



Hewlett Packard
Enterprise

Extreme testing

for Hewlett Packard Enterprise
LTO Ultrium Storage Supplies

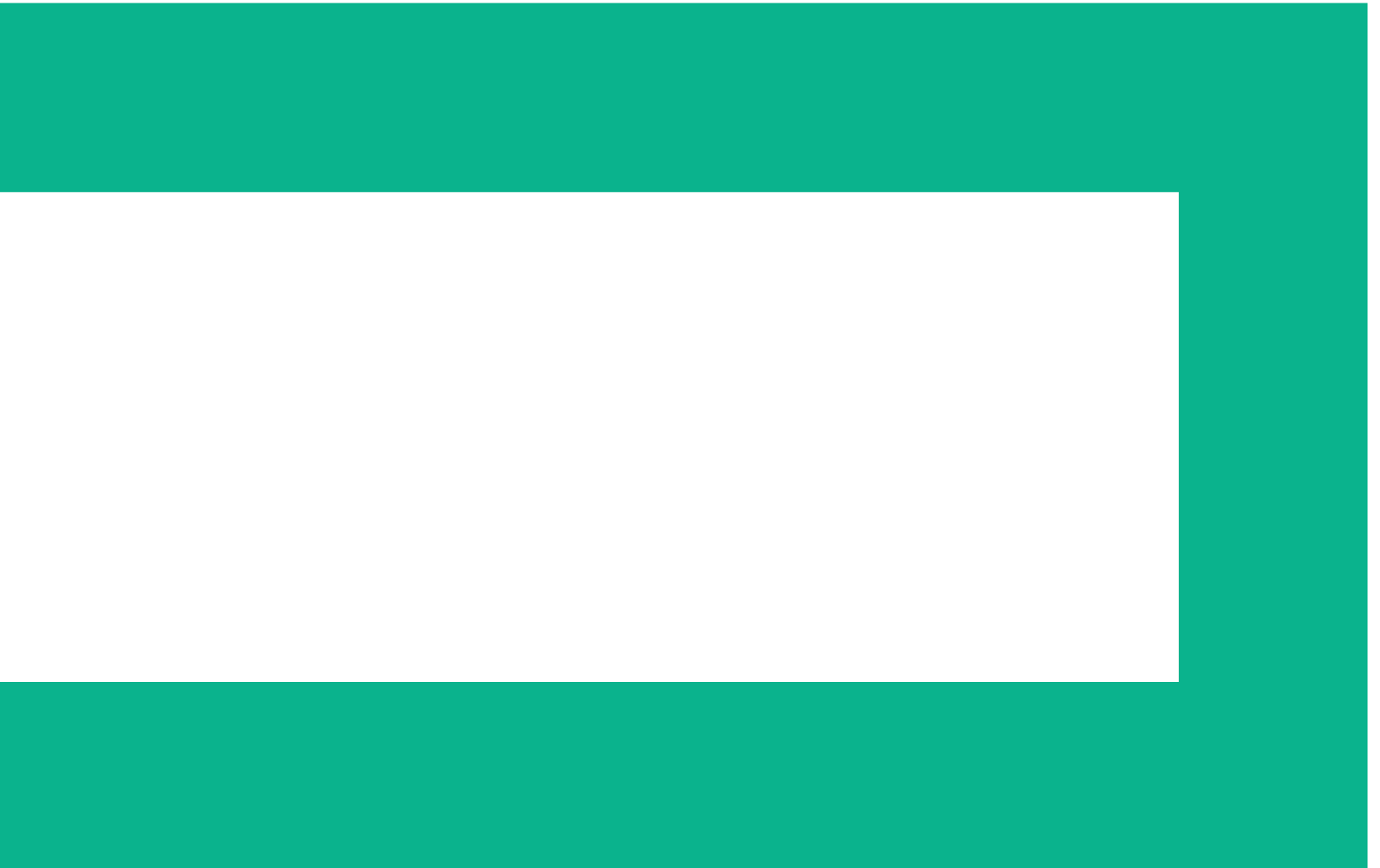


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Introduction

Hewlett Packard Enterprise branded Linear Tape Open (LTO) Ultrium cartridges are designed, manufactured and tested to provide outstanding reliability for backing up, archiving and restoring your data. We continuously monitor the quality of our branded tapes using what we believe is the industry's most comprehensive and thorough testing regime.

