An Oracle White Paper
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Protecting Your Archival Data With Improved Tape Dimensional Stability

Executive Overview

This white paper addresses tape dimensional stability as a key factor in long-term data archiving using magnetic tape. As with most materials, magnetic tape will change its dimensions as a function of environmental changes. Minimizing any tape dimensional changes will ensure the robustness of data, even after storage in different environments. Oracle’s selection of aramid as the StorageTek T10000 T2 substrate assures superior tape dimensional stability performance and long-term archival life.

Introduction

When data is saved to tape, you want to be confident that data will be accessible decades from now, as well as tomorrow. Magnetic tape storage has one of the longest archive lifetimes, up to 30 years, of all storage solutions currently on the market. How does Oracle test magnetic tape to ensure data is safe and can be recovered years from now? As data densities get higher on tape, and there are more tracks written on a tape, dimensional stability becomes more important to ensure data can be read after long-term storage. Oracle’s StorageTek T10000 T2 tape media, used with Oracle’s StorageTek T10000C tape drive, has significant increases in both the number of data tracks and tape dimensional stability. This white paper will address tape dimensional stability as a key factor in long term data archiving using magnetic tape.

What is expected for long term archiving of data? Data is often stored on tape to meet legal requirements (Sarbanes-Oxley, HIPAA, etc), as well as to protect critical information. The data will be written on a tape cartridge using one or more tape drives. Short term, the cartridge may be stored, on-site, in a library. However, for data that is infrequently accessed, it is common for tape cartridges to be stored off-site. The expectation is that the cartridge can be retrieved, and the data accessed, at a much later date, if necessary. Often, the tape cartridge will be read using a different tape drive in a different location and environment. In fact, the tape drive may even be a different generation. The data written on the cartridge needs to be readable for up to 30 years. Data corruption, through magnetic and/or physical degradation, is unacceptable. In the case of barium ferrite (BaFe) particles, used in the StorageTek T10000 T2 tape media, Fujifilm has demonstrated the chemical stability and superior storage performance of BaFe as compared to other metal particles in extreme environmental conditions. Environmental stability is a key consideration when designing and testing magnetic media used for tape storage.

What is Tape Dimensional Stability?

Tape cartridges have environmental guidelines for long-term storage, with both temperature and relative humidity (%RH) ranges specified. Often, these guidelines are assumed to address concerns over magnetic particle oxidation or chemical changes. The environmental storage guidelines are to address the dimensional stability of the tape. As with all materials, magnetic tape can change its dimensions when exposed to different temperatures and humidities. One example, on the macroscopic level, would be how a wooden door swells in high humidity making it difficult to open. In many cases, these dimensional changes are not noticeable. However, data bits on magnetic tape are tiny enough that small changes in the dimensions of the tape can impact the likelihood of successfully recalling data.

To understand this better, examine Figure 1. Data is initially written under recommended environmental conditions with excellent read back quality. Data is written on the tape with multiple writers on the tape head. The distance between each written track is controlled by the spacing of the writers on the recording head. The magnetic data bits on the tape are well aligned with the magnetic recording head. The tape is then stored, under tension, at a certain temperature and humidity. Over time, the width of the tape may shrink or expand. Physical properties of the tape, such as the coefficients of temperature, humidity, and tension narrowing, determine the amount of dimensional change. Finally, when the tape cartridge is re-read, the environmental conditions may be different. The spacing between the data tracks written on the tape will have changed. The data written on the tape now is shifted in relation to its original location. If there is too great a difference between the spacing of the written tracks on tape and the readers on the recording head, the data cannot be read back.

