

# HP DAT tape drives—Proven reliability

Why HP enhanced the MTBF and error rate specifications for DDS-4 and DAT 72 tape drives



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## Introduction

Two of the key metrics of reliability used by the tape industry are mean time between failures (MTBF) and uncorrectable error rate. MTBF is the average time the drive will operate without failing, and the error rate is the ratio of the number of bits received in a data stream that are found to be in error to the total number of bits transmitted, usually expressed as a negative power of 10.

HP provides MTBF and bit error rate specifications for its tape drive products as a guide to the reliability a customer can expect in using the drive. The industry determines these specifications by analyzing data gathered at preproduction testing during the development of the product.

Up to now, the published specifications for the HP DAT tape drive products were:

- MTBF—400,000 hours at a 12% duty cycle
- Unrecoverable error rate—1 in  $1 \times 10^{15}$  bits

These specifications indicated the high reliability of HP DAT tape drive products. However, a recent examination of field data has shown that the actual reliability experienced by HP customers is even higher than the published specifications. Therefore, based on empirical data gathered for HP DAT 40 (DDS-4) and HP DAT 72 tape drives, HP has updated the reliability specifications for these drives to give a more representative measure of the real reliability of HP DAT tape drive products.

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### Revised reliability specifications for DDS-4 and DAT 72

MTBF—1 million hours at 12% duty cycle  
(or 125,000 hours at 100% duty cycle)

Unrecoverable error rate—1 in  $1 \times 10^{17}$  bits

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Clearly, the reliability of HP DAT products has benefited from more than 15 years of experience with DDS tape. Furthermore, because this determination of the new MTBF specification is based on real field data for the HP DDS-4 and DAT 72 products shipped since their release rather than any recent changes or improvements to the product, this change applies to the whole field population of these drives and not just those units shipped from now on.

## Determining initial reliability specifications

Before looking at how the new specifications were determined, it is important to look at how the original specifications were established. The initial MTBF and error rate specifications are developed before the launch of any product by putting many drives through a rigorous MTBF demonstration test bed. The potential field MTBF and unrecoverable bit error rates are calculated from the results of this analysis.

While the MTBF test bed is designed to be as representative as possible, it cannot cover all aspects of customer usage. However, HP test beds are designed to be at least as demanding as a typical customer environment to ensure that the product meets customer expectations at launch.

## No substitute for real customer data

Test-bed calculations are certainly no substitute for data obtained in real customer environments. With accurate field return data for the HP DDS-4 product, HP conducted a full analysis of the actual MTBF experienced by customers. The results of this analysis showed that the true MTBF of the HP DDS-4 is much higher than had been indicated during the test-bed analysis.

With the DAT 72 being a later edition to the HP DAT tape drive product line, the volume of field data is not yet sufficient for a full MTBF analysis. However, the DAT 72 is already showing a low return rate similar to the DDS-4, and HP is confident that the same assumptions apply to both products.

## Where the data came from

HP actively gathers data from all customer interactions regarding HP tape drives in the field. This includes:

- Tracking all calls to customer call centers, support centers, and information centers
- Claims on the warranty of the product
- Failure analysis of the field returns to the factory

This data is an appraisal of exactly when the unit failed (after how many hours, weeks, months, or years of operation) and a diagnosis of the reason for the failure. From this data, HP can model more accurately the behavior of products in the field and understand the reasons for product return. This insight has enabled HP to continually enhance its products and ensure that the lessons learned from every generation of DAT tape drives have been incorporated into the development of the next generation.

## Assumptions

To generate an accurate specification, the characteristics of the failing population must be understood. For example, a portion of the returns population is classified as “no trouble found”—the product itself is tested but not found to be at all defective. The return and subsequent claim against warranty could be the result of numerous factors, including an error in another part of the system, such as software, server, or media. Although HP strives to minimize avoidable returns during the initial support contact, such drives do make up a small proportion of the drives for which claims are made against warranty. The population of “no trouble found” drives is not included when determining the revised MTBF and error-rate specification because they do not have reliability issues that have any bearing on the calculation.

## Modeling the data

To determine the failure rate and the characteristic behavior of the HP DDS-4 drives in the field, HP used Weibull analysis on the population of failed drives. Weibull analysis (also known as life data analysis) is a powerful tool that can be used to classify failures and model failure behavior. It involves fitting a “time to fail” distribution to failure data.

A three-parameter Weibull analysis provided the best fit to the field data because it allows for an offset in the timing of returns generated by the initial product delivery process through distribution channels to end users. The three-parameter analysis enabled HP to concentrate on the hours of operation when the failure occurred, regardless of how long the drive had been in the field.