Using real life conditions and both Hewlett Packard Enterprise and non-HPE drives, we supplement extensive in-process QA parametric testing with ongoing drive based scrutiny, to make sure performance is excellent for any combination of device, duty cycle and environment.

Because Hewlett Packard Enterprise is a drive manufacturer as well as the leading supplier of LTO Ultrium storage supplies, we have the ability to re-create many different scenarios mirroring how customers use their cartridges. We go the extra mile (over half a million miles of tape pulled in a single year, in fact) so that you don't have to!

The purpose of this white paper is to describe all of our data cartridge testing in detail and demonstrate how this constant commitment to quality makes Hewlett Packard Enterprise LTO Ultrium storage supplies the safest choice for keeping your precious data secure.

Real life testing for real life data protection: Hewlett Packard Enterprise vs. industry standards

The main point is that Hewlett Packard Enterprise's real life testing program for LTO Ultrium storage supplies goes far beyond the lab tests that ensure compliance with the specification for the Ultrium format.

Although important, the scope and purpose of the LTO format requirements are often misunderstood. The LTO format is not a quality standard; it is simply intended to specify how a LTO Ultrium cartridge should function. This is to ensure that any new cartridge will work in any new drive. But the LTO logo itself is not an assurance of ongoing quality or reliability.

That consistent quality standard is the primary purpose of the Hewlett Packard Enterprise brand specification for LTO Ultrium storage supplies.

Hewlett Packard Enterprise's strict charter measures the most important variable parameters of the manufacturing process. Compared to the logo test, it has tighter, more controlled specifications in key areas like environmental interchange and load/unload. HPE also has stringent process controls like regular ongoing Full Volume Life and 'Green Tape' Testing (GTT)¹, in addition to a lengthy list of multiple lot specifications.

The LTO format stipulates none of these benefits. It is an annual procedure only. And to the very best of HPE's knowledge, no other supplies or hardware vendor comes even close to the scale of testing summarized in this white paper.

Ultimately, the best possible microscope to test tape cartridges is a tape drive, or rather thousands of tape drives, performing the same backup and restore tasks as end users. As a leader in hardware and storage supplies for all of the mainstream tape technologies, Hewlett Packard Enterprise has established comprehensive R&D and manufacturing programs to scrutinize the performance of tape backup solutions under every conceivable kind of stress.

While no one can predict the future, the breadth and depth of Hewlett Packard Enterprise LTO Ultrium tape cartridge testing gives us more confidence that your data will be safe on HPE tapes, no matter which brand of hardware you own.

¹ A green tape is a brand new data cartridge that has never been previously used. Green Tape Tests are important because newer media is typically more abrasive than cartridges that have been used several times and duty cycles using large quantities of green tape (e.g. archiving) affect tape drive performance differently to those where tapes have been rotated and used repeatedly.

Error rate: the ultimate measure of storage supplies quality

How does Hewlett Packard Enterprise ensure its LTO Ultrium data cartridges are so reliable?

Simply by performing the most comprehensive study of error rates, capacity and transfer rates that technology can deliver.

Error rate is a critical measure of how well your tape drive and data cartridges are performing together. It indicates the reliability of the write (backup) and read (restore) processes, together with the associated 'margin' for each process.

