MAGNETIC TAPE STABILITY: TALKING TO EXPERTS OF FORMER TAPE MANUFACTURES

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In memoriam Werner Singhoff

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1. Introduction

Unlike film, whose instability has kept film archivists on alert since its invention, the stability of magnetic tape has only become the subject of systematic investigation in more recent years. Because of the critical instability of nitrate cellulose, film conservation and archiving has always been in the hands of chemists, while electronic engineers dominated the archiving of sound and, later, videotapes. The engineers, generally, did not worry greatly about the stability of the base materials of tapes until problems became apparent. Therefore, apart from the early and authoritative study by Picket and Lemcoe in 1959, it was not until the 1980s that tape stability became the subject of concern. By that time, modern audio and videotapes had started to get sticky: a phenomenon that soon became known as "Sticky Tape Syndrome," later termed "Sticky Shed Syndrome" (SSS).[13]

This phenomenon triggered a series of publications written by concerned users and archivists. They felt responsible for the survival of the recorded content, whether for commercial reasons or because they felt a moral obligation as representatives of memory institutions. This does not mean that tape manufacturers were not involved in actions to rescue affected tapes. They worked in close and discrete cooperation with the holders of such tapes whenever major problems were discovered. Obviously, commercial considerations prevented an open scientific dialogue between tape manufacturers and archivists unlike that established between film manufacturers and film conservators.

Research into magnetic tape stability and life expectancy culminated in the 1990s and was one of the key topics of the Joint Technical Symposia.[14] It faded to some degree, however, after 2000 when the urgent need to transfer audio and video content into digital repositories was recognized. This was because of the ever-growing threat of the loss of replay equipment in operable condition because of the withdrawal of manufacturers from the field and the unavailability of spare parts. Still, a deeper understanding of tape deterioration remained important in order to arrive at a solid basis for reconditioning problematic tapes for optimal replay.

Consequently, magnetic tape stability, deterioration, and recovery were part of project *KUR-ILKAR* of the Department of Ethnomusicology at the Ethnological Museum in Berlin—more colloquially known as the "Berlin Phonogramm-Archiv." This project was jointly carried out with the Rathgen Research Laboratory.[15]

12 Updated version of a paper originally presented at ARSC 2012, Rochester, USA, May 2012.

13 The phenomenon of SSS is very well known. Tape layers stick together to a greater or lesser extent, tapes squeal during replay, back coating may stick on the pigment side and sticky tape components are deposited on the tape guides and heads. This prevents the intimate tape-to-head contact obstructing the replay of the high frequencies of audio and causing severe replay problems, if not complete breakdown, of video signals. Before these interviews explained additional reasons, the hydrolysis of pigment binder was the generally assumed reason for SSS. Gilmour and Fumic (1992) is a representative article of that time, while Kevin Bradley (1992) expresses early skepticism. For more references see IASA-TC 05.

14 Specifically, the Joint Technical Symposia from 1990-2000.

15 The KUR-ILKAR-project was a conservation programme and had two main objectives: Conservation of the unique holdings of copper negatives of the cylinder collection of the archive, and stabilizing and reconditioning of the archive's tape collection.

The author was consultant in this project and his major engagement was focused on establishing contacts with experts of the former tape manufacturers BASF and Agfa.

Parallel to development of the "Magnetophon" by AEG in the 1930s, the chemical company IG Farben had developed magnetic tape and was the only producer until the end of World War II. Thereafter, magnetic tape production in West Germany was continued by two offsprings of IG Farben, BASF and Agfa, who were in competition with each other.[16] In 1990 BASF took over Agfa Magnetics, maintaining both companies' production plants: Willstätt (originally BASF) and Munich (originally Agfa). In 1997 BASF Magnetics was sold to an investor and renamed EMTEC. In 2004, however, EMTEC stopped the production of magnetic tape.

In this post-commercial, post-competitive situation it was possible to contact former experts from BASF and Agfa and to ask them for interviews about magnetic tape stability, centred on the Sticky Shed Syndrome. Interviews were arranged with experts formerly working with Agfa and BASF before the takeover in 1990.

