TECHNOLOGY BRIEF

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Compaq Computer Corporation

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Tape Drives, Media, and the Importance of Cleaning

This brief describes why tape drives must be cleaned periodically and outlines the cleaning requirements for Compaq tape drive technology. Several other topics are addressed, including:

- *Magnetic recording overview*
- *Types of media and mechanical defects*
- *Media life and tape streaming*
- *Supported Compaq tape technologies*
- *Recommended cleaning intervals*
- *Tape drive cleaning procedures*
- *Recommended tape and cleaning media*

EXECUTIVE OVERVIEW

Cleaning is an essential part of tape drive maintenance. If a tape drive is not cleaned regularly, particle buildup will interfere with operation of the tape drive mechanism and the read/write head. Buildup on read/write heads slows tape drive operation, increases signal dropouts, wastes storage capacity due to rewrites, increases the chance of data errors, and may cause tape backup failure. To achieve optimum tape drive performance and reliability, Compaq Computer Corporation recommends following the maintenance procedures and using the tape media and cleaning products specified for Compaq storage systems.

Please direct comments regarding this communication to the ECG Technology Communications Group at this Internet address: TechCom@compaq.com

COMPAQ

NOTICE

Tape Drives, Media, and the Importance of Cleaning

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INTRODUCTION

Cleaning is an essential part of tape drive maintenance and is required for optimum performance and reliability.

Tape drives operate by passing a thin piece of plastic tape covered with magnetic particles (the tape media) across a read/write head. As the tape media passes across the head, wear occurs on both the tape and the read/write head. This wear causes small amounts of magnetic particles from the tape media binding materials to collect on the head. Excessive buildup of debris can interfere with head-to-tape contact, which is critical to normal tape operation. Since tape drives are not airtight, dust and other debris may build up on the head and other parts of the drive mechanism. Tape drives must be cleaned periodically to maintain optimum tape performance and drive reliability.

CAUSES OF MAGNETIC RECORDING ERRORS

The best way to avoid errors is to clean the tape heads and storage media regularly.

Errors encountered during backup are due to the deterioration or partial loss of signal strength from the tape media to the read/write head. If that signal drops below a predetermined minimum threshold value, the drive erroneously detects a "bad spot" on the tape media and rewrites the data to the next "good spot." These bad spots or unused sections of tape media are referred to as dropouts. Errors during backup can be caused by inherent defects in the magnetic coating on the tape media. Damage to the tape and/or drive mechanism caused by worn or dirty read/write heads results in reduced tape capacity and backup performance. Mechanical defects also negatively influence efficient and reliable data recording. Regular cleaning reduces the occurrence of dropouts due to dirty read/write heads.

Inherent Media Defects

- Minute blemishes in the tape coating can cause dropouts, other random errors including complete signal loss, and poor head-to-tape contact.
- Loose debris that remains after tape manufacture, particularly with low-quality tape manufacturing processes, or caused by wear from excessive use results in particle buildup.
- Scratches can be caused by poor quality in the finished cartridge shells.
- Tape width fluctuations (variations in the width of the tape) can cause tapes to weave up and down across the recording head, making proper tracking difficult.

Compaq recommends the use of specific tape media for each drive as the best defense against these problems (see Tables 1 and 2).

Tape Damage after Writing

- Helical damage is caused by debris between the helical recording heads and the tape media.
- Longitudinal damage (scratches occurring along the length of the tape) is caused by debris stuck to the tape guides.
- Transverse damage (scratches occurring across the width of the tape) could be caused by the drive mechanism as it "jerks" the tape when changing speed or direction (usually repeatedly at the same spot).
- Tape surface damage (debris from damaged tapes) can produce scratches or other surface damage by sticking to the heads or tape guides and the debris then transfers to other tapes.

Specific cleaning procedures, as listed in the Users Guide, are provided with Compaq tape drives.

Defects that Affect Drive Mechanisms

- Head clogs occur when debris sticks to the head gaps (where the tape is read/written).
- Tracking errors occur when the heads fail to "follow" the tracks accurately.
- Mechanical jitter and noise occur infrequently. This error results from poor drive design or improper operation.