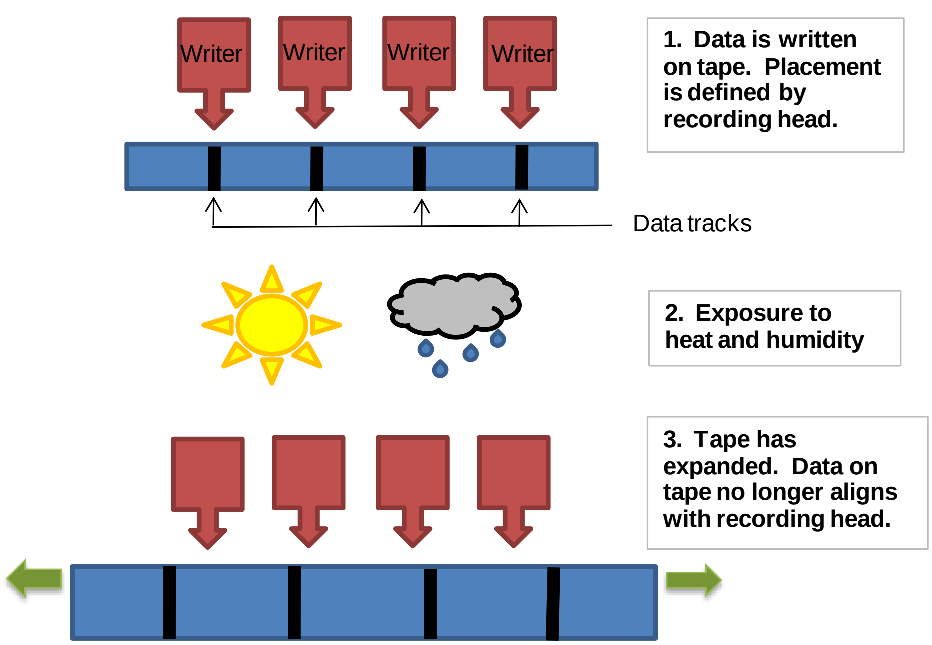

Figure 1. Small changes in the dimensions of the tape can affect the read back quality of data.

Tape Substrates and Dimensional Stability

Substrate choice is the largest contributing factor to tape dimensional stability. Previous generations of magnetic media have been coated on polyethylene naphthalate (PEN) or polyethylene teraphthalate (PET). Oracle's latest tape offering, the second generation of StorageTek T10000 tape media, T2, uses a different substrate material, one that has much better dimensional stability. The new substrate is an aromatic polyamide known as aramid. The most widely known aramid variant is Kevlar. Just as Kevlar protects, the aramid used in the tape cartridge adds further protection to written data as it is exposed to different storage environments. Magnetic coating on aramid is 3-4 times more dimensionally stable than other magnetic coatings on PEN. See Figure 2.

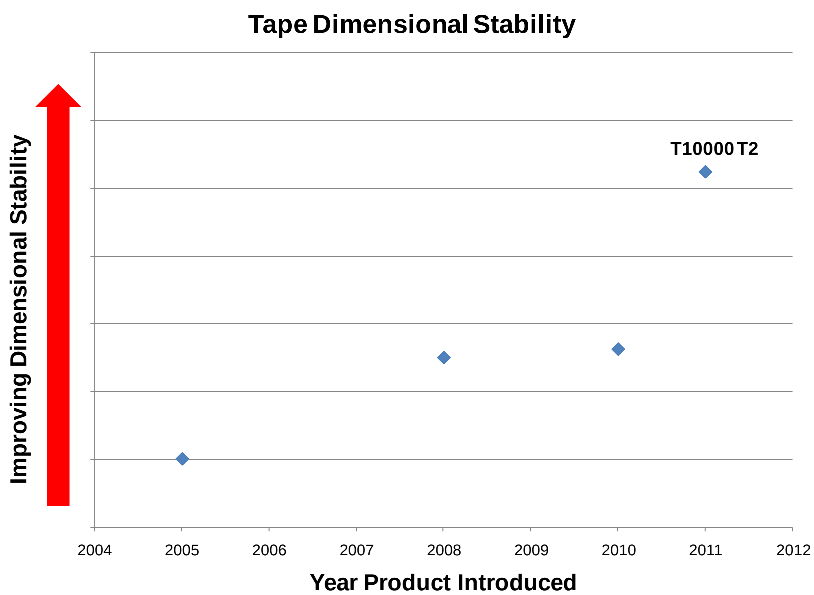

Figure 2. Tape dimensional stability is improving with new tape drive offerings. The StorageTek T10000 T2 tape media has the greatest tape dimensional stability. This is made possible through the use of aramid as the tape substrate.

Testing to Ensure Long Term Stability

Minimizing any tape dimensional changes will ensure the robustness of data, even after storage in different environments. Oracle tape development is extremely cognizant of this fact when selecting the materials used in data tape. Several tape dimensional stability parameters, such as creep, are specified and tested as part of the media qualification process.

Tape dimensional stability is typically reported in parts per million (ppm). The larger the value, the more the tape dimension will change as it cycles through different environmental conditions. Tape creep is defined as the viscoelastic change in tape width resulting from prolonged exposure to tension and pack compression and is measured in ppm.

In a standard creep measurement test, the width of the media is initially measured. The cartridge is then held at 50C for 96 hours. Subjecting the cartridge to temperatures above the specified storage condition guidelines is a means to accelerate any physical changes within the tape. After 96 hours, the cartridge is removed from the test chamber and the width is re-measured. Although the physical width can be measured using a microscope, greater accuracy, especially for small changes, can be obtained by measuring the distance between the bands of servo patterns on the media using the actual tape drive. With this method, changes in tape dimension can be measured along the entire length of the tape cartridge.

Shipping environments can be more extreme than the long-term archival environment. Because of this, shipping and medium term storage tests are also conducted. The shipping test lasts for at least 10 days at the shipping environmental extreme (52C, 10% RH). The medium term storage test runs for 4 weeks in an environmentally controlled chamber held at 32C and 80% RH. Not only are the tape physical dimensions measured, but it is confirmed that the tape cartridge can be re-read in the tape drive with no permanent errors.

