

## SURVEY: ADOPTION OF PUBLISHED STANDARDS IN CYLINDER AND 78RPM DISC DIGITIZATION

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### Abstract

This paper reports on a survey used to determine the best practices in use among archives, heritage institutions, and commercial organizations involved in the preservation and digitization of instantaneous and commercial 78rpm phonographic discs and cylinder recordings. After reviewing the literature on audio preservation and digitization, a 51-question online survey was designed. In addition to demographic information, the survey addressed three main areas of inquiry: use of, and adherence to, published standards; digitization procedures; and physical storage conditions. Specifically, the variables investigated include: types of equipment in use in digitization, transfer facility selection, formats for digitized recordings, practices associated with digitization, and the skill-level and number of staff performing physical preservation and digitization. Twenty-nine respondents, including audio archivists, librarians, audio engineers, project managers, and consultants at institutions across North America and Europe, were recruited from a list based on member directories of prominent national and international audio preservation associations and by invitations sent to archival audio listservs. Most respondents were aware of published standards but reported following them to greater or lesser degrees. In many areas, the results show widespread adoption of standards with practices that meet or exceed published guidelines. In other areas, respondents reported using alternative technical practices that are not in adherence to published standards. The results may be of interest to the library and archival professions, standards-creating organizations, and the commercial recording industry, all of whom will benefit from a better understanding of whether and how current standards are being met, and what standards and practices are in use in the field.

### Acknowledgements

The authors would like to thank Sarah Payne and Guillaume Boutard for assistance in statistical analysis, and the members of the Multimodal Interaction Lab at the School of Information Studies, McGill University, for their support.

### 1. Introduction

At least since the late 1950s, engineers and archivists have voiced concern over the physical degradation of cylinders, 78s, and instantaneous discs held in library and archival collections.<sup>38</sup> In recent decades it has become clear that the original cylinders and discs, along with the subsequently developed physical media (both analog and digital) are ultimately doomed to failure, and their contents must be transferred to file-based digital formats in order to survive in the long term.<sup>39</sup> However, the simple realization that digitization is a necessity did not lead directly or immediately to standardization of digitization practices for archival audio.

38 See George Boston, *Survey of endangered audiovisual carriers 2003*, (Paris: United Nations Educational, Scientific and Cultural Organization, 2003) and A. G. Pickett & M. M. Lemcoe, *Preservation and storage of sound recordings: a study supported by a grant from the Rockefeller Foundation*, (Washington: Library of Congress, 1959).

39 Dietrich Schüller; "Preserving the facts for the future: principles and practices for the transfer of analog audio documents into the digital domain," in *Journal of the Audio Engineering Society*, 49(7/8), 2001, 618-621.

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In 2001 Virginia Danielson reported that archivists overseeing audio collections were “plagued by the view that we have no established standards for preservation and therefore should not proceed with projects.” The same year, Dietrich Schüller warned that before mass digitization projects take place, certain “principles and prerequisites” must be met or agreed upon, arguing that to digitize without set standards may lead to lost data, greater expenditures, and further degradation of media caused by additional playback. In 1998, George Boston stated in a UNESCO report that there were “no official standards for the preservation of these materials.”<sup>40</sup>

In more than a decade since the statements of Danielson and Schüller, universities, governments, and industry groups have published guidelines, recommendations, and standards for the digitization of archival audio, and many collections have been partially or completely digitized. In that time, there has also been a consistent counterargument that for certain media, especially early instantaneous and mass-manufactured disc and cylinder recordings, there is little time to worry about standards before the media, already near the end of their lifespans, suffer critical failures.<sup>41</sup>

While previous studies have been carried out to ascertain the extent and condition of audio collections<sup>42</sup>, and recent publications address the many steps yet to be taken to ensure the longevity of our audio heritage<sup>43</sup>, a literature review revealed no major study to determine adherence to or acceptance of published standards for preservation and digitization of archival audio. As a result, the present research was carried out to measure adoption of published standards and best practices in the field of archival audio digitization, and to offer a framework for collecting similar data in the future.

A survey was designed to measure practices throughout the digitization process at institutions engaged in the preservation of instantaneous and commercial discs and cylinder recordings. The data from the survey was analyzed, and a limited selection of results is presented below. The authors believe this data will be of use to the developers of past and future standards, such as the technical committee of the International Association of Sound and Audiovisual Archives (IASA) and to governmental organizations engaged in preservation planning, such as the U.S. National Recording Preservation Board (NRPB) and the Federal Agencies Digitization Guidelines Initiative (FADGI).

## 2. Literature review

Because of the rates of change in audio technology, data storage, and communication technology, documents published as recently as the late 1990s fail to reflect the current archival and digital audio scenarios. Regarding digital audio in general, the present literature review includes only documents from the last two decades. In terms of standards documents and reported practices, the review is limited to the last decade and the collected survey data concerns only digitization projects carried out between 2005 and 2010.