Using recommended equipment and maintaining the equipment within specified environmental limits minimizes the occurrences of these problems.

TAPE MEDIA LIFE EXPECTANCY

Most manufacturers specify tape media life expectancy in terms of the number of passes expected, rather than the number of backups for any specific tape. The term *pass* means any forward or reverse motion of the tape media across the read/write head. For full backups, the life expectancy of tape media can be estimated by dividing the number of rated passes of a tape by the number of tracks on that media. For example, the 4/8-gigabyte (GB) single-channel linear recording (SLR) drive uses 46 tracks on the tape media. The recommended media for that drive has a life expectancy rating of 5,000 passes for full backups under extreme conditions. The calculation states that 5,000 passes divided by 46 tracks yields approximately 108 full backups. This calculation assumes that the drive is streaming, and that a pass uses all available tape media from end-to-end. Please note that this calculation does not apply to digital audio tape (DAT) drives, and that limited testing by Compaq shows most pass estimates to be conservative.

Determining factors in the actual life expectancy of tape media are:

- design of the head and tape path
- number of passes and/or tracks a drive requires for one complete backup
- humidity and ambient temperature
- additional passes caused by frequently reading and update the header at the beginning of the tape
- tape streaming

Tape Streaming

Tape streaming is an important factor affecting media life expectancy (see Figure 1). The term *streaming* means that the tape media has a continuous motion in one direction across the read/write head during a backup. Tape drives and backup software are designed to stream.

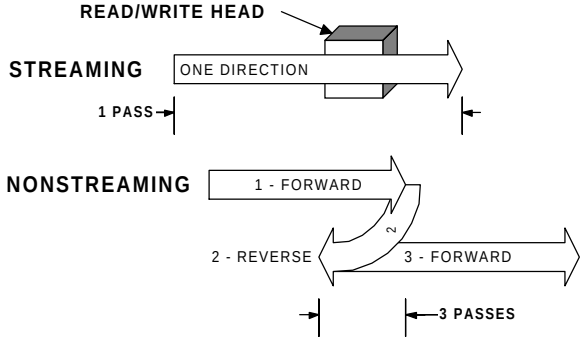

Figure 1. Backup performance is best and wear on the read/write head is minimized when the media streams continuously in one direction rather than stopping, repositioning, and then restarting.

When a tape drive is cleaned, problems associated with dirty tape heads are minimized.

The term *nonstreaming* means the tape media has a non-continuous, back-and-forth motion across the read/write head. Nonstreaming significantly reduces media life, increases head wear, and lowers backup performance.

Tape drives stream if the following conditions are met:

- The disk drive and/or disk drive array can supply data at least as fast as the tape drive can accept data.
- The configurations of the operating system and backup software are correctly optimized to support streaming.
- The processor has sufficient and available processing power to handle the overhead of tracking the backup progress. The processor must also be able to handle the tape drive streaming while accessing the disk drive or disk drive array during the backup procedure.

SUPPORTED TAPE TECHNOLOGIES AND CLEANING PROCEDURES

Compaq recommends three tape drive technologies:

- Quarter-inch cartridge (QIC) single-channel linear recording (SLR) drives
- Digital audio tape (DAT) drives
- Digital linear tape (DLT) drives

Cleaning a tape drive is a simple procedure; it requires only that an appropriate cleaning cartridge be inserted in the drive and allowed to cycle. Depending upon the type of tape drive, a cleaning cycle may last approximately one minute. To determine the recommended procedure and supplies for cleaning a Compaq tape drive, refer to the user documentation provided with each drive.

QIC Drives

Quarter-inch tape cartridge

Tape drives that record data on quarter-inch tape media are referred to as QIC drives. Compaq currently offers one QIC drive option, the 4/8-GB SLR Tape Drive[1]. This entry-level drive is a reliable, low-cost data-recording device that uses a similar recording technology as high-end DLT tape drives.

