

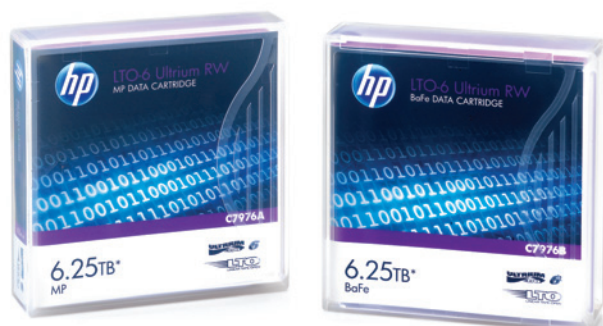


HP LTO-6 Ultrium Storage Media Interleave Testing

An extreme comparison of BaFe and MP 'green tape' performance

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Introduction

For the first fourteen years of its existence, Metal Particle (MP) technology has been the cornerstone for all Linear Tape Open (LTO) Ultrium data cartridge manufacturing. But with LTO-6 technology, HP began shipping a new media type, based upon Barium Ferrite (BaFe), to sell alongside LTO-6 MP.

In a different White Paper, called “The Best of Both Worlds”, HP presented the differences between these two media technologies and explained how both provide the same outstanding performance that customers have come to expect from HP LTO Ultrium storage media.

Industry standards reveal much: HP demands more

The Compliance Verification (CV) process for the awarding of LTO Ultrium logo status is primarily concerned with interchange, to ensure products from different vendors work across platforms. It is not a measure of quality – i.e. how reliably those products perform.

HP Storage Media Brand Testing requires potential HP LTO cartridges to pass a number of extremely demanding procedures that other media are never subjected to during CV evaluation. All tests must be successfully negotiated.

And where there is overlap with CV, the HP procedures are tens, sometimes hundreds of times more stressful. For example, the HP Locate/Rewind/Append Test surpasses the industry standard by 1000%. And the HP Shoeshine Test, which measures the ability of the media to withstand repeated passes over the tape head (as in a demanding library environment), repeats for 25,000 cycles. The Industry Logo Test has no Shoeshine equivalent.

Every hour spent in the lab and every mile of tape examined is relentlessly driven by the objective of making HP LTO Ultrium tapes the most reliable you can buy.

Interleave Testing. Not just one extra mile, but hundreds

For this document, HP has gone further than ever before to prove that nobody understands more about the ‘DNA’ of tape reliability than HP.

In an exhaustive set of new tests known as ‘Interleave Testing’, HP has subjected its LTO-6 MP and LTO-6 BaFe media to unprecedented levels of scrutiny. In doing so, HP has thrown new light on the performance of MP and BaFe designs, to give end users complete confidence that both types offer identical performance for backup and archiving.

What’s more, having already completed over 2 million hours of testing in 2013 and 2014 on HP StoreEver drives for the new Interleave Tests, **HP used a non-HP tape drive from a leading competitor**, proving beyond all doubt that HP LTO-6 tapes (both MP and BaFe) work as well in solutions from other vendors as they do in HP StoreEver products.

So what is Interleave Testing?

Interleaving is the ultimate measure of how well your tape solution is performing in an intensive archival environment. It involves:

- Using a non-HP drive.
- Taking a brand new piece of media, starting with HP LTO-6 BaFe, and conducting a full volume backup.
- Exchanging the original BaFe tape for a brand new HP LTO-6 MP tape and repeating the full volume write process.
- Swapping out the MP tape and repeating the process again using a brand new LTO-6 BaFe tape.
- Reporting the capacity and transfer rate for each cartridge during each cycle.
- Determining the excess capacity for individual cartridges at frequent intervals throughout the test.

In total, HP performed 600 full volume write backups in a unique test pattern that lasted for almost six months. It involved 300 HP LTO-6 MP and 300 HP LTO-6 BaFe cartridges on the same non-HP tape drive.

The ultimate interchange reliability test for an archival usage model

There are several reasons why this is the ultimate interchange reliability test.