In lab testing, differences in how tapes change dimension in varying environments can be seen. The degree of change for PEN based tapes is dramatically larger than for aramid-based tapes. Figure 3 illustrates this for temperature, while Figure 4 is an example of humidity's impact.

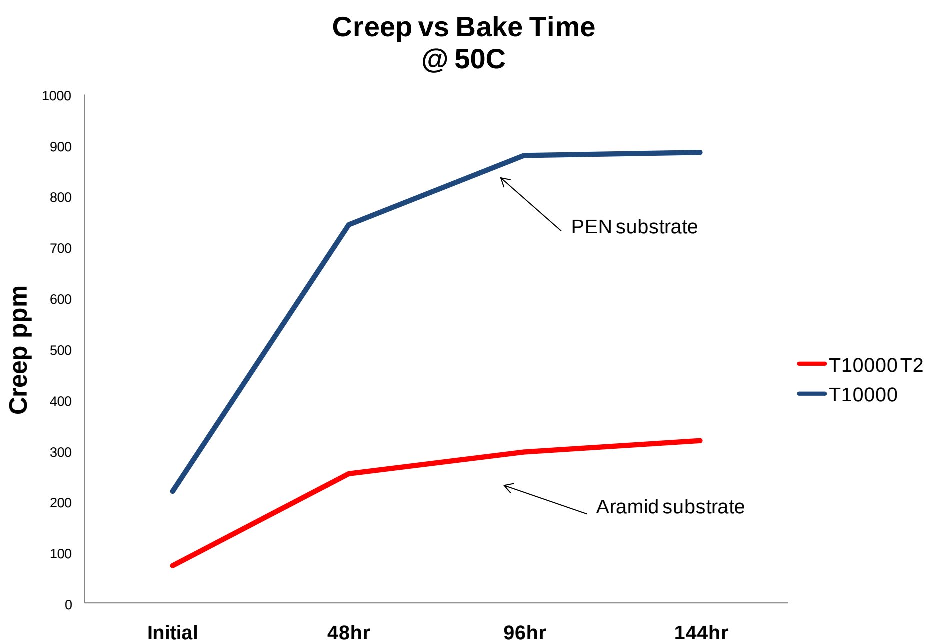

Figure 3. Magnetic tapes with a PEN substrate change width appreciably more than the newest magnetic tape offering from Oracle, StorageTek T10000 T2, for use with the StorageTek T10000C tape drive.

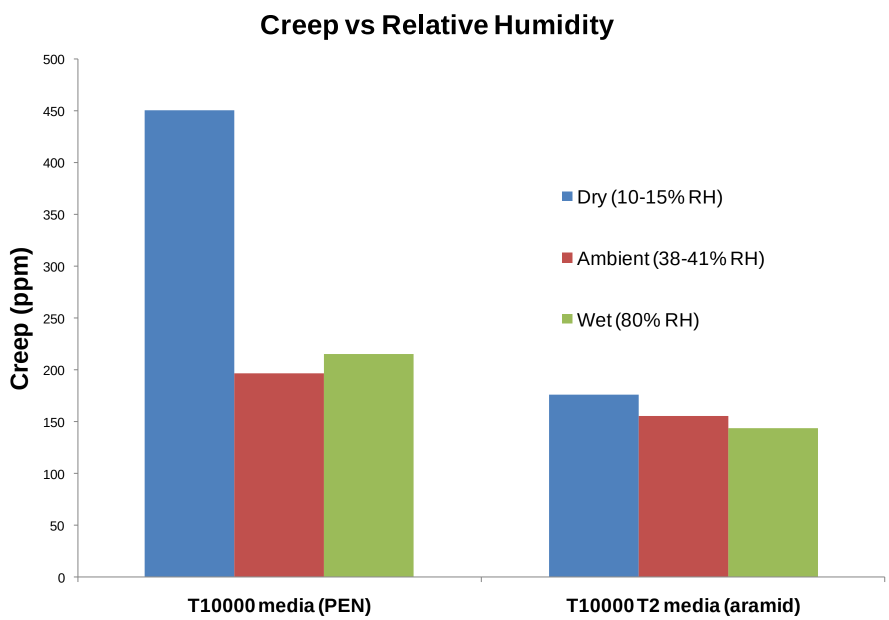

Figure 4. This data shows how changes in humidity can also influence tape dimension. Media using PEN substrates are affected more than the new, second generation of StorageTek T10000 media (T2), which uses aramid.

Conclusion

As with most materials, magnetic tape will change its dimensions as a function of environmental changes. Control and understanding of this phenomenon is critical to ensure data archivability. Oracle's selection of aramid as the StorageTek T10000 T2 substrate assures superior tape dimensional stability performance and long-term archival life.

References

"Long Term Archivability and Stability of Fujifilm Magnetic Tape Using Barium-Ferrite (BaFe) Particle." http://www.fujifilm.com/news/n100910.html

Wang, Linus, "Using Component Position Error Signals (PES) to Measure Tape Distortion", U.S. Patent # 6690535, Storage Technology Corp.

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