The 4/8-GB SLR tape drive records one track at a time and employs serpentine recording. The write/read/erase head has two sets of read and write head gaps. One set works when the tape is running in one direction, and the other set works when the tape is running in the opposite direction. At the end of a tape, the head assembly repositions to the next track location, tape direction is reversed, and a new track is recorded from the end of tape to beginning of the tape. This process repeats until all 46 tracks are recorded. This serpentine recording technique provides for faster backups and faster access to data on the tape when restoring files.

QIC drives feature a curved tape path that reduces tension on the tape media and increases the life expectancy of the device read/write heads.

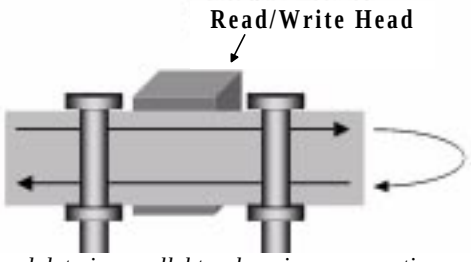

Figure 2. QIC tape drives record data in parallel tracks using a serpentine recording technique, which is similar to that of DLT tape drives.

[1] For additional information on the technology of the 4/8–GB SLR tape drive, refer to the Compaq Technology Brief, *Compaq Tape Backup Solution for Workstations and Entry-level Serves*, document number ECG095/1197.

QIC Cleaning

SLR drives are sensitive to particle buildup on the tape head and require regular cleaning.

SLR drives are sensitive to particle buildup on the tape head. They require regular, periodic cleaning. Compaq recommends cleaning SLR drives after every 8 hours of tape running or after every 7 days of "power on," whichever occurs first (see Table 1). Compaq also recommends using the Compaq quarter-inch dry-process cleaning cartridge for SLR series or higher drives.

> ***CAUTION:*** *Hard or sharp objects should never be used to clean debris from the drives. Even a small scratch can permanently damage the heads or other mechanisms.*

DAT Drives

Digital audio tape cassette (type DDS-3)

DAT drives[2] represent the mainstream, low-duty cycle recording devices, with advanced technologies that provide high performance and reliability. DAT drives provide fast backup performance on 4-mm digital data storage (DDS) tape media. To ensure data integrity, DAT drives use hardware data compression and three levels of error correction with 32-bit cyclical redundancy check (CRC) detection.

DAT drives employ a helical-scan recording technique, similar to that used in VCRs. Linear recording technology has tape movement only, while helical scan has both tape and head movement. The helical-scan method records data in diagonal stripes using a rotating transport drum (Figure 3). The tape media wraps around that drum creating a track length, which is nearly 10 times longer than the tape width. This tape path around the transport drum increases tape tension that may contribute to higher levels of wear and the possibility of more debris collecting on the heads. The rotating drum incorporates the two read and two write heads, which are diametrically opposite one another. Each of the four heads is positioned 90-degrees from the other. The transport drum is mounted 6 degrees from vertical, overcomes the limitations of crosstalk and mechanical tolerances by recording tracks diagonally across the tape. The transport drum in Figure 3 is intentionally skewed for illustration purposes only and does not represent actual mechanical design.

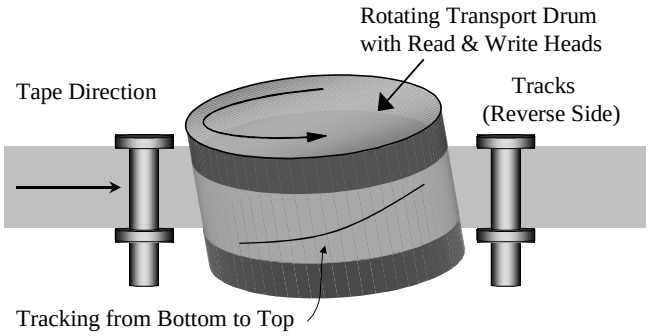

Figure 3. DAT drives record data by means of helical scanning.

The four heads design allows use of read-after-write (RAW) data verification, instead of the read-while-write data verification used in linear products such as the SLR and DLT.

[2] For additional information about DAT tape technology, refer to the Compaq Technology Brief, *DDS-3: Enhancing DAT Reliability, Capacity, and Performance*, document number ECG036/1297.

