Hewlett Packard Enterprise

Technical paper

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EXTREME TAPE MEDIA RELIABILITY FOR PROTECTING AND PRESERVING BIG DATA ARCHIVES

How the HPE LTO Ultrium Media Brand Specification and Testing program ensures the highest levels of quality and reliability

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INTRODUCTION

In its Worldwide Global DataSphere[1] forecast, IDC reports that 64.2 ZB of information was created in 2020 and that this will rise to 181 ZB by 2025. The analyst forsees that data created in the cloud will grow at 36% annually, while data collected at the edge through various IoT and sensing devices is growing at 33% annually and will make up 22% of the total global datasphere by 2025.

The amount of data that is actually kept and stored is far smaller than the amount of data being created. In its separate Global StorageSphere report, IDC calculates that the installed base of storage capacity reached 6.7 ZB in 2020 and is steadily growing but at a slower annual growth rate than that of the Global DataSphere. This still means, however, that storage capacity will need to increase by 240% and whether the data is on-premises or in the cloud, it still requires to be monitored and managed.

IDC comments:

"Many organisations believe there is latent, potentially unmined value from analysing older data. Yet the cost to store more data holds organisations back from modifying their data retention policies that would lead to retaining data longer. This is a factor that is expected to continue to be a headwind for faster expansion of the Global StorageSphere until organisations begin to show a positive ROI on data analytics initiatives, especially with older data. Proven ROI on analytics initiatives would buttress the need for storing more data or retaining data longer."

LTO Ultrium tape technology remains a key part of the storage landscape, therefore, because its immense scalability, lowest cost of ownership and durability make it the perfect host for storing massive quantities of less frequently accessed, but still strategically important, data in an active archive or tiered storage system.

Additionally, tape is increasingly being seen as an essential layer of protection against cybercrime and ransomware attacks. By providing a true, physical 'air gap' barrier for data, tape helps lower data centre risk with reliable offline and off-premises data protection. Tape is the ideal last line of defence to complete the layers of protection offered by other solutions like HPE StoreOnce (hidden backups), HPE Cloud Volumes (offsite backups) and HPE Zerto (immutable, continuous data protection backups) which provide different protections against ransomware threats.

HPE LTO Ultrium solutions, featuring the newest 45 TB LTO-9 technology, allow customers to offload primary storage and cold data to tape, for long term retention and future data analysis, while reducing their overall risk and increasing resiliency against downtime or disruption.

THE HPE LTO ULTRIUM MEDIA BRAND SPECIFICATION

Because HPE offers this comprehensive data protection portfolio for hybrid IT (traditional IT, private and public clouds), it understands the requirements for current and next generation LTO Ultrium tape solutions. In particular, the importance of media reliability in providing a long-term home for archive data, as well as a final safeguard against natural disasters, network or power outages, human error, or malicious acts.

This is why HPE has a unique set of demanding quality standards for HPE LTO Ultrium cartridges. Unlike LTO logo tests, the HPE brand specification measures how tape performs in 'real world', automated, Hybrid IT infrastructures, a foundation that underpins and supports other HPE storage solutions.

Hewlett Packard Enterprise branded LTO Ultrium cartridges are designed, manufactured and tested to provide outstanding reliability for backing up, archiving and restoring your data.

Using real life conditions and both Hewlett Packard Enterprise and non-HPE devices, 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.

The goal of this technical paper is to describe our media 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 business data secure.

[1] Worldwide Global DataSphere Forecast, 2021–2025, IDC, 2021

REAL LIFE TESTING FOR HYBRID IT DATA PROTECTION: HEWLETT PACKARD ENTERPRISE VS. LTO LOGO OR 'INDUSTRY STANDARDS'

The major 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 a consistent quality standard is the intrinsic purpose of the HPE brand specification for LTO Ultrium storage supplies.

HPE'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 (FVL) and 'Green Tape' Testing (GTT), in addition to a lengthy list of multiple lot specifications. All of these enable us to pinpoint with incredible degrees of accuracy how well your tape drive and media will perform across a range of applications and environments.

Ultimately, the best possible microscope to test tape cartridges is a tape drive, or rather multiple 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 comprehensive R&D and manufacturing programs that scrutinise the performance of tape backup solutions under every conceivable kind of stress.