Poor error rate indicates that the backup or restore operation may be slow or even fail, whereas good consistent error rate indicates an optimum data transfer process with excellent performance. High error rate can be caused by several factors, including poor manufacture, tape edge damage or debris on the tape head. Regardless of the source, however, it means more attempts are required to successfully write and validate the data on the tape. This pulls more tape through the drive, reducing the overall capacity and, in the worst case scenario, leading to corruption or backup failure.

Capacity and transfer measurements are real life metrics in that customers may observe for themselves if a tape is performing badly. Reduced capacity means more tapes are needed to backup the same amount of data. Slower transfer speeds mean longer backups or backup windows being exceeded, which can lead to inconvenience and time disruption. In both cases, the hidden cost of even minor deviations from optimum performance can soon add up to be significant.

For example, the capacity and transfer rate of multiple LTO-6 MP and LTO-7 cartridges used during Hewlett Packard Enterprise LTO-7 Drive Green Tape Testing is shown in the two charts below. In these examples, all cartridges deliver full capacity thanks to the very low error rate of HP branded LTO media.



Step by step – Hewlett Packard Enterprise LTO Ultrium Media tests in detail

The influence of Hewlett Packard Enterprise over data cartridge quality begins in the formative stages of R&D. HPE collaborates with leading manufacturers to define the parameters for recording media in its drives, such as physical characteristics (for example, tape thickness), recording density (for example, number of bits/inch) and signal performance (for example error rate).

The Hewlett Packard Enterprise brand qualification program addresses the four main areas of concern for end user customers:

- Restore. Will I get my data back whenever I need to restore from the tape?
- Archival life. Will the tape meet and even surpass regulatory and corporate requirements for data retention?
- Compatibility. Not just “Will it work with...?” but “Will it work to the level I expect from my tape device, regardless of who made it?”
- Good day to day experience. Will it survive the rigors of everyday use in a busy and challenging environment?

Ongoing commitment

Compared to the current LTO specification, which requires testing a limited quantity of cartridges for initial LTO-1 through LTO-7 format compliance tests (with re-evaluation taking place every 12 months), Hewlett Packard Enterprise tests a minimum of 500 data cartridges taken from at least two separate manufacturing batches. Other LTO certified media are guaranteed to interchange between HPE and non-HPE drives as well, but the LTO logo does not guarantee a minimum, consistent level of quality.

Full volume Green Tape Test (GTT)

One of the things that distinguishes Hewlett Packard Enterprise is our awareness of the importance of Green Tape Tests (GTT). This specialized test supports the ever increasing number of customers using brand new cartridges for each and every backup and restore operation – e.g. in archival activities.

Hewlett Packard Enterprise performs monthly Green Tape Tests of HPE LTO Ultrium cartridges at manufacturing facilities, and further procedures at Hewlett Packard Enterprise laboratories. To provide full test coverage, and to make sure differences in drive design do not affect the performance of HPE tapes, such tests incorporate the use of HPE and non-HPE drives. Key metrics such as user capacity and transfer rates are monitored throughout the tests to ensure good performance is maintained.

These metrics continue to grow, as conducting regular GTT is an important aspect of Hewlett Packard Enterprise’s commitment to ongoing media quality and the evolving role of tape in archiving. GTT has been a vital aspect of testing during LTO-7 R&D so that even before launch:

- Over 1,000 LTO-7 cartridges have undergone GTT
- Over 750 million meters of LTO-7 tape have been pulled – 462,000 miles

And this is on top of the ongoing quality controls for prior generations of Hewlett Packard Enterprise LTO Ultrium storage supplies. Each month, a series of Green Tape Tests are conducted using multiple cartridges (taken directly from production) using HPE and non-HPE drives.

In the rare event of an issue being discovered, affected batches can be quarantined while supply of Hewlett Packard Enterprise LTO Ultrium cartridges is switched to alternative qualified sources. If you only have access to one production line, your options are extremely limited.

Full Volume Life (FVL) test

This requires no capacity loss or significant error rate degradation when multiple full volume write/read operations are conducted using a single cartridge. FVL is used by Hewlett Packard Enterprise to verify sustained product performance for those customers that use the same cartridge for each and every backup and restore operation.