Figure 1.

$$f(t) = \frac{\beta}{\eta} \left( \frac{t - \gamma}{\eta} \right)^{\beta-1} e^{-\left( \frac{t - \gamma}{\eta} \right)^\beta}$$

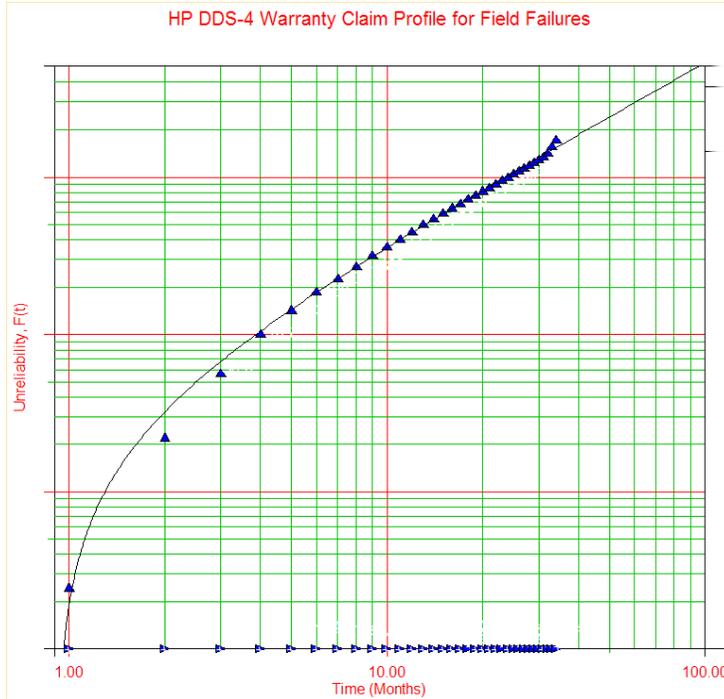
In the Weibull distribution (the equation shown in Figure 1), the scale parameter  $\eta$  (eta) defines where the bulk of the distribution lies. The shape parameter  $\beta$  (beta) defines the shape of the distribution, and the location parameter  $\gamma$  (gamma) defines the location of the distribution in time.

After calculating the parameters to fit a life distribution to a particular data set, HP could obtain a variety of plots and calculated results from the analysis including:

- **Mean life**—The average time that the products in the population are expected to operate before failure (MTBF)
- **Failure rate**—The number of failures per unit time that can be expected to occur for the product

Figure 2 illustrates the output from this analysis.

Figure 2.



In this chart, it is beta ( $\beta$ ) that determines the shape of the distribution.

- If beta is greater than 1, the failure rate is increasing.
- If beta is less than 1, the failure rate is decreasing.
- If beta is equal to 1, the failure rate is constant.

The chart shows a beta of virtually 1, indicating that there are no significant early failure modes. The implication is that the technology is mature and close to the bottom of the bathtub curve with extremely high levels of reliability.

## Determining the new MTBF

The analysis of this data enabled HP to measure the real MTBF experienced by customers at varying levels of confidence.

Table 1.

Upper confidence limit (80%)	1.14 million hours
Mean value	1.025 million hours
Lower confidence limit	930,700 hours

This is the MTBF calculated as an average over the whole population of HP DDS-4 drives shipped. The MTBF could reasonably be stated as 1.025 million hours used with a typical customer duty cycle.

But what is a typical customer duty cycle? HP DAT specifications have always quoted a duty cycle of 12%, which means, on average, a DAT drive is in operation (storing or restoring data) for 12% of the time (approximately three hours per day), and the rest of the time it is idle.

At a 12% duty cycle, HP calculates that its DAT drives have an actual MTBF of 1.025 million hours.

The 12% duty cycle sometimes causes confusion with customers who use their DAT drives more or less than the time quoted or believe that this is a recommended usage statistic. Furthermore, the tape industry now generally specifies MTBF at a 100% duty cycle, including HP for its own LTO Ultrium tape drive products. For this reason, HP will now show the DAT tape drive MTBF specification expressed as 100% duty cycle to make it easier to compare to other tape formats. When applying a 100% duty cycle to the new DAT MTBF calculation, HP calculates 125,000 hours MTBF at 100% duty cycle. In practice, however, unlike Ultrium tape drives, which are the most popular choice for large tape libraries, few DAT drives would ever be used 24 hours a day. Therefore, DAT tape drives effectively increase their MTBF by 2.6 times at a 12% duty cycle, from 400,000 hours to 1 million hours.

## Determining the uncorrected error rate

The published specification for uncorrected error rate on DAT technology has remained unchanged for many years, despite numerous quality improvements. The new MTBF and associated analysis has also provided the basis for a recalculation of the error rate specification.

The uncorrected error rate is calculated using the number of bits that the drive could write in its expected lifetime and comparing this to the number of bits in error. For HP DDS-4 and DAT 72, the new data that reflects the true performance of the drives in the field changes the specification from 1 bit in error per  $10^{15}$  bits written to 1 bit per  $10^{17}$  bits written.

Furthermore, it is unlikely that all the failures found are caused by uncorrectable errors. The specification, while based on empirical data, is still conservative, and the actual error rate of DAT tape drives is likely to be better than the stated spec.

## Summary

Real field data has shown that the HP DDS-4 tape drive has a far higher MTBF and lower uncorrectable error rate than previously specified. HP has enough confidence in this data to amend the specifications. With the recently introduced HP DAT 72 products showing an equivalent field return rate to DDS-4, the new specifications can be applied equally to both products.

This dramatic increase just confirms what HP has always claimed about its DAT products—they are the most reliable tape drives in their class.

# For more information

<http://www.hp.com/go/tape>

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