Whilst 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.

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.

Bit error rate (BER) 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.

High BER 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 BER can be caused by several factors, including poor manufacture, tape edge damage or debris on the tape head, but how does it impact you in practice?

Regardless of the source, excessive BER 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 that you may observe for yourself if a tape is performing badly. Reduced capacity means more tapes are needed to back up the same amount of data. Slower transfer speeds mean longer backups or backup windows being exceeded, which leads to inconvenience and disruption.

In both cases, the hidden cost of even a minor deviation in performance can soon become a significant expense.

HPE LTO ULTRIUM MEDIA BRAND SPECIFICATION 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 impact on signal performance (for example error rate).

The Hewlett Packard Enterprise brand qualification program addresses the four main areas of concern that you are likely to have:

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?"

DAILY EXPERIENCE

Will it survive the rigours 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-9 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.

GREEN TAPE TEST (GTT)

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

Hewlett Packard Enterprise performs monthly Green Tape Tests of HPE LTO Ultrium cartridges at manufacturing facilities, and further procedures at HPE laboratories. 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. Since the beginning of 2016:

- Over 9,500 cartridges have been tested in HPE's demanding Green Tape Test protocol.
- Over 1.2 billion meters of media has been pulled.
- Over 72 million gigabytes of data has been written.

All of these ongoing tests are intended to make sure that you receive the most reliable tape media possible.

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 if you are using the same cartridge for each and every backup and restore operation.

RIGOROUS ENVIRONMENTAL INTERCHANGE TESTING

Hewlett Packard Enterprise thoroughly checks its storage supplies across all specified operating environments using multiple tapes on multiple drives. The latest specified operating conditions for LTO-9 media are:

- 79°F/26°C and 80% R.H. cold and wet.
- 90°F/32°C and 55% R.H. cold and dry.
- 90°F/32°C and 20% R.H. hot and dry.
- 59°F/15°C and 20% R.H. hot and ambient.
- 59°F/15°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 HPE engineers. Data is continuously written to, and read from the tapes for over 24 hours at each environment. The benefit to you 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 centre. In addition to the aforementioned environmental testing, HPE also ensures a tape written in one corner environment can be read back in the opposite corner environment (e.g. write at hot/wet conditions and read back in cold/dry conditions).

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 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 you 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 metres of tape wound onto a take-up reel), unthread, park LPA, and unload. Each cycle is repeated a minimum of 20,000 times.

Today, the vast majority of HPE LTO Ultrium drives will be integrated into automation systems like HPE StoreEver MSL, Spectra T950 and Spectra Tfinity. 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.

The benefit to you of the HPE 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 whilst 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).

SHIPPING AND STORAGE TESTING

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 cartridges 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

In the LTO compliance procedures, there are only limited shoeshine tests. The HPE testing procedure measures the ability of the media o 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 20,000 times and at the end of the test, a full volume read operation is conducted to verify that all the data on the tape can still be read.

The benefit to you is that the tape withstands very intensive use even if it is restricted to a small part of the tape. This is especially relevant if you are a library customer who may be using named tapes for specific applications and who only fills the same part of the tape each time data is written.

TESTING FOR ACHIVAL STABILITY

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?

Ultimately, this is the primary objective for any archival storage technology in a modern data protection infrastructure.

The extreme conditions in which we can test our tapes enable HPE to say with confidence that data can be retrieved over the predicted archival life of 30 years, when kept under the recommended storage conditions.

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 HPE storage 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 particle technology in recent years and the magnetic particles used in earlier generations of HPE LTO Ultrium tapes incorporate an extremely effective 'armour 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.

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 lower Signal to Noise Ratio, and hence higher BER. 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 usually 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.