Compaq offers four DAT drive options:

- 2/4-GB DAT Drive
- 4/8-GB DAT Drive
- 12/24-GB DAT Drive
- TurboDAT AutoLoader, which combines a DDS-2 drive mechanism with either a 4-tape or a 12-tape cassette magazine

DAT Cleaning

Advances in DDS-2 and DDS-3 DAT drive mechanisms allow for automated cleaning, which prevents the buildup of debris that can cause dropouts.

Among the tape drives available today, DAT drives are the most susceptible to particle buildup. If a DAT drive is not kept clean, increased dropouts will occur. It is possible to sacrifice 20 percent of backup capacity and performance if the recommended head-cleaning schedule is not followed. DAT drives monitor the total number of dropouts. When dropouts reach a predetermined threshold, the green LED on the tape drive flashes indicating that the tape drive needs cleaning. DDS-2 and DDS-3 DAT drives provide automated internal cleaning. Compaq recommends the following cleaning schedule to optimize DAT performance and reliability:

- When using a new tape, DAT drives *must be* cleaned frequently: after each 8 hours of read/write operation until the entire data cassette has been used five times.
- When using data cassettes that have already been used five times, 2/4-GB DAT drives require cleaning after each 25 hours of read/write operations. The 4/8-GB and 12/24-GB drives require cleaning after each 100 hours of read/write operations.
- DAT drives should be cleaned before doing a complete server backup.

When using a DAT Autoloader, keeping a cleaning cassette in the last magazine slot enables automatic cleaning. Refer to the software user manual for instructions on how to schedule and perform cleaning operations using the software application.

DAT cleaning cassettes typically last 50 passes. After 50 uses, discard the cassette. An expired (>50 passes) cleaning cassette ejects in less than 20 seconds from insertion, rather than the usual 30 seconds.

DAT cassettes should include a label to track the number of times a tape has been used for backup. Writing this information on the label provides a convenient record of how many times a cassette has been used.

No alcohol or cleaning solutions should be used to clean DAT drive read/write heads.

Occasionally a single cleaning cycle may not fully clean the read and write heads on a DAT drive. If the backup software is reporting errors, clean the drive to eliminate the possibility that dirty heads are causing the error. In case of very dirty mechanisms, as many as four or more cycles may be needed for thorough cleaning, because DAT drives perform only a minimum cleaning cycle to reduce head wear. The magazine guide path in a DAT Autoloader may also become dirty. The cassette rollers and magazine rollers should be cleaned every 2 weeks.

> ***CAUTION:*** *To avoid damaging a DAT drive, do not clean the read and write heads or the transport drum with a cotton swab, as the fibers from a cotton swab can cause permanent damage to the heads and drum. Alcohol or cleaning solutions should* ***not*** *be used to clean DAT drive read and write heads. Always use the recommended cleaning cassette.*

DLT Drives

DLT cartridge

Developed for a minicomputer environment, DLT drives[3] use advanced linear recording technology, a highly accurate tape guide system, and an adaptive control mechanism. They record using a serpentine technique, using two parallel tracks at a time (see Figure 4). DLT drives also feature a state-of-the-art curved tape path that reduces tension on the tape media and increases the life of read/write heads. This provides a high-capacity, high-duty-cycle backup system.

DLT cartridges are specified to last from 500,000 up to 1,000,000 passes across the read/write heads. Under optimum environmental conditions, this specification equates to 19,230 backups using the entire tape capacity. This long media life is the result of the reduced head-to-media interface and dynamic tape path adjustment technologies used in the DLT drive.

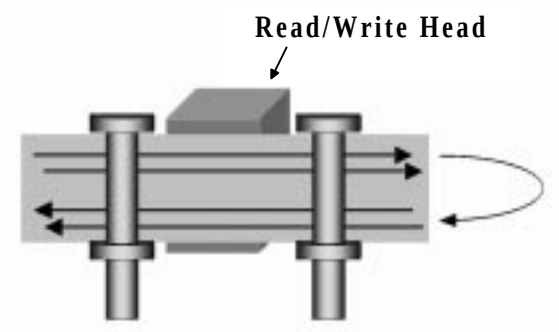

Figure 4. DLT drives record data using two parallel tracks in a serpentine fashion.

