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Magnetic Tapes, Playable or Not?

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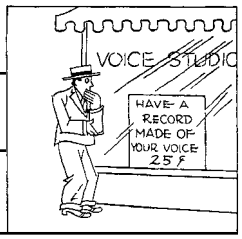

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Magnetic tape was the dominant audio and visual recording medium for several decades before the digital era. Recent surveys report that over 40 million magnetic tape recordings are held by institutions in the United States. The **Library of Congress**, for example, maintains more than 750,000 tapes. Many institutions are migrating analog recordings from unstable tapes to digital media through a process involving playback on vintage equipment, digitization of the analog signal and transfer to a new medium. Tapes composed of polyester urethane undergo hydrolysis degradation when exposed to humidity in storage. Hydrolysis causes tapes to become sticky, a phenomenon known all too well by archivists as "sticky shed syndrome" which manifests as tapes stick and shed onto playback equipment. Playback is the only way to identify degraded tapes that are non-playable, but may result in permanent data loss, impairment of scarce playback equipment, and downtime for equipment cleaning. Tapes identified as degraded can often be restored to a playable state by 'baking' at elevated temperatures, but treatment is time intensive. The efficiency and efficacy of this process is significantly hampered by the absence of a reliable method for evaluating tape playability without actually playing them.

Clearly, a non-destructive and rapid tool to detect sticky shed is needed. The **Library of Congress** partnered with analytical chemists at the **University of South Carolina** under the auspices of the **Institute of Museum and Library Services (IMLS)**. The premise of our research is that construction of such a tool would allow institutions to triage their collection: tapes identified as non-playable can be baked, while tapes identified as playable can be digitized. Recent literature suggested that infrared (IR) light might be used to differentiate degraded from non-degraded magnetic tapes. A beam of IR light is directed on the tape and an absorbance spectrum is recorded which reveals the molecules present. Infrared spectrometry is already widely used in cultural heritage institutions for identification of organic compounds and polymeric materials.

We disseminated a survey to over 50 U.S. archives, museums, and libraries to identify the most common tape formats in need of restoration. The responses indicated that quarter-inch reel-to-reel audio tape are in greatest need. Over 100 quarter-inch tapes were acquired from the **Library of Congress** Motion Picture Broadcasting and Recorded Sound Division (MBRS, Culpeper, VA). Each tape was played by an audio engineer using original playback equipment to determine its playability status. IR analysis was then carried out on each tape using a portable instrument (Figure 1).

Figure 1. Infrared Analysis of a quarter-inch tape using a Portable Spectrometer.

Similarities and dissimilarities among magnetic tape spectra are often found by looking for one or more absorption peaks associated with specific chemical components. Magnetic tapes, however, are chemically complex, and hydrolysis may not be the only chemical marker of degradation. When a tape begins to degrade, chemical changes manifest in a "fingerprint" of multiple degradation products that appear in the IR spectrum. A combination of correlated changes is often the key to recognizing significant differences between the spectrum of a tape that is playable, and one that is too sticky to be played. Because IR spectra require assessment at several hundred to several thousand wavelengths, simple visual inspection does not suffice. Our analysis of over 2,000 spectra from more than 100 quarter-inch magnetic tapes has demonstrated that multivariate statistical analysis is able to discriminate IR patterns of degraded tapes from those of non-degraded tapes. We have also developed a user-friendly software application that enables tape custodians to predict playability status of tapes from IR spectra. The appealing aspects of this approach from the tape conservator's point of view are: (a) the non-invasive nature of the infrared analysis, which does not compromise sound fidelity; (b) IR spectra can be obtained in less than a minute per spectrum; and, (c) a decision to "bake" or "digitize" is available almost immediately. The combination of FTIR analysis and multivariate statistics has proven to be reliable: a prediction model based on 1900 spectra from 95 representative tapes produced 94% accuracy for prediction of non-playability. When this model was applied to another 760 spectra from 38 different tapes, the prediction accuracy was 92% for prediction of non-playability, as previously determined by the audio engineer.

The outcome of this IMLS-funded research is the development of an effective tool for use by collection custodians to rapidly and non-destructively predict magnetic tape playability. This project will directly impact preservation and digitization work flows at museums, archives, and libraries by providing a validated tool for reliable identification of degraded tapes prior to playing — thus rescuing the nation's recorded heritage from loss.

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