Because of the need to keep the survey to a reasonable length for completion by busy archivists and engineers, the number of variables tested is much smaller than the total num-

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40 George Boston, *Safeguarding the documentary heritage: A guide to standards, recommended practices and reference literature related to the preservation of documents of all kinds*, (Paris: United Nations Educational, Scientific and Cultural Organization, 1998).

41 Kevin Bradley, “Critical choices, critical decisions: sound archiving and changing technology,” paper presented at the Researchers, Communities, Institutions, Sound Recordings Conference, Sydney, Australia, 2004.

42 A. Smith, D. R. Allen, & K. Allen, *Survey of the State of Audio Collections in Academic Libraries*, (Washington, D.C.: Council on Library and Information Resources, 2004).

43 R. Bamberger and Sam Brylawski, *The state of recorded sound preservation in the United States: a national legacy at risk in the digital age*, (Washington, D.C.: Council on Library and Information Resources, 2010), and Brenda Nelson-Strauss, Sam Brylawski, A. Gevinson, & National Recording Preservation Board (U.S.), *The Library of Congress National Recording Preservation Plan*, (Washington, D.C.: The Library of Congress, 2013).

ber of variables covered by the sometimes quite exhaustive published standards. Variables were selected based on perceived importance to the overall process, as well as upon the relative ease of collecting quantitative or concise qualitative data. Below are the published recommendations for the variables tested by the portion of the survey being reported on at present.

## 2.1. Sources of digitization recommendations and standards

The standards and practices found in this review have been sponsored, supported or published by a wide array of library, archival and audio groups, including IASA, the Association for Recorded Sound Collections (ARSC), the Association of Research Libraries (ARL), the Council on Library and Information Resources (CLIR), the Library of Congress (LC), and Library and Archives Canada (LAC). Some documents are authored by committees, others are single-author reports and still others are part of broader digitization documentation portals on the Internet.

While there are many publications on the topic, two audio digitization standards and best practices documents appear to be in greatest usage in the field. These are the IASA Technical Committee publication TC-04, or *Guidelines on the production and preservation of digital audio objects: Standards, recommended practices, and strategies* (now in its second edition, published in 2009), and the *Sound Directions* report published by Harvard and Indiana University in 2007, which relies heavily on the first edition of TC-04.<sup>44</sup>

## 2.2. Technical standards

### 2.2.1. Signal chain and equipment

In the same report cited above<sup>45</sup>, Dietrich Schüller argued that “only the most advanced equipment” is to be used in digital transfer of analog media. However, documents reporting on completed and ongoing digitization show that, while quality and accuracy are a priority, even relatively well-funded cultural institutions do not always use the “most advanced” equipment in the digitization signal chain. This seems especially true in the analog portion of the signal chain, where “most appropriate” and “most advanced” may not be synonymous.<sup>46</sup> With few exceptions, the published guidelines suggest the use of modern turntables featuring finely-adjustable playback speed rather than the phonographs available at the time the discs were recorded. In published reports, Stanford University is the only institution found to have used antique equipment in the capture of archival audio, during a cylinder digitization project.<sup>47</sup> It is recommended that transfer engineers keep multiple sizes of styli and to select a stylus matching the characteristics of the disc or cylinder being transferred.<sup>48</sup>

The analog-to-digital converter (ADC) is often cited as the key piece of equipment in the digitization signal chain, and specifications for ADCs in archival digitization have been discussed

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44 R. Bamberger and Sam Brylawski, *The state of recorded sound preservation in the United States: a national legacy at risk in the digital age*.

45 Dietrich Schüller, “Preserving the facts for the future: principles and practices for the transfer of analog audio documents into the digital domain.”

46 Michael Casey & Bruce Gordon, *Sound directions: Best practices for audio preservation*, (Bloomington: Indiana University, 2007); V. Danielson, “Stating the Obvious: Lessons Learned Attempting Access to Archival Audio Collections,” *Folk Heritage Collections in Crisis*, 4-14, (Washington DC: Council on Library and Information Resources, 2001); and J. Farrington, “Cylinder Preservation and Digitization Project,” *Notes-New York Music Library Association*, 64(1), 121, 2007.

47 Stanford University, “Technical information,” (California: Stanford University, 2002), accessed August 2013, <http://ccrma.stanford.edu/groups/edison/>.

48 International Association of Sound and Audiovisual Archives, *IASA-TC04 Guidelines on the production and preservation of digital audio objects: Standards, recommended practices, and strategies*, (Aarhus, Denmark: International Association of Sound and Audiovisual Archives, Technical Committee, 2009).