Rigorous environmental interchange testing

In contrast to limited interchange using a single data cartridge, on a single drive under one or more test conditions, Hewlett Packard Enterprise thoroughly checks its storage supplies for full interchange between multiple tapes on multiple drives in all the following conditions:

- 50°F/10°C and 80% R.H. cold and wet
- 50°F/10°C and 10% R.H. cold and dry
- 113°F/45°C and 10% R.H. hot and dry
- 113°F/45°C and 24% R.H. hot and ambient
- 84°F/29°C and 80% R.H. hot and wet

During full volume write and read operations, the error rate must remain within stringent performance levels that have been determined by Hewlett Packard Enterprise engineers. Data is continuously written to, and read from the tapes for 24 hours at each environment. The benefit for the user is that the drive and cartridge are robust enough to withstand sustained use in all conditions, not just in controlled environments such as an IT data center. The Hewlett Packard Enterprise tests also examine a wide range of performance by using several drives and several cartridges to ensure complete consistency of results, as opposed to a narrower, customized test involving a single data cartridge.

Tough drop testing

In the LTO format specifications there are no cartridge drop test requirements. However, Hewlett Packard Enterprise testing evaluates HPE branded LTO Ultrium data cartridges against a minimum standard of fragility, and verifies that there shall be no irreversible loss of function to a data cartridge following a 0.75 m/2.46 feet drop onto a concrete floor. This requirement shall be met when 20 data cartridges are dropped successively on their top and bottom faces, and edges. In separate tests, this requirement shall apply when the data cartridges are dropped by themselves, in their library cases, or any packaging configurations.

The benefit to the user is that the data cartridges are robust enough to withstand daily use and transportation (for example, to an off-site storage solution) without being damaged or causing data loss.

Extensive testing of load/unload operations

In the LTO Ultrium format specifications, there are no loading or unloading requirements. However, Hewlett Packard Enterprise has led the development of LTO technology in this area and proposed several format changes that increase the reliability of the leader pin assembly, a core component of the load/unload operation. This test uses an automated mechanism cycle of load, grab Leader Pin Assembly (LPA), thread (with a few meters of tape wound onto a take-up reel), unthread, park LPA, and unload. Each cycle is repeated a minimum of 20,000 times.

A majority of Hewlett Packard Enterprise LTO Ultrium drives are integrated into library automation systems. As a result, the load/unload performance of HPE branded data cartridges is actually assessed in three different drive orientations – horizontal, tape path up, and tape path down – rather than just a single horizontal orientation. This is to replicate how the drive and tapes are used in real working environments.

The benefit to the user of the Hewlett Packard Enterprise load/unload tests is that the cartridge leader mechanism is robust enough to perform effectively throughout its expected use and will not break, causing damage and disruption to the drive. This in turn prevents a backup having to be repeated, or costly downtime while the drive is repaired. In addition, the cartridge will load successfully into a drive without the risk of a poorly seated cartridge introducing further downtime (even after the cartridge has experienced several thousand load operations).

Locate/rewind/append testing

This test measures the ability of a section of the tape to withstand repeated stress (i.e. file locate, retrieve and append operations) in a highly demanding customer environment (84°F/29°C, 80% R.H.). During the logo compliance tests, a 'locate-rewind' cycle is repeated 250 times.

Hewlett Packard Enterprise performs an equivalent test to the logo test, except that HPE testing is 1000% more stressful as the tape is passed through the drive 2,500 times. The benefit to the user is that the data cartridge performs under the most extreme daily conditions, reducing the number of failed backups and restores and minimizing the risk of disruption to the network.

Large scale for shipping and storage

This test is performed using a single data cartridge and a single drive.