The first interview took place on 13 May 2011 in Munich with experts from the former Agfa plant: Werner Singhoff and Rudolf Müller, who were engaged in professional customer service; and Klaus Koepe, who specialised in tape testing and tape recovery. Their experience predominantly concentrates on professional audiotapes. Wulf Münzner, formerly working at BASF on videotape development, was interviewed on 6 and 7 October 2011 in Berlin.[17] The interviewing team consisted of Elena Gómez Sánchez, chemist; Simon Kunz, conservator; Katrin Abromeit, conservator (in Berlin only), all from Rathgen Research Laboratory; and the author.

A list of questions had been sent to the interviewees in advance. The interviews (Munich four hours, Berlin six hours) have been logged in German. The interviewees partly amended the minutes with additional information before giving their final approval. Abstracts of these interviews, again authorised by the interviewees, have been published in the ILKAR Project Documentation DVD. This DVD also contains the minutes, a close-to-verbatim transcript, of the Munich interview. The minutes of the Berlin interview has not (yet) been published.

A discussion of the interviews in light of previous publications is not the aim of this article. The intention is to point to the abstracts of the interviews, briefly summarise their essence, and to draw some personal conclusions therefrom.

2. The essence of the interviews

2.1. Sticky Shed Syndrome (SSS)

Sticky Shed Syndrome, the causes and treatment of affected tape, was the central interest of the discussions.

The Agfa team mentioned hydrolysis of pigment binder in association with too high pigment concentration (PEM 469) as the main reason. Tape surface damage, caused by mistreated tapes and ill-serviced machines, enhanced the problem as damages act as a "port of entry" for dete-

16 A third offspring was Agfa Wolfen, later ORWO, in Eastern Germany. Their cellulose acetate based professional tapes, specifically "Agfa Wolfen C," were popular with broadcasters in the entire former Eastern Bloc, from Eastern Germany to Vietnam.

17 In the late 1980s and early 1990s, Werner Singhoff and Rudolf Müller were frequent participants in the discussion groups of manufacturers and archivists arranged at the fringe of AES conventions in the US by William D. Storm and Gerald Gibson, which led to the establishment of the AES Standard Sub-Committee on Audio Restoration and Preservation (AES SC 03). The contacts with Dr. Wulf Münzner were kindly established by Friedrich Engel. The author is indebted to the experts for their enthusiasm in supporting magnetic tape preservation studies, and for their generous, time-consuming engagement before, during, and after the interviews. Sadly, Werner Singhoff unexpectedly passed away in May 2012. His presence will be missed in future studies on magnetic tapes and the details of their production.

rioration. Lubricant exudation was reported as a second reason for SSS, particularly common around 1988 with PEM 468 tapes as a result of a change in recipe.

At BASF, hydrolysis of pigment binder was never experienced. However, the following other reasons were reported:

- Primer exudation—at BASF, a PVC-based 0.1 µm layer on the base film, to facilitate cohesion between base film, pigment, and back coating.
- Superfluous dispersion agents.
- Lubricant exudation, often as a result of temperatures below 5-6°C.
- Insufficiently cross-linked binder components, only occurring in consumer video tapes produced at high speed.

An exclusive relation between SSS and back coatings, as reported by some American authors, was not confirmed from either group.

Agfa treated affected audio tapes, suffering from hydrolysis as well as lubricant exudation, by mechanical cleaning with lint free tissues and temperature treatment at 60°C. BASF offered mechanical cleaning by agate blades and temperature treatment at 40°C, in order to avoid geometrical tape distortion of video tapes. Both confirmed that temperature treated tapes were playable only for a limited period and returned to sticky conditions. As the transfer of content was the objective of treatment, the further behaviour of temperature treated tapes was not observed.

2.2. The role of the production process for tape quality and stability

The other topic discussed in both interviews was the important, if not predominant, role of the production process for the quality and stability of magnetic tape. The production speed of professional tapes was between 100 and 200 m/min. Great precision was required to achieve the optimum chronological sequence (in terms of seconds) in the application of chemical and physical processes:

- Application of the primer (BASF)—at Agfa, the base film was delivered with primer already added.
- Coating of pigment/binder layer.
- Pre-orientation of magnetic particles by a magnetic field—binder must still be soft enough to allow this.
- Calendering—the use of heated rollers to shape the surface of the pigment layer. The pressure and temperature of the calender rollers determine surface evenness and hardness, as well as the size of pores for lubricant delivery. The binder must have sufficiently hardened before this process can be undertaken.

