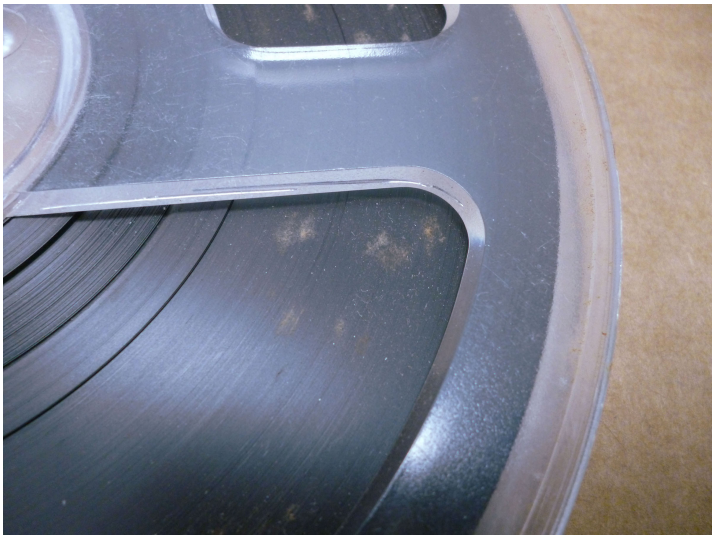

Image 2
Step pack with mold on tape

The majority of the reels surveyed had similar issues, generally related to either previous storage or vices inherent in the media itself. The main issues that were noticed were dust, a musty odor, step packing, and blocking[6]. Over all, other than the step packing (Image 2) which

[6] FACETS, “Surveying Sound Recording Collections” by Hannah Frost, and “Magnetic Tape Storage and Handling” by Dr. John W. C. Van Bogart, include descriptions of various condition issues noted in magnetic tape. Blocking is when the tape sticks to itself, caused by binder hydrolysis, storage in high temperatures, and/or excessive stress on the tape pack.

could be from improper storage, one instance of obvious spoking and one instance of cinching, the reels were well wound, showing no signs of very loose or tight winding. Most, if not all of the reels had either visible splices or possible splices, as small gaps in the wind where a splice might be, were often noticed in the wind. Mold and white powder, as well as evidence of insect activity were also noticed regularly.

Many of the reels had a musty odor and a few had a more mildewy odor, indicative of storage in a damp, warm environment. There were a few reels with boxes that showed obvious damage from water: tide lines, deterioration, mold growth (Image 3). These reels often showed mold on the reel flange and occasionally on the tape itself. Some boxes with no visible water damage or mold on the outside, had mold on the inside, on the flange or on the tape. Insect damage was also noticeable, primarily on the boxes, but also on paper leader tape. In addition to damage caused by insects, excrement and insect bodies were apparent throughout the collection, both in the reel boxes and in the larger cardboard storage boxes. Insects generally prefer a warm and humid climate, indicating that the tapes were at some point stored in an environment not conducive to the preservation of the tapes.

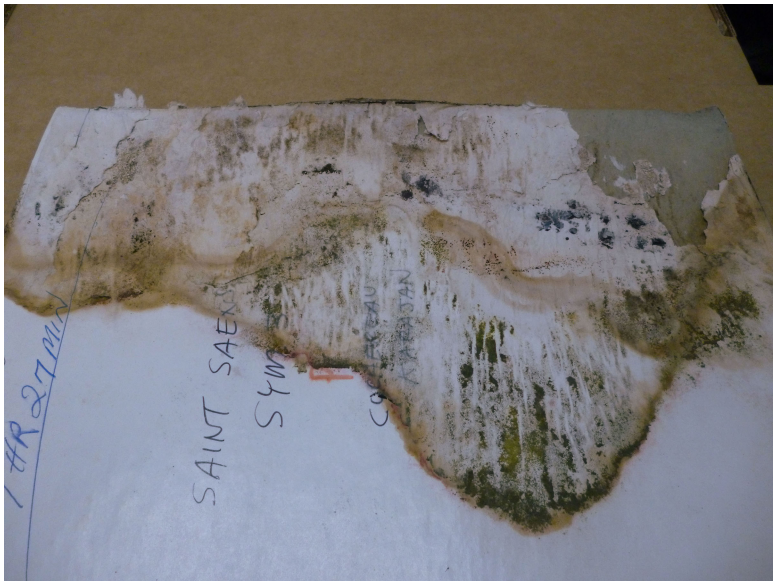

Image 3
Tide lines, deterioration and mold on reel box

Mold is an issue for tapes, not only because it is indicative of temperatures and relative humidity levels too high for preservation of the tapes, but it can also over time cause dropouts of information on the tape[7] (Images 4 and 5). And, mold can be a health hazard to individuals who are exposed to it. If possible, the moldy tapes and boxes should be separated from the non-moldy items to prevent contamination, until they can be cleaned if possible or disposed of.