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extensively in the literature.<sup>49</sup> Two models of ADC are cited in use in the literature, both in *Sound Directions*: the Prism AD-2 and Benchmark ADC-1.<sup>50</sup>

### 2.2.2. Bit depth and sampling frequency

All of the reviewed documents discussing bit depth recommend 24-bit encoding for archival audio transfers.<sup>51</sup> The literature is nearly unanimous in suggesting that 48kHz is the minimum sampling frequency that qualifies as high fidelity, with 96kHz being preferred for archival digitization.<sup>52</sup> The highest combined resolution recommended in the literature review is 192kHz/24-bit.<sup>53</sup> In published reports of completed projects, the lowest sampling frequency reported in use is 44.1kHz, for a cylinder digitization project.<sup>54</sup>

Within institutions, the technical parameters used in preservation are shown by the literature to be elastic. In 2001, Harvard University reported that the "Music from the Archives" program was digitizing audio at 88.2kHz/24bit<sup>55</sup>, while the 2007 report from Casey and Gordon finds Harvard digitizing at 96kHz/24bit. The time elapsed between reports (six years), the guidelines published in the meantime (including from NRPB and IASA), or perhaps the number of departments and variety of work underway at large institutions may account for this shift.

### 2.2.3. Equalization

The matter of whether or not to apply equalization during digitization, and what curves to apply, was not considered settled in the literature at the time of the review, and was further muddled by the limited number of commercially available phono pre-amplifiers that do not automatically impose a pre-defined equalization curve.<sup>56</sup> With the publication of the NRPB *State of Recorded Sound Preservation* report, the consensus seems to be tilting towards flat transfers.<sup>57</sup> However, this report was published after the present survey was conducted, and while the contributors to the report may have previously exerted influence in the field, the published report could not have influenced the survey respondents. In reports of work completed, *Sound Directions* was the only document found listing equalization parameters, and in this case the signal was split to allow encoding of both an equalized and a flat version.<sup>58</sup>

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49 Michael Casey & Bruce Gordon, *Sound directions: Best practices for audio preservation*; International Association of Sound and Audiovisual Archives, *IASA-TC04*; Dietrich Schüller, "Preserving the facts for the future: principles and practices for the transfer of analog audio documents into the digital domain"; and K. C. Pohlmann, "Measurement and Evaluation of Analog-to-Digital Converters Used in the Long-Term Preservation of Audio Recordings," paper presented at the "Issues in Digital Audio Preservation Planning and Management" roundtable discussion, Washington, DC, March 10-11, 2006.

50 Michael Casey & Bruce Gordon, *Sound directions: Best practices for audio preservation*.

51 Michael Casey & Bruce Gordon, *Sound directions: Best practices for audio preservation*; International Association of Sound and Audiovisual Archives, *IASA-TC04*; National Recording Preservation Board, *Capturing analog sound for digital preservation*, (Washington, D.C.: Council on Library and Information Resources and Library of Congress, 2006); and K. C. Pohlmann, "Measurement and Evaluation of Analog-to-Digital Converters Used in the Long-Term Preservation of Audio Recordings," paper presented at the "Issues in Digital Audio Preservation Planning and Management" roundtable discussion, Washington, DC, March 10-11, 2006.

52 Ibid.

53 Elizabeth Cohen, "Preservation of audio," *Folk heritage collections in crisis*, (Washington DC: Council on Library and Information Resources, 2001), 20–27.

54 J. Farrington, "Cylinder Preservation and Digitization Project," *Notes-New York Music Library Association*, 64(1), 121, 2007.

55 V. Danielson, "Stating the Obvious: Lessons Learned Attempting Access to Archival Audio Collections," *Folk Heritage Collections in Crisis*, (Washington DC: Council on Library and Information Resources, 2001), 4–14.

56 Michael Casey & Bruce Gordon, *Sound directions: Best practices for audio preservation*; International Association of Sound and Audiovisual Archives, *IASA-TC04*; and Dietrich Schüller, "Preserving the facts for the future: principles and practices for the transfer of analog audio documents into the digital domain."

57 R. Bamberger and Sam Brylawski, *The state of recorded sound preservation in the United States: a national legacy at risk in the digital age*.

58 Michael Casey & Bruce Gordon, *Sound directions: Best practices for audio preservation*.

## 2.2.4. Storage format

In all the reviewed standards and field reports, the Wave (WAV) and Broadcast Wave (BWF) file formats are suggested or reported in use as master preservation files (Bradley, 2004; Casey & Gordon, 2007; IASA, 2009; Schüller, 2001).<sup>59</sup>

In figure 1, shown below, reported practices are listed as they appear in the original publications. In the case of format, this leads to a column listing a mix of digital audio stream type such as PCM and file format wrappers such as WAV and BWF. While these formats are all interrelated—all WAV and BWF files utilize a PCM stream; BWF is a sub-format of WAV—the lack of specificity in the original publications makes it difficult to determine exact practices and, therefore, to measure adoption of published standards. For instance, an institution listing only PCM could be using AIFF or other PCM-based formats besides WAV or BWF. The survey results reported later in this article are intended to offer more uniform data on format choice in digitization projects.

| Organization/<br>Researcher | Year      | Bit Depth | Sampling<br>(kHz) | EQ during<br>transfer           | Format |
|-----------------------------|-----------|-----------|-------------------|---------------------------------|--------|
| ARL / LC /<br>Fleischhauer  | 2007      | 24        | 96                | N/A                             | WAV    |
| ARSC                        | 2009      | 24        | 96                | N/A                             | BWF    |
| NRPB / Pohlmann             | 2006      | 24        | 96 or 192         | Yes/No*                         | PCM    |
| CLIR / Cohen                | 2001      | 24        | 192               | N/A                             |        |
| LAC                         | 2008      | 24        | 96                | N/A                             | BWF    |
| NRPB / LC                   | 2006      | 24        | 96                | Yes, if known;<br>otherwise, no | PCM    |
| IASA                        | 2004/2009 | 24        | 48+               | Yes/No*                         | BWF    |

Figure 1: Published standards or recommendations (published previous to survey).