In the last period of tape manufacture, the production speed reached 1000 m/min. This required cross-linking of binder components during the coating process. Uneven distribution of binder components, however, led occasionally to sticky areas. This kind of SSS cannot be cured, either by mechanical, or by temperature treatment. The high-speed process, however, was only used for the production of video consumer tapes.

It was also stated in both interviews that the development of new magnetic coatings was an expensive and time-consuming process, which could last up to two years. Consequently, the tendency was to keep production stable over long periods. Corrections or alteration were exceptions.

The unanimous statement of Agfa and BASF experts is that the chemical recipe is the basis, but not the guarantee, for tape quality and stability. The production process is equally, if not more, essential and consequently it is a highly protected industrial secret: competitors were never admitted into production plants.

Another production-related phenomenon was observed when storing great lengths of tapes (e.g., 10,000 m) on one roll before slitting. This caused high pressure on surfaces of inner layers, changing their properties when compared with the outer layers.

Noteworthy is the BASF experience that problems occurred, at the latest, within two to three years after production.

2.3. Lubricants and re-lubrication

Fatty esters, fatty acids, fatty acid salts and amides were used in many combinations to determine the point of solidification of the lubricants, commonly chosen at a temperature of 5–6°C. On modern tapes, the loss of lubricant has not been observed. However, insufficient lubricant delivery because of too small pores resulting from too high calender pressure has been found. Re-lubrication is unanimously discouraged: this would always lead to excessive amounts of lubricants which would contaminate replay equipment as well as other tapes replayed on the machine.

2.4. Summary

The interviews underline the important role of the production process. This also explains what has been found empirically before: SSS replay problems do not necessarily concern all tapes of the same types; they are often related to production batches or periods. Convincing evidence has also been provided that performance differences may even occur within the same reel. Therefore, lists of endangered tape types rarely provide solid help.

The interviews have also demonstrated that tape manufacturers have developed their own procedures and traditions. The results of studies of and experiences with one type of tape cannot be extrapolated uncritically to other magnetic tapes, and particularly not to tapes of other manufacturers.

3. Personal questions and conclusions

Apart from mere scientific interest, one of the main reasons for chemical analysis of magnetic tapes was the intention to establish a hierarchy of urgency for digitisation. Analytical methods should reveal which tapes are closer to deterioration and therefore in need of immediate transfer, while others are less endangered and may wait.[18] The logic of this strategy, however, was overthrown by the ever-accelerating lack of tape replay equipment and spare parts of all types. Until recently, the remaining time was considered to be 10–15 years, but from the perspective of 2013 this may already seem overoptimistic. Furthermore, following the emphasis given to the importance of the production process in both interviews, chemical analysis alone may provide an incomplete picture, as production related problems would not necessarily be fully revealed.

In light of the BASF experience that problems caused by lubricant, primer, and dispersion agents arise fairly soon after production, we should examine more closely SSS caused by binder hydrolysis and its development over time. This phenomenon was described from the early 1980s onward and it seems that it also appeared fairly soon after production of the affected tapes. Have we ever observed that tapes were in good condition after production for several years, before they became sticky, despite being stored in good conditions? Archives that have inspected their tapes in regular intervals over the past thirty years are challenged to look into their records.[19]

18 In the 1990s, the author had also started a research project in cooperation with the Austrian Plastics Institute aiming at prioritizing digitization according to the individual levels of instability progression. The project was interrupted because of funding problems and, due to of the changed situation after 2000, it was not taken up again. Cf. Hinterhofer et. al. (2000).

19 A quick request to IASA TC members for information about SSS did not lead to conclusive reports.

Whatever closer studies of the development of binder hydrolysis may reveal, chemical analysis will remain of interest, as a deeper understanding of tape deterioration may lead to improved and more sustainable reconditioning of problematic tapes for optimal replay. As the time window left for replay is obviously shrinking, the pragmatic conclusion is that **all** magnetic tapes should be considered equally endangered: their transfer into digital repositories cannot wait any longer.

Apart from the results discussed here, the interviews have disclosed a number of details that provide a fairly realistic view on magnetic tape production. Specifically, American colleagues are encouraged to seek similar cooperation with experts from former tape manufacturers in North America.

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20 The DVD can be obtained from Albrecht Wiedmann, Ethnologisches Museum, Staatliche Museen zu Berlin (a.wiedmann@smb.spk-berlin.de).