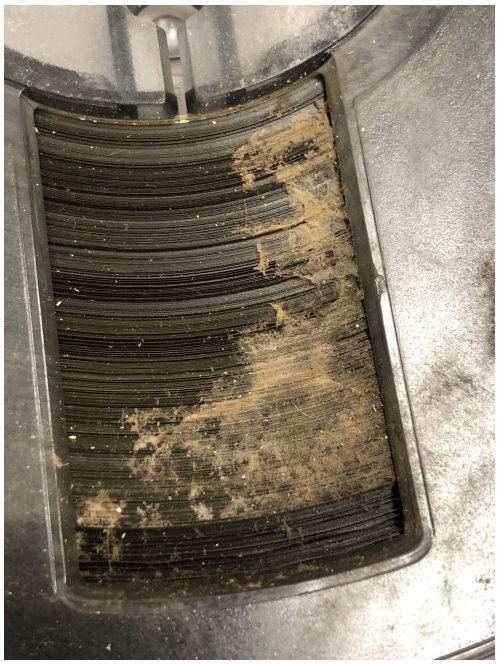

Image 4
Mold growth on tape found in a moldy box

If properly wound and stored, the tape in a flange should sit in the center with a gap between the tape and the flange sides. If improperly wound or stored, the tape can slip in the flange leading to step packing, flange packing, or popped strands. Generally, this occurs due to poor winding, however fluctuations in temperature and humidity leading to changes in tape pack tension, loosening and tightening the tension as the temperature and humidity change, often combined with tapes being stored not in an upright position can also cause these issues. As the tension changes, the pack can become more loosely wound, leading to slipped tape. Approximately 88% of the reels surveyed showed signs of step packing, from slight step packing where there were splices in the tape, to extreme step packing combined with popped strands.

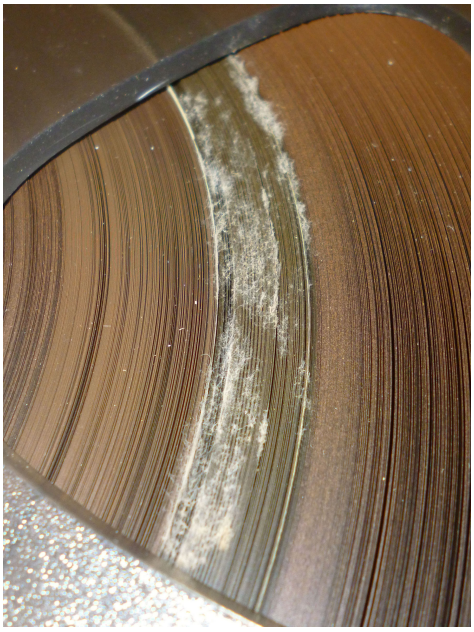

Image 5
Mold growth on one length of spliced tape

[7] "FACETS" (pg. 30)

Step packing, flange packing and popped strands (Image 6) can lead to edge damage, which could lead to information loss closet to the edge of the tape. Step packing and popped strands can also lead to binder hydrolysis on the strands of tape that stick out of the pack and are exposed to moisture.