The Hewlett Packard Enterprise qualification plan ensures that HPE branded LTO Ultrium storage supplies can be shipped and used repeatedly. The test is performed using multiple drives in an environmental chamber under the following environments:

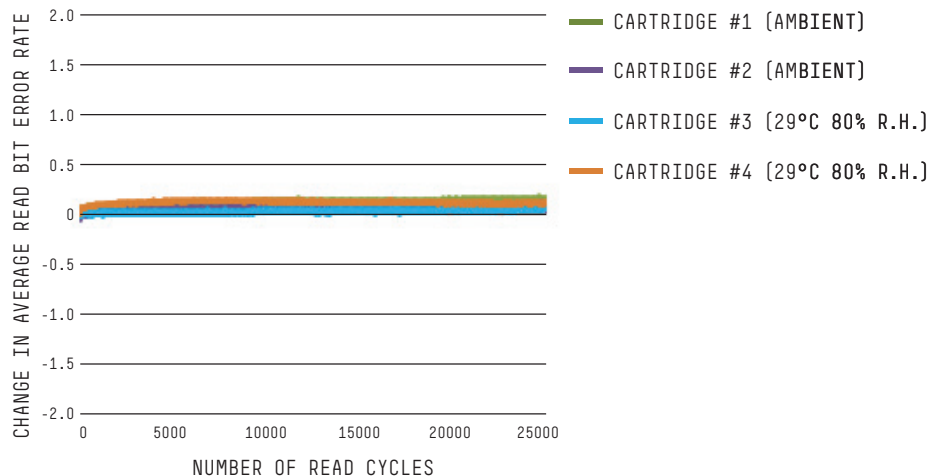
- Store the test data cartridges for two days at 50°F/10°C, 10% R.H.
- Store the test data cartridges for two days at 120°F/49°C, 15% R.H.
- Store the test data cartridges for two days at 84°F/29°C, 80% R.H.

A full volume write operation is conducted prior to the cartridges entering the environmental chamber. After storage, a full volume read operation is performed.

Shoeshine testing for high duty cycle automation

In the LTO compliance procedures, there are no shoeshine tests. The Hewlett Packard Enterprise testing procedure measures the ability of the media to withstand repeated passes over the tape head by simulating excessive repositioning or error recovery on a short length of tape.

Data is written to a short section of tape. The tape is rewound, the data is read and error rate checked. This 'rewind-read-error check' procedure is repeated up to 25,000 times and at the end of the test, there should be no loss of performance. The benefit to the user is that the tape withstands very intensive use even if it is restricted to a small part of the tape. This is especially relevant to library customers who may be using named tapes for specific applications and who only fill the same part of the tape each time data is written.



Testing to ensure archival stability

Introduction

If you place a tape into an archive and a legal officer, sales manager, publisher or newsroom asks you to produce the data ten years from now, how certain can you be that it has been preserved, complete and good as new?

What kind of threats could your tapes face in a long term archival storage facility? Of course, tapes do not get wrinkles or grey hairs but they are vulnerable in other ways. We don't have a time machine, but we have the next best thing: the Hewlett Packard Enterprise media test laboratories. The extreme conditions in which we can test our tapes enable us to say with confidence that our data cartridges will last for at least their 30-year warranty life.

Built to last

Particulate media like LTO Ultrium incorporates a binder system to hold the magnetic particles in place and bond them to the substrate. Early binder systems could suffer from hydrolysis (i.e. the binder could absorb moisture and eventually degrade leading to debris). However, today's advanced binder systems used in Hewlett Packard Enterprise media products are far more tolerant to high humidity conditions and, as such, binder hydrolysis no longer poses any significant risk.