\*In these documents, arguments are made in favor of both options.

| Institution /<br>Researcher | Year | Bit<br>depth | Sampling<br>(kHz) | Converter          | Turntable             | EQ   | Format | Referenced<br>standard |
|-----------------------------|------|--------------|-------------------|--------------------|-----------------------|------|--------|------------------------|
| Harvard /<br>Danielson      | 2001 | 24           | 88.2              | N/A                | N/A                   | N/A  | N/A    | N/A                    |
| Harvard /<br>Gordon         | 2007 | 24           | 96                | Prism AD-2         | Technics<br>SP-15     | N/A  | BWF    | IASA TC-04             |
| Indiana / Casey             | 2007 | 24           | 96                | Benchmark<br>ADC-1 | Technics<br>SP-15     | Y/N* | BWF    | IASA TC-04             |
| UCSB /<br>Farrington        | 2007 | 24           | 44.1              | N/A                | N/A                   | N/A  | WAV    | N/A                    |
| Stanford                    | 2002 | 16/24        | 44.1/48           | N/A                | Antique<br>phonograph | N/A  | N/A    | N/A                    |

Figure 2: Best practices listed in use in published field reports.

\*Simultaneous encoding of equalized and flat signal

<sup>59</sup> Kevin Bradley, "Critical choices, critical decisions: sound archiving and changing technology"; Michael Casey & Bruce Gordon, *Sound directions: Best practices for audio preservation*; International Association of Sound and Audiovisual Archives, *IASA-TC04*; and Dietrich Schüller, "Preserving the facts for the future: principles and practices for the transfer of analog audio documents into the digital domain."

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### 3. Methods

#### 3.1. Survey

A web-based survey consisting of fifty-one questions was created based on the practices addressed in the literature. The survey was broken down into four sections: demographics, digitization practices, adherence to internal and external standards, and physical storage conditions. Of these, only a subset is addressed in the present report. All questions were optional, and all binary (yes/no) questions featured a “Don’t Know” option. Not all respondents answered all fifty-one questions, so results reported below are often for subsets of the respondent group, with the total number of answers received cited in each case. Some questions included an “Other” category with a free-format text response area. Responses to open-ended questions and responses in “Other” fields were coded for analysis. All respondents were presented with the survey in the same order. No compensation was offered for completing the survey.

A list of sixty potential respondents was developed from the published membership lists of IASA and ARSC. One or more individuals identified within each institution were sent direct recruitment e-mails. In addition, an open invitation was distributed to the e-mail discussion lists of ARSC and the Society of American Archivists.

#### 3.2. Respondents

Twenty-nine respondents completed surveys that were collected over four weeks in February and March of 2010. Twenty-eight responded via the web and one answered via telephone. Twenty respondents listed their age (mean = 50; range = 31-67, *SD* = 12.5). Twenty-two respondents represented institutions, six represented audio contractors and one respondent was a private collector. The respondents or their institutions were based in the United States (21), Canada (5), Norway (1), Serbia (1), and France (1). In two cases, two respondents replied from the same institution. While twenty-one respondents reported digitizing items from their collections within the last five years, all twenty-nine respondents indicated direct involvement in the planning or implementation of digitization projects.

Universities were the largest group targeted for recruitment, and they make up the greatest number of respondents (13). Frequencies for the remaining types can be seen in figure 4. Respondents were asked to classify their positions, as seen in figure 3. The three responding as technical staff represented a broadcaster, a museum, and a national library.

#### 3.3. Collections

The first table below (figure 5) shows the number of institutions holding each of the three types of audio recordings defined for investigation, as well as the mean and median collection size for each type, as reported by the respondents. The second table (figure 6) shows the number of items from each collection that has already been digitized. For cases in which collection size was reported as approximate, the given approximation was used in calculating the averages shown. If a range was given, the mean of the range was used in further calculations.

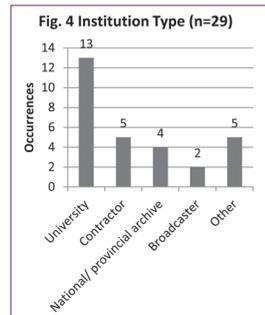
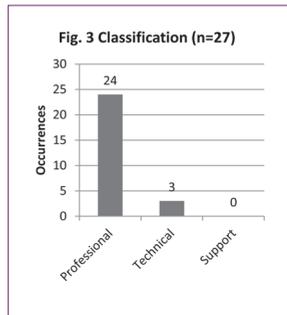


Figure 3: Job classification of respondents.