DLT Cleaning

DLT drives are not as susceptible to particle buildup as other types of drives. Therefore, they do not require cleaning as frequently.

DLT drives are not highly susceptible to particle buildup; therefore, they do not require frequent cleaning. The yellow "Use Cleaning Tape" indicator on the front panel of the DLT drive illuminates automatically signaling that the drive needs cleaning. A DLT drive should be cleaned when this indicator illuminates.

If a defective tape causes the cleaning light on the DLT drive to come on during a backup rather than during a restore function, that tape should be discarded immediately. Such a tape can contaminate the drive, which may then contaminate other tapes and subsequently other devices. In fact, this chain of events can be expected for almost any tape drive. In this specific circumstance, the DLT drive mechanism must be cleaned between loads.

Heavy usage of the DLT Drive in the DLT 15 Cartridge Library Model 1530-1 is expected. Because this level of use is heavier than that of a manually operated single drive, Compaq recommends that the drive in a library be cleaned more frequently than a single drive. Cheyenne ARCserve version 6.5 automatically enables the cleaning process whenever the 'cleaning requested' or 'cleaning required' error condition is recognized.

A DLT cleaning cartridge will last until it reaches the end of the cleaning medium, as it only uses a small section for each cleaning. DLT cleaning cartridges are effective for 20 cleaning cycles; this limit should not be exceeded.

> ***CAUTION:*** *To avoid damage to the DLT drive, never try to clean a DLT drive with anything other than a specified cleaning cartridge. One cleaning cycle is sufficient to clean a DLT drive. Do not perform multiple cleaning cycles on a DLT drive because doing so may damage the drive mechanisms.*

[3] For additional information on DLT technology, please refer to the Compaq Technology Brief, *DLT Hardware Technology*, document number 395A/0197.

RECOMMENDED TAPE DRIVES AND MEDIA

Compaq recommends tape cartridges that have been tested with the matching tape drive.

The use of unapproved tape cartridges is discouraged because they may not be compatible with Compaq tape drives.

Compaq exhaustively evaluates tape media for quality and reliability of the magnetic media and cartridge or cassette before recommending tapes to customers. Compaq recommends only tape media that have been tested in the designated tape drive. The use of unapproved tape media is discouraged because the media may not be compatible with Compaq tape drives. Table 1 lists Compaq tape drives and available media (current as of November 1997).

TABLE 1: COMPAQ TAPE DRIVES AND RECOMMENDED TAPE MEDIA

Drive Model	Tape Drive Option Kit	Type of Data Media	Approved Data Media Part Number	Media Life[A]			Rated Backups[B]
				Type of Interface	Media Width	Rated Passes	
4/8 GB SLR (QIC)	295480-B21	4 GB-QIC SLR	295482-B21 (5 pack)	SCSI	¼ inch	5,000[C]	108
2/4 GB DAT	142019-001	DAT DDS-1	131107-001 131107-002	SCSI	4 mm	2,000	300
4/8 GB DAT	295353-B21	DAT DDS-1 DAT DDS-2	131107-001 131107-002	SCSI	4 mm	2,000	300
12/24 GB DAT	295513-B21	DAT DDS-1 DAT DDS-2 DAT DDS-3	137611-001 131107-002 295515-B21	SCSI	4 mm	2,000	300
DAT Autoloader (internal) (external)	142183-001 142187-001	DAT DDS-1 DAT DDS-2	137611-001 131107-002	SCSI	4 mm	2,000	300
10/20 GB DLT (internal, rack) (external)	199742-001 199675-001	DLT	199702-001	SCSI	½ inch	50,000	7,812
15/30 GB DLT (internal) (external)	242456-001 242457-001	DLT	242465-001 (single) 242466-001 (7 pack)	SCSI	½ inch	50,000	7,812
35/70 GB DLT (internal) (external)	242250-B21 242251-B21	DLT	295194-001 (single) 295192-001 (7 pack)	SCSI	½ inch	1,000,000	19,230

Notes to Table 1:

A. The life expectancy of tape media is approximate. Tape media may last longer than the number of full backups listed above or it may not last that long.