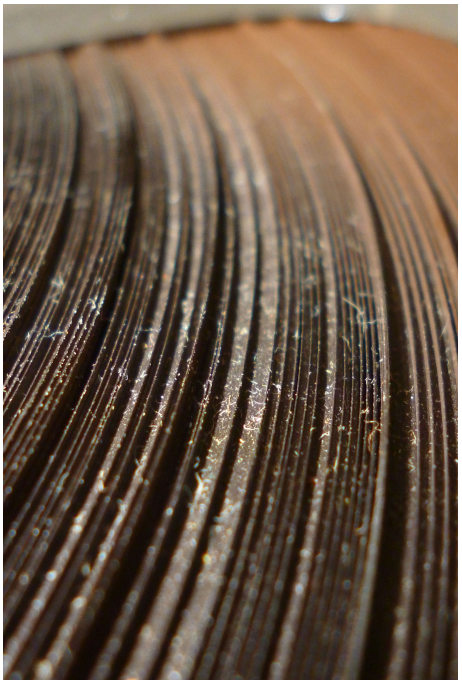

Image 6
Step pack with popped strands

Blocking, or when the tape sticks together (Image 7), was another common issue noted in the survey. Blocking is generally caused by hydrolysis of the binder which holds the magnetic media to the tape base. Binder hydrolysis can lead to sticky shed syndrome (or soft binder syndrome)[8], which can cause the binder and magnetic particles to shed during playback. Unfortunately, sticky shed is common in higher grade tapes, Ampex and Scotch tapes primarily. These particular tapes are generally polyester with a back-coating that is often black in color (Image 8). Out of the 177 tapes surveyed that showed some signs of blocking, 144 of them had a black backcoating. Four of the tapes that showed blocking were stored in boxes that showed obvious signs of water damage, and had dormant mold on the flange near the area of blocking.

Image 7
Blocking of tape

[8] See Richard Hess “Tape Degradation Factors and Challenges in Predicting Tape Life” for more information on sticky shed or soft binder syndrome.

Although it is has been noted that backcoated tapes are prone to sticky shed, the fact that the tapes were stored at some point in a warm and humid environment is just as likely the cause of the blocking of the tape. This is supported by the fact that not all of the tapes that showed signs of blocking had a backcoating. When stored in a damp environment, the binder holding the magnetic media to the tape absorbs moisture from the air, the more moisture in the air, the more the binder absorbs and the higher the chance of sticky shed syndrome or binder breakdown. During the process of hydrolysis, longer molecules of polyurethane in the binder are broken down into smaller molecules, which then exude from the binder, sticking to the tape next to which it sits, and shedding from the base as it is played. Although little to no oxide shed was noted during the visual inspection of the tapes, it is possible that due to the breakdown of the binder, shedding could occur during playback. Unfortunately, there is no cure for binder hydrolysis and sticky shed syndrome, although baking the tapes at very low temperatures for long periods of time appear to draw some of the moisture out of the binder and prevent the sticking and oxide shed for at least a short period of time.

Image 8
Magnetic tape with matte black backcoating

White powdery residue (Image 9) on the tape can also indicate binder hydrolysis[9]. Out of the 67 tapes, about 25% of all of the tapes surveyed, that showed some white powder, 52 also showed signs of blocking. White powder sometimes affected all of the tape on a reel, but often only affected one or more sections of a spliced reel. This can lead to difficulty during playback, as it may seem as though a tape is playing with no problems, until a spliced section of a differing type of tape exhibits sticky shed and starts to lose oxides from the tape. Generally, when white powder is seen, similarly to when blocking is noted, baking the tape can help draw out moisture and prevent sticking and oxide shed at least for a short time.

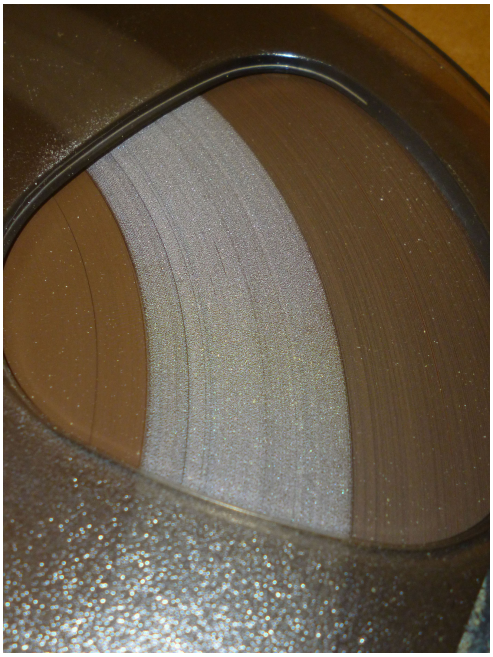

Image 9
White powdery residue on portion of a spliced reel

Another common occurrence that could affect playback comes from the presence of splices. Unfortunately, the tape that holds together splices eventually fails, leaving either a sticky ooze or causing the splice to fall apart completely during playback. As many of the tapes in the collection have multiple splices (Image 10), care will need to be taken during playback to ensure no damage comes to the tape from splices falling apart. During