Figure 4: Institution type. "Other" responses include one each of the following: Museum, record label, private collector, philharmonic, and public library.

| Type of Recording  | No. Reporting Collection Size | Mean   | Median |
|--------------------|-------------------------------|--------|--------|
| Commercial 78      | 18                            | 45,563 | 14,000 |
| Instantaneous disc | 21                            | 16,065 | 1,000  |
| Cylinder           | 9                             | 3,802  | 400    |
| Total responses    | 22                            |        |        |

Figure 5: Holdings and collection size by media type.

| Type of Recording  | Responses | Mean | Median |
|--------------------|-----------|------|--------|
| Commercial 78      | 14        | 398  | 150    |
| Instantaneous disc | 14        | 566  | 113    |
| Cylinder           | 6         | 1428 | 70     |
| Total responses    | 20        |      |        |

Figure 6: Digitized portion of collections.

#### 4. Analysis

Descriptive statistics were the primary means of analysis. Occurrences for each question have been analyzed for frequency, and numerical values are averaged across all responding institutions. For qualitative data, categories emerging from the free format responses were identified using the constant comparison method<sup>60</sup> for descriptive purposes.

#### 5. Results

##### 5.1. Standards

Fifteen respondents reported use of external, published standards and seven reported no use of published standards (n=22). In response to an open-ended question of whether enough

60 Barney G. Glaser and Anselm L. Strauss, *The Discovery of Grounded Theory: Strategies for Qualitative Research*, (Chicago: Aldine Publishing Company, 1967).

standards have been published, nine replied “yes” with some qualifications and five replied “no” with some qualifications (n=14). The qualifications generally identified one or two areas of the preservation process as well standardized and several others as insufficiently standardized. Smaller institutions were more likely to cite the unrealistic economic constraints imposed by current standards. When asked, respondents listed the following institutions as sources of standards (figure 7).

| Standards Organization | Occurrences |
|------------------------|-------------|
| IASA                   | 8           |
| AES                    | 7           |
| ARSC                   | 6           |
| CCI                    | 1           |
| LC                     | 1           |
| NARAS                  | 1           |
| Total responses        | 16          |

Figure 7: Institutions consulted for standards.

Among the responses, only two documents were specifically mentioned: IASA TC-04 (8) and the *Sound Directions* report (2). Seven institutions reported using an internal best practices document (n=20). Reported attributes of internal documents generally reflect recommendations found in published standards, but also offered modifications of published standards to meet internal needs.

## 5.2. Transfer practices

### 5.2.1. Hardware and software

Turntables reported in use include (by brand): Technics (10, including six SP-15s and two SP-10s), Esoteric/Rek-O-Kut (5), and eight other various models. For cylinder playback: Archeophone (3), Amberola (1), Shablin (1), and house-built players (2). Fourteen respondents listed the ADC in use. Of these, the only repeated brand was Apogee (3), for both the Rosetta and Mini series converters. The rest were a mix of other brands of professional ADCs, as well as several consumer-grade USB audio interfaces or sound cards.

The smallest stylus in use was 0.7mil, the largest 16mil. Seven respondents reported at least five different sizes in use, and six reported ten or more sizes. Elliptical, spherical, conical and Shibita-type stylus shapes were listed. For tracking force, the minimum listed among seventeen responses was 1 gram, and the maximum was 5 grams. While a question was asked about anti-skating adjustment, no clear trend was visible among the nine responses, which varied from an indication of adjustment without direct measurement to a small number of respondents providing numerical values.

Asked whether playback speed is adjusted for each disc, eighteen answered yes, six answered no. For playback speed adjustment of cylinders, thirteen answered yes, five answered no. Reported strategies for determining correct playback speed included: establishing the key of each piece (8), reference to 50Hz/60Hz hum on electrical recordings (3), using the presence of fixed-reed instruments to determine pitch (2), expert opinion of musicologist/musician/producer (2), manufacturer data (2), perfect pitch of the technician (1). Two respondents reported digitizing at standard speeds and only adjusting for pitch digitally on subsequent copies of the master file.

Audio editing software listed in use included WaveLab (10), ProTools (4), Audacity (2), and SoundForge (2). Software mentioned by only one respondent each included Nuendo, Pyramix, Audition, and Peak.

### 5.2.1.1. Sampling frequency and bit depth

Figures 8 and 9 display sampling frequency and bit depth selection. Twenty out of twenty-five respondents reported using sampling frequency above 44.1kHz, as recommended by the standards. Two of the five respondents working at 44.1kHz were contractors, and one was a private collector. All but one of the five using 44.1kHz indicated working with all three types of recording (commercial discs, instantaneous discs, and cylinders), with the other working with commercial and instantaneous discs. Twenty-one of twenty-six respondents indicated a bit rate at or above 24 bits, as recommended by the standards. Among the five respondents digitizing at 16 bits was one consultant, who was also among those sampling at 44.1kHz.