B. Under optimum environmental conditions of 50 percent relative humidity and 22 degrees C. Assumes that drive is streaming and that entire tape capacity is used for each backup.

C. The Compaq Technology Brief, *Compaq Tape Backup Solution for Entry-Level Servers and Workstations*, Document Number ECG095/1197, cites the life expectancy of the SLR tapes as 10,000 passes, 217 full backups under normal conditions. The numbers in this table are representative of passes and full backups under extreme conditions. Testing by Compaq shows these pass estimates to be conservative.

TAPE DRIVE CLEANING INTERVAL

Regular cleaning of a tape drive minimizes particle buildup on the read/write head. When a tape drive is cleaned according to a regular schedule, problems associated with dirty heads are minimized. When designing a schedule for data backup, it is important to include regular cleaning of tape drives as an integral part of the overall backup plan.

Compaq offers cleaning media for QIC, DAT, and DLT tape drives. Customers worldwide can contact their Compaq sales representatives to obtain appropriate supplies for proper tape drive maintenance. Table 2 identifies part numbers for appropriate cleaning media (cartridges or cassettes) and the recommended cleaning intervals for Compaq tape drives. If approved media does not have a part number, that approved media (cartridge/cassette) is not available through Compaq. Recommended cleaning frequency is based upon drive vendor specifications. Actual cleaning intervals may vary depending on ambient temperature, humidity, and the tape media manufacturer.

TABLE 2: RECOMMENDED CLEANING INTERVAL FOR COMPAQ TAPE DRIVES

Drive Model	Tape Drive Option Kit	Cleaning Media Part Number	Recommend Media Cleaning Intervals	
			New Media[A]	Used Media[B]
4/8 GB SLR (QIC)	295480-B21	295483-B21	After 8 hrs. read/write	After 25 hrs. read/write
2/4 GB DAT	142019-001	242781-001	After 8 hrs. read/write	After 25 hrs. read/write
4/8 GB DAT	295353-B21	242781-001	After 8 hrs. read/write	After 100 hrs. read/write
12/24 GB DAT	295513-B21	242781-001	After 8 hrs. read/write	After 100 hrs. read/write
DAT Autoloader (internal) (external)	 142183-001 142187-001	242781-001	After 8 hrs. read/write	After 25 hrs. read/write
10/20 GB DLT (internal, rack only) (external)	 199742-001 199675-001	199704-001	When "Use Cleaning Tape" LED turns on	After 1000 hrs. read/write
15/30 GB DLT[C] (internal) (external)	 242456-001 242457-001	199704-001	When "Use Cleaning Tape" LED turns on	After 1000 hrs. read/write
35/70 GB DLT[C] (internal) (external)	 242520-B21 242521-B21	199704-001	When "Use Cleaning Tape" LED turns on	After 1000 hrs. read/write

Notes to Table 2:

A. In this context, the term *new media* refers to a new, unused tape cartridge or cassette (media) and to media that has previously been used in its entirety five times or less.

B. The term *used media* refers to media that has been used – in its entirety – for backup more than five times.

C. Compaq recommends more frequent cleaning of a DLT library drive using the approved cleaning cartridge.

CONCLUSION

Cleaning a tape drive is a simple procedure and should be a regularly scheduled event; it requires only that an appropriate cleaning cartridge or cassette be inserted in the drive and allowed to cycle. If a tape drive is not cleaned regularly, particle buildup will eventually interfere with the normal operation of the tape drive mechanism and the read/write heads. To achieve optimum backup performance and tape drive reliability, Compaq recommends the use of approved tape media and cleaning products, and following the recommended cleaning procedures as listed in the Users Guide for each Compaq storage system. Recommended periodic cleaning is essential in maintaining optimum tape performance and drive reliability. The best way to avoid errors in backups is regular cleaning of the tape heads and drive mechanisms.