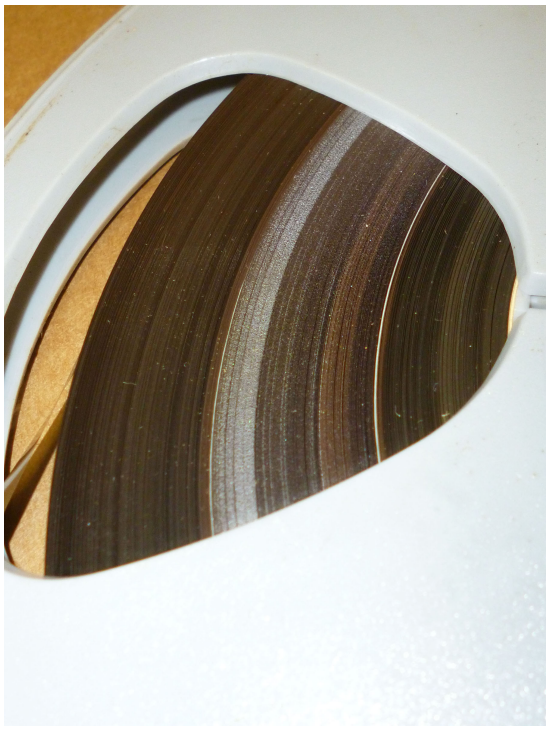

Image 10
Spliced reel with area of white powder

[9] Hannah Frost, “Surveying Sound Recording Collections” Appendix

storage, areas where tapes are spliced together can cause step packing as the splice creates a small gap between tapes and allows for the tapes to slip. This should not be a problem for tapes that are stored upright, however in some cases the tapes have slipped to the point that only rewinding will restore a proper pack. Splices can also cause an issue if acetate tapes are spliced with polyester tapes showing signs of binder hydrolysis and sticky shed, as acetate tapes cannot be baked.

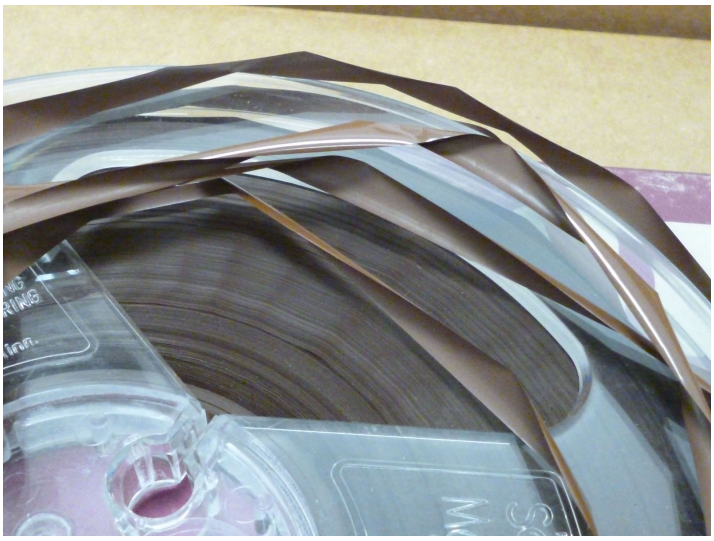

Image 11
Curling and spoking of tape

Cupping or curling was noted in a few tapes (Image 11). This is generally caused by the differing rates of shrinkage between the tape base and the magnetic media binder. It can cause issues during playback as the entire width of the tape may not come into contact with the player head, which can lead to missing information during playback[10]. Spoking, which is caused by improper tension while winding or poor storage conditions, also showed up. Only one reel had obvious spoking, but there was a slight distortion in a few other reels. Spoking can also lead to issues during playback as the tension can cause the edges of the tape to stretch more than the middle, which can cause the tape to sit poorly on the player head, leading to missing information in the digital copy.

There were a few other interesting conditions noted. In one of the reels, there appeared to be windowing, however when observed closely, the tape had wrinkled up in a few places and

[10] “FACETS” (pg. 21).

caused space between the layers of tape. This cinching (Image 12) only occurred in one tape. It is generally caused when a loose tape pack is stopped suddenly and the tape slips and buckles. It is a small area of damage, however it may lead to loss of information during playback[11]. A few reels had pieces of paper placed into the winds, perhaps to mark a spot where the tape should be stopped, or to mark the beginning of a particular section of tape. It is unknown how the pieces of paper will affect playback of the tape or if they caused any damage to the tape.