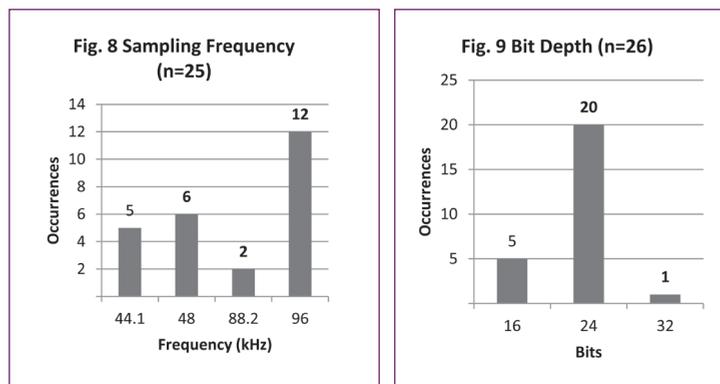


Figure 8: Sampling frequencies reported in use. Values in bold meet or exceed recommendations.  
 Figure 9: Bit depths reported in use. Values in bold meet or exceed recommendations.

### 5.2.1.2. Equalization

Response to a question on the application of equalization is shown in the following graph (figure 10). No qualitative data was collected to explain the application or lack of application of equalization. Among the twenty respondents who reported applying EQ either before or after digitization, seventeen consulted published lists of manufacturers' roll-off curves in determining the applied EQ curve.

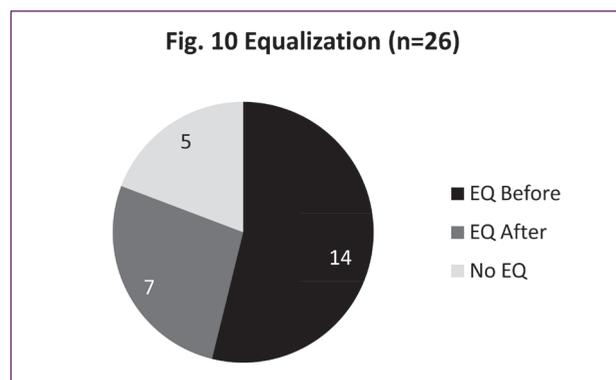


Figure 10: Application of equalization (EQ) before or after digitization.

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### 5.2.1.3. Storage format

Twenty-two respondents reported using either WAV or BWF format (n=25). Of these, eight listed BWF. Use of the BEXT chunk associated with BWF was not measured.

## 6. Discussion

### 6.1. Summary of findings

At present, the literature on preservation and digitization of 78s, instantaneous discs, and cylinders offers several sets of standards and recommended practices. Also found in the literature are reports of completed or ongoing digitization projects and national planning frameworks. However, at the time of this research no reports had been published on adoption of published standards. While two joint CLIR and NRPB publications published after the survey was carried out address many challenges in audio preservation, including the deteriorating condition of collections and the need for broader institutional support for preservation projects, neither publication directly measures adoption of published standards.<sup>61</sup>

While there are certainly professionals in the field with extensive anecdotal knowledge of practices in use at a variety of institutions, this information has not been collected, coded, analyzed, and published. The present study provides data that can be used as feedback by authors of current standards and as background information for authors of future standards. Institutions and preservation teams can use the data to determine how their own preservation practices are situated within the field.

In many areas, the results of this study show widespread use of practices that meet or exceed published guidelines (e.g., sampling frequency and bit depth). In other areas, the data does not indicate a clear trend, or insufficient data was collected to determine a trend. In cases where a standard is being met, it is not always clear whether there is a causal link between the availability of the standard and the implementation of suggested practices. Technical best practices are met more closely than many of the expertise-oriented best practices found in the literature, though the measures of expertise included in the survey are the subject of a separate report to be issued at a later date.

### 6.2. Standards in use

Barely more than half of the total number of respondents reported use of external standards, while only one quarter of the respondents reported using an internal standards document. This is of interest due to the fact that, in the cases of bit depth, sampling frequency, and file format, far more than half of respondents reported practices that are in agreement with published standards. One possible explanation for this is that the practices in widest use helped determine the standards. Most standards have been developed by consultation with panels of experts who are part of a broader community of practice, and these experts come from some of the surveyed institutions. Another explanation is that several practices recommended in the archival literature are not exclusive to the discipline. The indication of the Audio Engineering Society among standards sources points to this explanation, as AES standards are generally aimed at the wider audio community.

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61 R. Bamberger and Sam Brylawski, *The state of recorded sound preservation in the United States: a national legacy at risk in the digital age*, (Washington, D.C.: Council on Library and Information Resources, 2010), and Brenda Nelson-Strauss, Sam Brylawski, A. Gevinson, & National Recording Preservation Board (U.S.), *The Library of Congress National Recording Preservation Plan*, (Washington, D.C.: The Library of Congress, 2013).