1. **Brand new media – sometimes called ‘green tape’ – is the most demanding for a tape drive to work with.**

That is because new cartridges have not yet been subject to the ‘smoothing’ that occurs over time as media is used more repeatedly, making ‘re-used’ tapes less abrasive than ‘green’ tapes.

Abrasive and smoother (less abrasive) media types normally co-exist in a typical customer environment and neither state is ‘good’ or ‘bad’ in itself. What *is* unusual is for only one type ever to be used. In practice, few customers would use green tape cartridges exclusively as most typically incorporate new and reused media in their routines. Using only abrasive, ‘green tape’ media will put the tape drive under maximum stress because the read/write head has to be tough enough to withstand the continuous effects of the rougher surface. If it isn’t robust, the main consequence is premature head wear, which in turn means gradually increasing error rates, slower backups and eventual early drive failure¹.

2. **One in, one out interchange of MP and BaFe.** In the HP Interleave Test, not only is the tape drive having to cope with 100% green tape, but it also has to deal with both LTO-6 media choices: MP and BaFe. If there were any performance differences as a consequence of using one tape/particle design over another, Interleave would highlight the differences. Simply put, if one media type performs well, but another causes the drive to struggle, the capacity and transfer rate metrics for the sub-par formulation would be clearly visible.

There is no other kind of test that can make these distinctions so unambiguously. But in the real world, it is almost certain that no-one would switch between MP and BaFe tapes to this degree because of the impracticality of arranging a similar scenario, especially in an automation environment where there is no human intervention and hundreds of tapes may be in constant use. In this regard, however, every step away from one in/one out makes conditions easier for the drive, so the HP Interleave Test is the ‘gold standard’ for the severity of the archival usage model.

3. **Time and cost.** Performing this kind of test, using 600 tapes on a single drive and in a controlled environment, is a colossal undertaking. Almost certainly, it’s beyond the reach of end users who are unlikely to possess the time, facilities, budget and, most important, forensic diagnostic tools to complete such an analysis.

The only way to be certain how well a tape performs in a tape drive is to scrutinise it through the eyes of a tape drive. And no-one uses more tape drives and more media to demonstrate the reliability of tape backup and archiving than HP.

¹ It’s important to stress that abrasivity is not a bad thing. Too little abrasivity can lead to stain build-up, increasing spacing which ultimately impacts the electromagnetic recording process. Conversely, too much abrasivity is as potentially disruptive since this can lead to head wear, also increasing the head-tape spacing.

Interleave Testing Results

The key metrics tracked in this study were capacity and transfer rate. The reason why HP chose these parameters is because they are the 'real world' measurements that are most meaningful to end users.

If a tape is performing poorly, customers could see greatly reduced capacity per cartridge because the tape is filled by repeated attempts to record sections of data accurately. This also means much slower backups because of the excessive number of retries versus successful recording at the first attempt.

Establishing a base line for the test

To provide an absolute point from which to measure the capacity of each tape, data was written to the Early Warning End Of Media (EWEOM). This is a limit defined to ensure successful tape-to-tape copy can be achieved and is consistent across drive manufacturers. The EWEOM is set to be slightly less than the native capacity of 2.5 TB for LTO-6 cartridges, as required by the LTO format. The EWEOM also acts as a flag for the tape drive so the system knows the physical end of the tape is approaching.

Crucially, however, the EWEOM is slightly before the actual physical end of tape which means every LTO Ultrium format cartridge has a little bit more capacity than the stated headline figure. For LTO-6, this additional space is the equivalent of an additional 5% of capacity, although it is reserved exclusively for the system and cannot be accessed via the backup software. The excess tape is the first section of the media that is used when there are higher than expected errors so that any rewrite and error correction takes place without losing the stated capacity of the tape.

Obviously, with very high error rates, the excess capacity would be completely used, and the stated 2.5 TB nominal native capacity could be compromised. At this point, users would see reduced capacities to a greater or lesser degree depending on the severity of the errors.