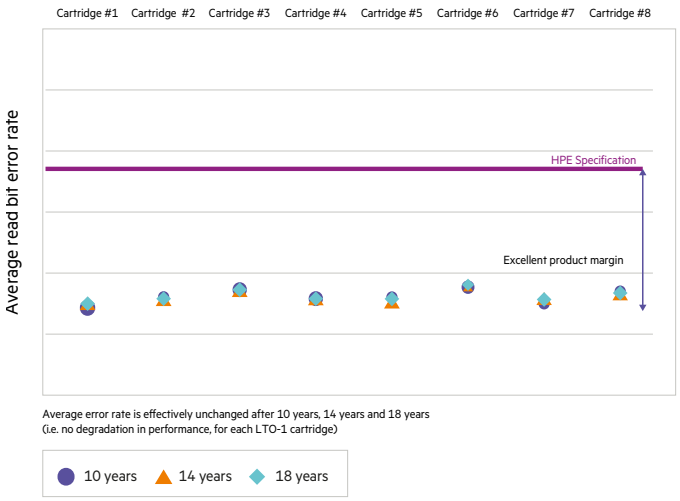
REAL TIME ARCHIVING USING LTO-1

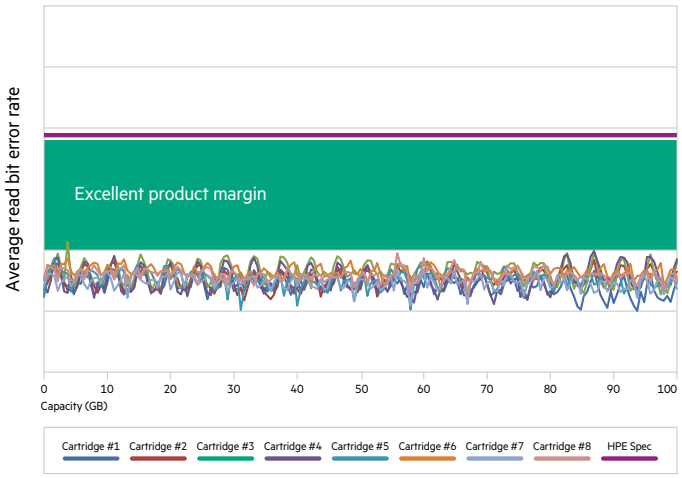
Given the maturity of LTO technology, it is now possible to highlight real time archival performance performance, rather than relying solely on accelerated laboratory tests. Since the early days of LTO technology, HPE has been tracking the performance of 8 x Hewlett-Packard LTO-1 cartridges that have been kept under archival storage conditions. These cartridges were all manufactured in June 2003, and a full capacity (100 GB native) backup of data was performed in July 2003, using a HP LTO-1 drive.

The cartridges have since been stored in the recommended archival conditions for 18 years, and periodically the original data on those tapes was restored using an LTO-2 drive. The results of all these data retrievals were truly impressive, as illustrated below.

After 18 years, the LTO-1 media displayed practically zero degradation in terms of performance and reliability, with significantly better results reported than the minimum threshold required for the HPE LTO Ultrium media brand specification. All data was successfully retrieved for all eight cartridges, with stable transfer rates throughout. In addition, the lower level error rate information demonstrated significant margin remained, with no discernable difference from the initial read error rates. This indicates there has been no detrimental effect from archiving the cartridges.

These results demonstrate the outstanding reliability of HPE LTO Ultrium media. And it should be emphasised that these LTO-1 cartridges still have a further 12 years of service before they reach the end of their nominal archival period.





CONCLUSION

A typical enterprise customer may have tens or even hundreds of tape drives in their organisation. But this number is still dwarfed by the quantity of devices that are used in HPE testing. However, unlike even advanced end users, HPE has the resources and expertise to forensically examine every aspect of the media manufacturing process, a complex, multi-stage process requiring mastery of production and materials.

Examples of low level detail obtained by HPE include servo quality, error rate performance and even the tape's abrasivity characteristics. None of this is directly visible in a data centre.

HPE not only listens, it learns from your experience and that of hundreds of thousands of HPE tape customers. Many features that you see on our products are a direct result of customer feedback, including pre-labelled media, anti-static shells, better leader pin design to prevent drive damage, robust cartridges to withstand impacts, and the introduction of differently coloured 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 HPE does all it can to help you reduce risk, reduce cost and manage your data growth. When you entrust your data to a HPE LTO Ultrium data cartridge, HPE would like you to feel that it's as safe as it would be in your own hands.

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