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## 6.3. Transfer practices

### 6.3.1. Signal chain / Hardware and software

While many of the turntables reported in use meet published technical requirements, few models of new, hi-fidelity cylinder players exist, which may be one reason for the use of a historical playback device, and for the use of the house-built players. Interestingly, in a market that offers turntables with prices that reach above \$100,000.00, with supposed benefits and features to match, the literature shows that two of the world's leading recorded sound archives choose to use the Technics SP-15<sup>62</sup>, which is well suited to the task, yet does not fall under the "most advanced" heading suggested by Schüller.<sup>63</sup> While the SP-15 is no longer in production, even a brisk secondhand market and the expense of repairs do not drive the price anywhere near the range of the boutique turntables mentioned above. The survey results confirm this trend towards the selection of what may be "most suitable," or simply within reach, with additional SP-15s as well as other appropriate but not extravagant turntables in use.

For styli, it may be enough to say that several institutions had a large enough variety to adjust to the needs of each recording. Price may be a prohibitive factor for those listing sub-standard turntables and phono pre-amplifiers or performing analog-to-digital conversion via consumer-grade USB interfaces or on-board sound cards.

### 6.3.2. Sampling frequency and bit-depth

As figure 8 illustrates, nearly half of the respondents digitize audio at 96kHz, which meets or exceeds most recommendations. Taking 48kHz as the recommended minimum, twenty out of the twenty-five respondents are within the scope of the standard. Two of those working at 44.1kHz cited use of standards that call for higher sampling frequency when responding to other sections of the survey. Their use of a sub-standard sampling frequency is unexplained. Because no qualitative data was collected for selection of bit depth and sampling frequency, it is not possible to determine why five respondents digitize at 16 bits. Concerns over digital storage space or use of relatively antiquated digitization equipment may be responsible. That one respondent is digitizing at 32 bits is of interest, as this rate is not mentioned in the literature, and it remains to be seen whether more standards or institutions will move towards 32 bit in the future. The same respondent sampled at 96kHz, rather than the technologically feasible 192kHz, which might be expected to accompany the increase in bit depth.

### 6.3.3. Equalization

The application of equalization in the digitization signal chain was not a firmly settled issue in the literature at the time of the survey, so the survey data are difficult to interpret in terms of the stated research goals. For critics of equalization in digitization, who seem to have been ascendant in the time following the survey, the results are discouraging, while for proponents of equalization in the digitization process, the results are encouraging.

### 6.3.4. Storage format

Results for file format are very encouraging in relation to published standards. Some of those listing WAV may in fact be using BWF, as it is a sub-type of WAV. Some of those reporting the use of WAV were also among the respondents who did not cite the use of

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62 Michael Casey & Bruce Gordon, *Sound directions: Best practices for audio preservation*.

63 Dietrich Schüller, "Preserving the facts for the future: principles and practices for the transfer of analog audio documents into the digital domain."

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external standards. The use of WAV is also common outside the archival audio field, and this may influence the format selection.

## **7. Limitations**

Several limitations of this research should be noted. First, the separation of media into three groups (instantaneous disc, commercial disc, cylinder recording) failed to take into account the distinction between instantaneous and commercial cylinders. It was assumed that cylinder collections would be smaller, with less respondents reporting work with them, and for the sake of expediency all cylinders were treated as equal. In addition, all genres of audio recording were treated as equal. There may be valid reasons for separate practices when digitizing spoken voice recordings as compared to music recordings, for instance. Future researchers may wish to determine whether significant differences exist in the preservation and digitization of different types of recorded content.

While the response rate for the survey was fairly large, the data collection period was limited to one month. A longer data collection period may have resulted in a greater response rate, which would further validate the results and enable inferential statistical analysis to compare practices across sub-groups of respondents. In addition, translation of the survey or further effort in recruiting participants from outside North America would allow for a better understanding of global practices.

Collection of qualitative data was kept to a minimum, to facilitate a more timely analysis. Collection of more qualitative data would no doubt answer several of the questions raised within the results and allow for clarification of unclear responses.

This research faces a drawback associated with any research on technological practices: changes in technology and the publication of new standards limit the value of the research in the future and require the same research to be repeated after only a few years. If the core elements of the current survey are adapted as a result of the lessons learned in this first iteration, a new version could be created with the intention of repetition on a multi-year basis.

## **8. Conclusion**

This research aimed to measure the adoption of recent archival standards in the field via an online survey. The survey tested not only whether institutions were aware of published standards, but also their current actual practices, regardless of their knowledge of published standards. Many respondents were aware of published standards, and many follow them to greater and lesser degrees. Some, through their responses, indicate awareness of standards but operate using alternative or sub-standard technical practices nonetheless. It is hoped that the availability of this research will help those developing future standards understand the effects of their publications, and help those who are implementing published standards to understand their work in the context of other, similar institutions.