In HP's Interleave Test, once the full volume write for each tape was completed, the amount of free excess capacity remaining in the space beyond EWEOM was calculated by using the 'tape directory' information in the LTO Cartridge Memory. The tape directory contains the number of datasets written on each wrap.²

Each dataset is a small quantity of information containing two error correction schemes. These error correction schemes are checked on each dataset and, depending on the type of errors that occur, the dataset is rewritten. By comparing the total number of datasets written versus the total number of datasets possible (from a format perspective), the rewrite rate and hence the excess capacity can be calculated. Both of these figures can be expressed as a %, providing a formula:

Reliability = Excess Capacity – Average Rewrite Rate

² A wrap is a complete pass of the tape head from one end of the tape to the other, along all 16 channels. The LTO-6 format specification requires 2,176 tracks written over 136 wraps (136 x 16 channels = 2,176 tracks covered) to fill a cartridge to the 6.25 TB capacity point with 2.5:1 compression.

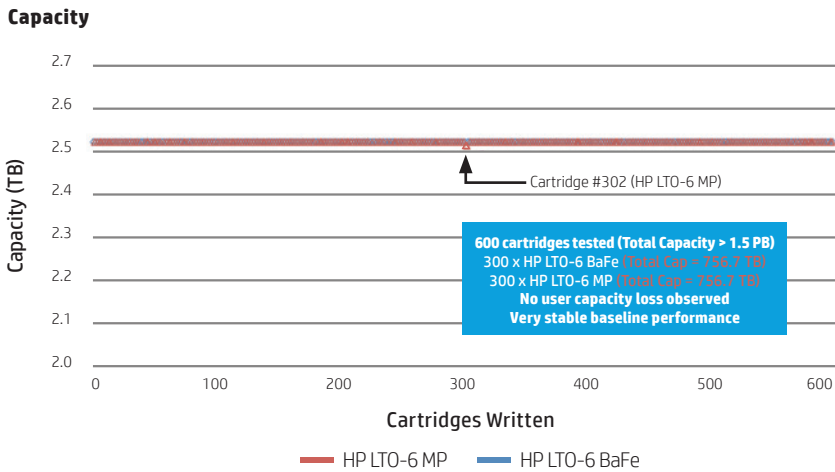
To illustrate, using the first two cartridges from the series as an example:

Cartridge	Excess Capacity (Format)	Average Rewrite rate (Calculated from CM)	Excess Capacity (Calculated from the Average Rewrite Rate)
Cartridge #1 (HP LTO-6 BaFe)	5%	0.21%	4.79%
Cartridge #2 (HP LTO-6 MP)	5%	0.20%	4.80%

The LTO Cartridge Memory was read for multiple cartridges at frequent intervals in order to provide additional visibility regarding any possible reduction of product margin, and hence any associated performance loss. This analysis would be difficult to do outside of a specialised test environment.

Using this methodology, HP’s engineers observed identical results for MP and BaFe media, proving beyond doubt that when it comes to differences that customers could perceive in the real world, there is no difference between the two designs. Under this extreme scrutiny, the average transfer speed for LTO-6 MP media is fractionally better than LTO-6 BaFe media, but in real world conditions this advantage would not be discernible. For capacity utilisation, across more than 1.5 PB of data written, the results show a dead heat of 756.7 TB.

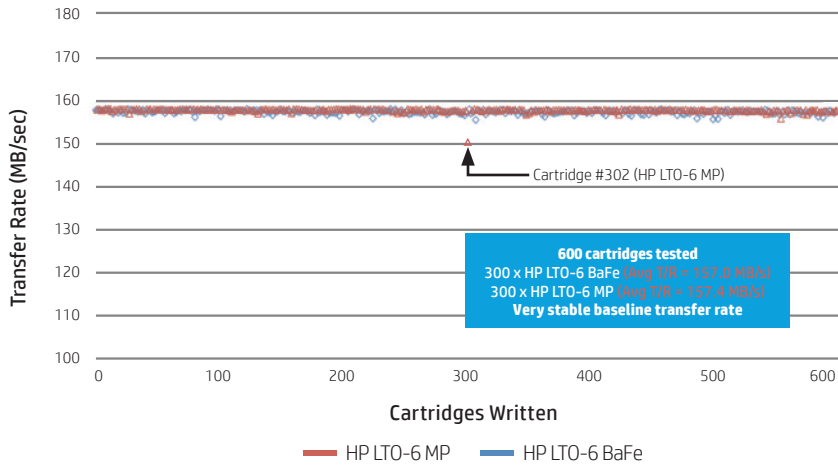
“Interleave” Green Tape Test (non-HP LTO-6 Drive)