Image 12
Cinching of tape, step pack and popped strands

Recommendations for Future Storage

It is always recommended that magnetic media be stored in a cool, dry environment with stable temperatures and relative humidity levels. The *ARSC Guide to Audio Preservation* recommends long term storage of audio materials be 46-53 degrees Fahrenheit and 25-35% relative humidity[12]. It is also noted that ARSC recommends that magnetic tape should not be stored below 46 degrees. Temperatures and relative humidity levels should be kept as steady as possible. Fluctuations in temperature and humidity can cause changes in tension of both the base tape materials and the binder, leading to issues such as cupping, step packing, flange packing, and popped strands. High temperatures and relative humidity can cause binder hydrolysis, which leads to sticky shed syndrome and oxide loss, and is conducive to the growth of mold which can damage the tape and is a health hazard.

[11] "Magnetic Tape Storage and Handling Guide" (pg. 38).
[12] *ARSC Guide to Audio Preservation* recommends these for long term storage of audio recordings. ARSC states that short term storage can be warmer, as long as it does not exceed 68 degrees Fahrenheit and relative humidity levels can be between 30% and 50% (pg. 69).

It is also recommended that magnetic tape that is currently stored in boxes that have mold growth, holes, or are very dirty, be rehoused in clean archival reel boxes[13]. There are a number of boxes in the collection that show deterioration from water, have mold growth, insect damage (Image 13), are very dirty or falling apart. The reels that are currently stored in these boxes should be rehoused if possible. Also, any reels that are not currently in boxes should be housed as well to prevent any further damage from accumulations of dirt and debris (Image 14). Reels that have mold either on the tape or the flange should be separated from the collection until they can be cleaned or rewound onto non-moldy flanges.

Image 13
Box with considerable insect damage

Recommendations for Digitization

As magnetic media is a particularly delicate format, the only way to make sure that the audio will last is by creating a digital surrogate. The Larry Monroe tapes are especially in need of digital preservation due to their condition and unusual subject matter. Preservation of radio shows is becoming more important as much of our culture is reflected in radio programming and that programming is being rapidly lost due to deterioration of the magnetic media upon which it is stored. Larry Monroe's shows are specifically interesting as they reflect a deejaying style that is unusual, given his more free-form method of choosing what music to play and when. Although

[13] Carla Arton, in her chapter "Care and Maintenance" from the *ARSC Guide to Audio Preservation* recommends that any housing that is torn, contaminated with mold, severe dirt or insect excretions, has water damage, or has holes that expose the media contained within them, be replaced (pg. 62).

some of his later work has possibly been preserved by KUT or KDRP, many of the tapes at the Briscoe Center are from his earlier years and these may be the only copies of some of his work. In particular there are a few tapes that, according to the information on the box or flange, contain interviews with noted musicians, which should be preserved if they do not exist elsewhere.

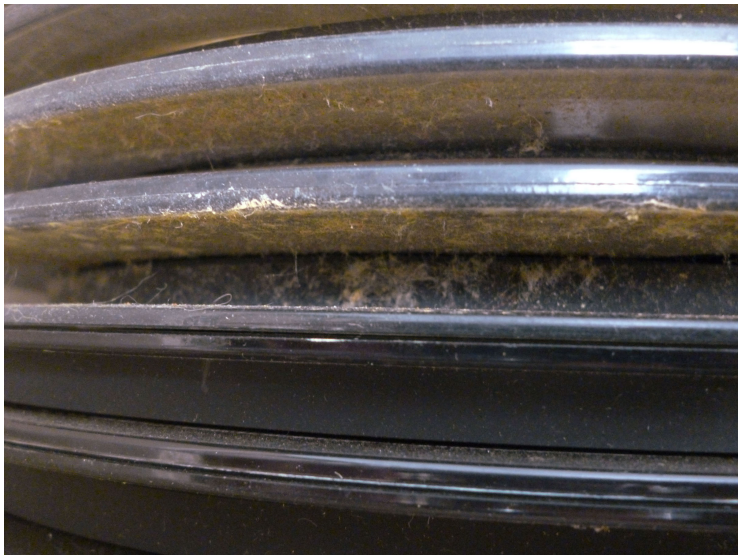

Image 14
Dirt and debris on reels not currently stored in boxes

However, there are a few complications that will need to be addressed prior to digitization. Many of the tapes are very dirty and will need to be cleaned before a good digital copy of the audio can be retrieved. Some of the tapes have mold, either on the tape itself or the flange (Image 15), and these will need to be cleaned carefully and in an area away from other materials so as to not spread mold spores to other delicate materials.