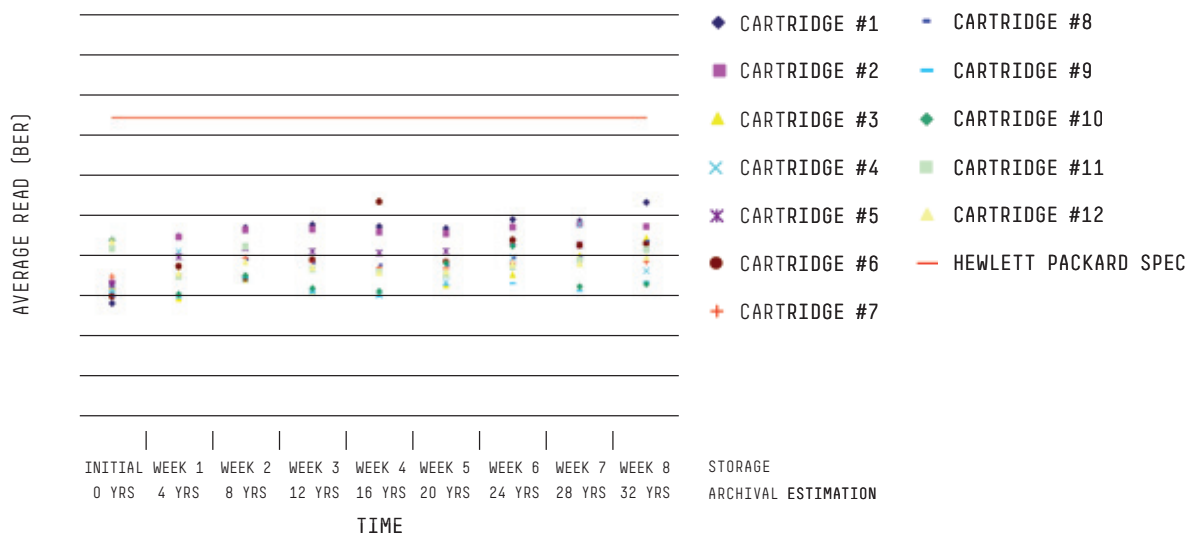
Signal degradation is another factor that could affect the archival properties of a tape. Historically, signal loss would occur due to oxidation of the magnetic particles (i.e. a chemical reaction would reduce the magnetic strength of each particle and as a result, the read back signal strength would diminish).

However, there have been several improvements to metal particle technology in recent years and the magnetic particles used in all Hewlett Packard Enterprise media incorporate an extremely effective 'armor coating'. This passivation layer, as it is termed, surrounds and protects the magnetic particles, effectively eliminating the oxidation process completely. Hence, there is no significant signal reduction during the read back (restore) process, even after prolonged periods of storage. The later generation Barium ferrite particles are oxides that are inherently more stable, and hence do not require a passivation layer. Hewlett Packard Enterprise LTO Ultrium data cartridges also utilise high coercivity particles and hence such media is far less susceptible to stray magnetic fields (again helping to ensure ongoing data integrity and restore reliability).

Any significant loss of magnetization would result in a reduced signal, and hence poorer error rate. This could ultimately compromise the integrity of the data backup. Thus, for archiving, it is essential that tapes are designed to resist the effects of both particle oxidation and binder hydrolysis. In order to demonstrate archive life, it is necessary to conduct accelerated aging tests. Such tests give an indication of how the magnetization will degrade over an extended period of time, and whether hydrolysis is likely to occur.

How to speed up time in a laboratory

Previous research² has shown that storing tapes at a constant environment of 140°F/60°C, 90% R.H. for 7 days is approximately equivalent to storing the same tapes at 77°F/25°C, 60% R.H. for a period of 4 years. Thus, in order to verify the archival properties of Hewlett-Packard data cartridges, 12 x Hewlett Packard LTO-3 WORM cartridges were stored in an environmental chamber at the aforementioned elevated temperature and relative humidity conditions. Data was initially written to (and read from) each tape to obtain a series of 'initial' read error rates. The cartridges were then stored in an environmental chamber at 140°F/60°C, 90% R.H. for 7 days, after which the data was re-read, and the cartridges returned to the chamber for a further 7 days of storage at 140°F/60°C, 90% R.H. This sequence was repeated until the cartridges had been stored for a total of 8 weeks at the elevated temperature and relative humidity conditions. The chart below shows the average read error rates for the 12 x HP LTO-3 WORM cartridges at each stage of the archival storage test.