Furthermore, since these tests were performed on a non-HP drive, HP has total confidence that regardless of whether a user uses HP LTO-6 MP or HP LTO-6 BaFe media, they will still observe the highest possible level of reliability – both in terms of achieving stated capacity and maximum drive throughput.

“Interleave” Green Tape Test (non-HP LTO-6 Drive)

Transfer Rate



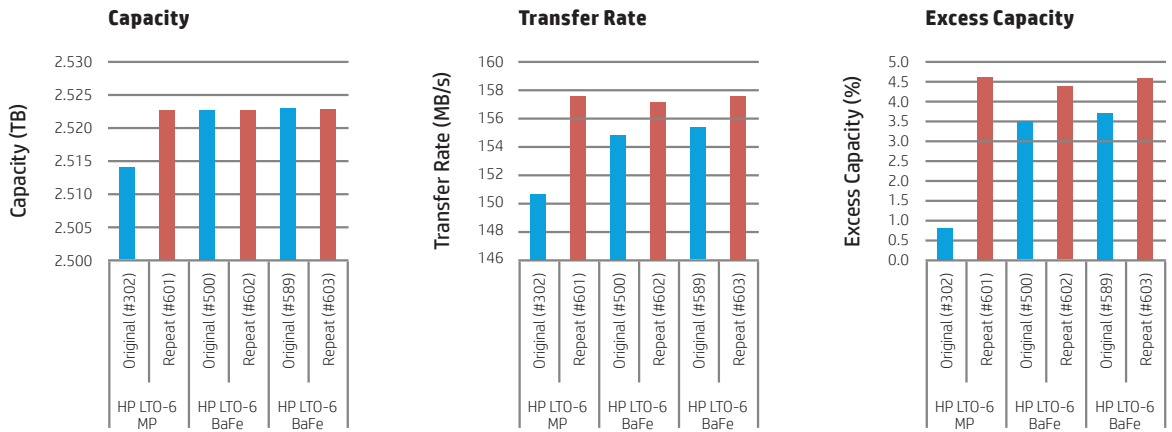
Double checking the results

During the course of the testing, potential issues were noticed with three tapes: #302 (MP), #500 (BaFe) and #589 (BaFe). These issues related to marginally lower (excess) capacity and transfer rate during parts of the backup process.

As a consequence of these results, three additional full volume backups were made to this trio of cartridges after the original 600 cycles had been completed. The results of the repeat tests can be seen alongside the original metrics in the chart below.

“Interleave” Green Tape Test (non-HP LTO-6 Drive)

Repeat Tests for cartridges #302, #500 and #589



All metrics from each repeat test were excellent, confirming degraded performance was transient.

Conclusion

The 'Interleave' LTO-6 Green Tape Test completed successfully, using a total of 600 cartridges. During the test, more than 1.5 PB of data was written.

There was no significant degradation of key metrics, indicating excellent stable performance in terms of:

- User capacity
- Excess capacity
- Transfer rate

Individual cartridges that showed a very slight performance loss on the first use were retested, and these then completed with excellent performance. A mixed media environment of HP LTO-6 MP media and HP LTO-6 BaFe media does not cause premature head wear. Full stated capacity and transfer rate capability were maintained throughout the test.

Therefore, all LTO customers, regardless of whether they have a HP StoreEver or non-HP tape device, can be confident that HP LTO-6 MP and HP LTO-6 BaFe media will provide outstanding reliability and performance even in the most extreme conditions.



Additional resources

Device compatibility: hptapecompat.com

HP LTFS technology: hp.com/go/ltfs

HP LTO Ultrium: hp.com/go/ultrium

HP LTO tape drives and tape automation: hp.com/go/tape

HP TapeAssure: hp.com/go/tapeassure

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