The other issue that will arise when playing the tapes for digitization is sticky shed syndrome. Many of the tapes have a black backcoating and show signs of binder hydrolysis, blocking and white powder, and have a greater chance of losing the oxides from the base when played. At this point, the only treatment that has shown to be at all effective is baking. Although this can be done in an oven, generally an incubator is used as it can hold a low temperature for an extended period of time, which is needed for baking a tape. Unfortunately, baking, which can remove some of the moisture in the binder, is only temporary and should be done shortly before

digitization of the tape. It is not recommended that tapes be baked more than once as baking the tape can cause damage.

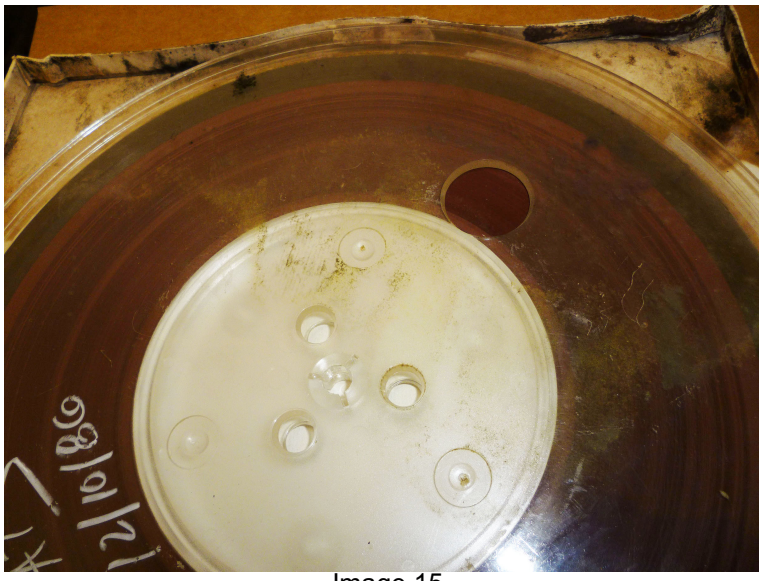

Image 15
Reel with mold on tape and interior of flange

Unfortunately, a visual inspection of a tape cannot determine every issue that will arise. Therefore, digitization of the tapes should be undertaken with care and should be performed by individuals who have training in the playback of magnetic media and are capable of recognizing when a tape is not responding in a manner that ensures a good digital surrogate or is in danger of being further damaged by the digitization.

4 Conclusion

Given the uniqueness of Larry Monroe's collection of magnetic tape, they are a good candidate for preservation and digitization. Many issues were noted in the visual inspection of the tapes, most related to previous poor storage: mold, dust and debris, step packing, popped strands, and blocking and white power indicative of binder hydrolysis. Although, as a Deejay, Larry Monroe used a higher grade of magnetic tape, many of his tapes, primarily those with a black backcoating, are prone to binder hydrolysis and sticky shed syndrome, exacerbated by storage in warm and humid surroundings.

Digital preservation of the tapes would ensure that future generations can enjoy Larry Monroe's unique style of free-form radio, but there are issues with the tapes that will need to be taken care of prior to any digitization. Many of the tapes are dirty or moldy and will need cleaning. The tapes that show signs of binder hydrolysis will most likely need to be baked before they can be safely played. Although some of his work has been preserved already, it is unknown if any of the tapes from earlier years have been saved, other than those few digitized by the Advanced Audio Preservation class at the University of Texas, School of Information.

	Reel Data							
Box #	Reel Box Data/Information	Reel Data/Information	Date	Tape Brand	Base Material	Gauge	Thickness	Oxide

Tape Data (if known)							
Reel Diameter	Pancake Diameter	Reel Length	Track Format	Black/Brown Tape	Contamination	Odor	Housing

Condition Issues

Step Pack	Flange Pack	Popped Strands	Blocking	Cinching	Cuppping/Curling	Windowing	Edge Damage	Spoking

Splices	Oxide Shed	Stretch	Object in Wind	Loose Wind	Tight Wind	White Powder	Ooze	Other Issues	Other Notes

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