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## Appendix: Survey questions

### Part I: Demographics

Your age (optional):

1. What is your position title?
2. How is your position classified? (Professional / Technical / Support)
3. Please identify the type of institution that you represent: (University / Historical Archives / Library / Museum / Government Archives / Other)
4. Which of the following types of media are held by your institution? Check all that apply. (Commercially Released 78rpm Discs / Instantaneous Discs / Cylinder Recordings)
  - 4a. How many commercial/mass produced 78rpm discs are in your institution's collection?
  - 4b. How many instantaneous discs (acetate, nitrate or other) are in your institution's collection?
  - 4c. How many cylinder recordings are in your institution's collection?
5. Has any part of your institution's collection of the above media been digitized within the last 5 years? (Yes / No / Don't know)
6. Were you/are you directly involved in the planning or implementation of the digitization program? (Yes / No)
7. Please identify the type of department carrying out digitization. If a collaboration between departments, check all that apply. (School of Music / Archives / Library / School of Library/Information Science / Other)
8. Who performs hands-on digitization in your institution? Check all that apply. (Professional Staff / Technical Staff / Support Staff / Student Assistant / Other)
9. How many people have worked on the digitization process in the last year?
10. Please indicate which of the following professions are represented on your institution's digitization team, or were involved in the development of the program? If possible, please enter the number of professionals from each category: (Librarian / Archivist / Audio Technician / Research Assistant / Research Scientist / Student Assistant / Computer Programmer / Other)

- I 1a. How many of your 78s have been digitized?  
I 1b. How many of your instantaneous discs have been digitized?  
I 1c. How many of your cylinders have been digitized?

## Part 2: Digitization

12. Has your institution performed analog preservation transfers (from disc/cylinder to analog audio tape) in the past? (Yes / No / Don't know)  
13. If yes, do you plan to digitize the tape transfers, the original discs/cylinders, or both? (Originals / Tapes / Both)  
14. In what type of facility do you perform digitization? (Purpose-built digitization studio / Other recording studio / Archival processing area / Office / Other)  
15. Was testing carried out to determine the acoustic characteristics of your institution's digitization room? (Yes / No / Don't know)  
16. If yes, please specify the types of testing carried out:  
17. Please list each type (rather than make/model) of component in your facility's digitization signal chain. (For example: turntable, amplifier, equalizer, A-to-D converter, PC)  
18. Are discs and cylinders cleaned prior to digitization? (Yes / No / Don't know)  
19. Is a mechanical record cleaner used? (Yes / No / Don't know)  
20. What other methods and materials are used in cleaning discs and cylinders?  
21. What variety of stylus shapes and sizes are on hand for use in digitization?  
22. Please list the maximum and minimum tracking force applied during digitization playback. (Grams)  
23. Please list the maximum and minimum anti-skating force applied during digitization playback. (Grams)  
24. Is the system set up for monitoring the signal at multiple points in the signal chain? (Yes / No / Don't know)  
25. Are grooves on discs and cylinders inspected with a microscope prior to playback? (Yes / No / Don't know)  
26a. Is playback speed adjusted for each disc? (Yes / No / Don't know)  
26b. Is playback speed adjusted for each cylinder? (Yes / No / Don't know)  
27. If yes, how is appropriate playback speed determined?  
28a. What model of turntable is used for digitization?  
28b. What model of cylinder player is used for digitization?  
29. What model[s] of analog-to-digital converter is used for digitization?  
30. At what bit depth is the audio captured? (16bit / 24bit / 32bit / Other)  
31. At what sample rate is the audio captured? (44.1kHz / 48kHz / 88.2kHz / 96kHz / Other)  
32. Is any equalization applied to the audio as part of the transfer process? (Yes, before / Yes, after / No / Don't know)  
33. Are published lists of manufacturer rolloff curves consulted in equalization? (Yes / No / Don't know)  
34. What optimal input level is used (in dB)?  
35. What software is used for audio capture? Please list all tools used.  
36. What is the target preservation format of the digitized audio? (For example, BWF, AIFF, WAV, etc.)

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### **Part 3: Standards**

37. Does your institution observe any published storage and/or digitization standards?  
(Yes / No / Don't know)
38. Please list the published physical media storage standards that are observed in your facility.
39. Please list the published audio digitization standards that are observed in your facility.
40. From what sources does your institution seek out digitization standards?
41. Does your institution have an internal best practices document for digitization?  
(Yes / No / Don't know)
42. What does it specify?
43. Would you be willing to provide a copy for this research? Specifications will not be identified with your institution in any publication.  
(Yes / No / Don't know)
44. Do you believe that adequate standards have been published in this area? Please justify.
45. What types of specifications would you like to see in future standards?

### **Part 4: Physical Storage**

46. At what temperature is/are your institution's collection[s] (78s, cylinders, instantaneous discs) stored?
47. At what humidity is/are your institution's collection[s] (78s, cylinders, instantaneous discs) stored?
48. Does your institution preserve damaged/unplayable discs? (Yes / No / Don't know)
49. Are your institution's 78/cylinder/instantaneous disc collections stored in conditions different from those of your institution's archival paper documents? (Yes / No / Don't know)

### **Follow-up questions:**

- Did you consult with other members of your team in completing this survey?  
(Yes / No)
- Would you be willing to participate in a telephone or in-person interview in connection with this research? (Yes / No)