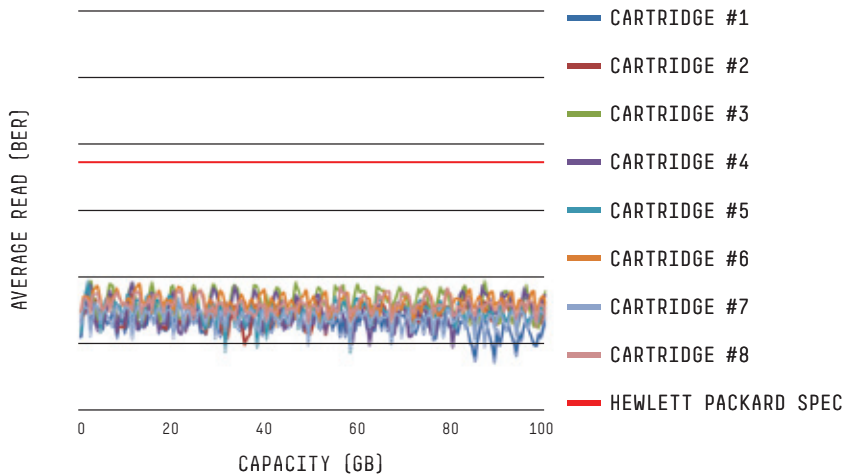


The tapes exhibited excellent performance with low stable read error rates throughout even after 8 weeks of storage in the accelerated environment (equivalent to 32 years' storage at ambient conditions). This same relentless focus on quality and archival performance has now been carried forward into a new era under Hewlett Packard Enterprise. A new company name but the same emphasis on reliability. You can be assured that whether old or new, your Hewlett Packard Enterprise LTO Ultrium tapes will have outstanding archival properties.

² Yamamoto et al, "Study of Corrosion Stability in Metal Particulate Media", IEEE Transactions on Magnetics, Vol. 26, No. 5 1990.

Real time archiving

Given the maturity of LTO technology, it is now possible to demonstrate real time archive performance, rather than relying on accelerated tests. In order to demonstrate such performance, 8 Hewlett Packard LTO-1 cartridges were retrieved from storage. These cartridges had all been manufactured in June 2003, and a full capacity (100 GB) backup operation was conducted in July 2003, using a Hewlett Packard LTO-1 drive. The cartridges were then stored in standard office conditions for 10 years, at which stage the original data was read, using a Hewlett Packard LTO-2 drive. The results were truly impressive, as illustrated below.



Conclusion

A typical enterprise customer may have tens or even hundreds of tape drives in their organization. But this number is still dwarfed by the quantity of devices that are used in Hewlett Packard Enterprise testing. While an isolated pollutant may eventually contaminate an entire river, only by scrutinizing the whole waterway can the source of the threat be traced. Similarly, examples of low level detail obtained by Hewlett Packard Enterprise include servo quality, error rate performance and even the tape’s abrasivity characteristics. None of this is directly visible on the production line or in a data center.

Hewlett Packard Enterprise listens and learns. Many features that you see on our products are a direct result of your feedback, including pre-labeled media, anti-static shells, better leader pin design to prevent drive damage, robust cartridges to withstand impacts, and the introduction of differently colored cartridges to make sure you never load the wrong media into your drives. Ultimately, tape drives are the best form of microscope to examine the quality of a data cartridge.

Your data is unique. It’s the DNA of your business and we do everything we can to help you reduce risk, reduce cost and manage your data growth. When you entrust your data to a Hewlett Packard Enterprise tape, we want you to feel it’s as safe as it would be in your own hands.

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