IBM TS4500

Introduction and Planning Guide

GC27-9594-00

Note

Before using this information and the product it supports, read the information in “Safety notices” on page xix and “Notices ” on page 163.

Edition notice

This edition applies to the 2 release of the *IBM TS4500 Introduction and Planning Guide* and all subsequent releases until otherwise indicated.

Homologation statement

This product may not be certified in your country for connection by any means whatsoever to interfaces of public telecommunications networks. Further certification may be required by law prior to making any such connection. Contact an IBM representative or reseller for any questions.

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Note: For suggestions on operating enhancements or improvements, contact your IBM sales team.

Safety and environmental notices

This section contains information about safety notices that are used in this guide and environmental notices for this product.

Safety notices

Observe the safety notices when using this product. These safety notices contain danger and caution notices. These notices are sometimes accompanied by symbols that represent the severity of the safety condition.

Most danger or caution notices contain a reference number (Dxxx or Cxxx). Use the reference number to check the translation in the *IBM Systems Safety Notices*, G229-9054 manual. This manual is on the publications CD-ROM that is shipped with the product.

The sections that follow define each type of safety notice and give examples.

Danger notice

A danger notice is a special note in the text that calls attention to a situation that is potentially lethal or extremely hazardous to people. A sample danger notice follows:

DANGER: An electrical outlet that is not correctly wired could place hazardous voltage on metal parts of the system or the devices that attach to the system. It is the responsibility of the customer to ensure that the outlet is correctly wired and grounded to prevent an electrical shock. (D004)

Caution notice

A caution notice is a special note in the text that calls attention to a situation that is potentially hazardous to people because of some existing condition, or to a potentially dangerous situation that might develop because of some unsafe practice. A caution notice can be accompanied by one of several symbols:

If the symbol is...	It means...
	A generally hazardous condition not represented by other safety symbols.
	A hazardous condition due to mechanical movement in or around the product.

If the symbol is...	It means...
	This part or unit is heavy, with a weight greater than 18 kg (39.7 lb). Use care when lifting, removing, or installing this part or unit. (*C008*)

Sample caution notices follow:

CAUTION: The battery is a lithium ion battery. To avoid possible explosion, do not burn. (C007)

CAUTION: The system contains circuit cards, assemblies, or both that contain lead solder. To avoid the release of lead (Pb) into the environment, do not burn. Discard the circuit card as instructed by local regulations. (C014)

Attention notices

Attention:

This product is not intended to be connected directly or indirectly by any means whatsoever to interfaces of public telecommunications networks.

Environmental notices

This information contains all the required environmental notices for IBM® Systems products in English and other languages.

The *IBM Systems Environmental Notices* (ftp://public.dhe.ibm.com/systems/support/warranty/envnotices/environmental_notices_and_user_guide.pdf) information includes statements on limitations, product information, product recycling and disposal, battery information, flat panel display, refrigeration and water-cooling systems, external power supplies, and safety data sheets.

Publication description

The *IBM TS4500 Introduction and Planning Guide* provides important introductory and planning information to help you integrate the TS4500 tape library into your data storage environment.

This publication includes the following information:

- Describes the primary components of the library
- Explains how the TS4500 tape library interacts in Open Systems environments
- Explains how the library can process both Linear Tape-Open (LTO) and IBM 3592 tape cartridges
- Provides methods for determining supported servers and operating systems, performance considerations, and the physical planning specifications for the TS4500 tape library
- Provides a list of available features that you can order to modify and enhance the performance of all models of the TS4500 tape library

Who should read this book

This book is intended for system planners, programmers, and administrators.

Terminology

For definitions of terminology, abbreviations and acronyms, see the "Glossary" on page 169.

Related information

The most up-to-date information about the IBM TS4500 and its associated products is available in the IBM Knowledge Center: https://www.ibm.com/support/knowledgecenter/STQRQ9/com.ibm.storage.ts4500.doc/ts4500_ichome.html.

Additional publications are available on the IBM support site (http://www.ibm.com/support/us/en/).

- *IBM TS4500 Introduction and Planning Guide* (SC27-5990)
- *IBM TS3000 and TS4500 System Console Maintenance Information* (PN 2727119)

Data storage values

Data storage values are displayed using both decimal (base-10) prefixes and binary (base-2) units of measurement.

Decimal units such as K, MB, GB, and TB are commonly used to express data storage values, though these values are more accurately expressed by using binary units such as KiB, MiB, GiB, and TiB. At the kilobyte level, the difference between decimal and binary units of measurement is relatively small (2.4%). This difference grows as data storage values increase, and when values reach terabyte levels the difference between decimal and binary units approaches 10%.

To reduce the possibility of confusion, the TS4500 tape library documentation represents data storage using both decimal and binary units. Data storage values are displayed by using the following format:

```
#### decimal unit (binary unit)
```

By this example, the value 512 terabytes is displayed as:

```
512 TB (465.6 TiB)
```

Table 1 on page xxii compares the names, symbols, and values of the binary and decimal units. Table 2 on page xxii shows the increasing percentage of difference between binary and decimal units.

Table 1. Comparison of binary and decimal units and values

Decimal			Binary		
Name	**Symbol**	**Value (base-10)**	**Name**	**Symbol**	**Value (base-2)**
kilo	K	10^3	kibi	Ki	2^{10}
mega	M	10^6	mebi	Mi	2^{20}
giga	G	10^9	gibi	Gi	2^{30}
tera	T	10^{12}	tebi	Ti	2^{40}
peta	P	10^{15}	pebi	Pi	2^{50}
exa	E	10^{18}	exbi	Ei	2^{60}

Table 2. Percentage difference between binary and decimal units

Decimal Value	Binary Value	Percentage Difference
100 kilobytes (KB)	97.65 kibibytes (KiB)	2.35%
100 megabytes (MB)	95.36 mebibytes (MiB)	4.64%
100 gigabytes (GB)	93.13 gibibytes (GiB)	6.87%
100 terabytes (TB)	90.94 tebibytes (TiB)	9.06%
100 petabytes (PB)	88.81 pebibytes (PiB)	11.19%
100 exabytes (EB)	86.73 exbibytes (EiB)	13.27%

Chapter 1. Overview

The overview of the features and functions of the IBM TS4500 tape library is useful for high-level evaluation of the product and planning for the implementation of the product.

Introduction to the IBM TS4500 tape library

The TS4500 tape library is a next-generation cloud storage solution that delivers high storage density and integrated management.

Highlights

- Store up to 351PB (1,053PB compressed) per library with IBM 3592 cartridges
- Proactively monitor archived data with policy-based media verification
- Strengthen security and compliance with encryption and WORM media
- Simplify user access to data stored on tape via IBM Spectrum Archive
- Provide a flexible upgrade path to expand tape storage as needs grow
- Reduce the storage footprint and simplify cabling with 10U of rack space

IBM TS4500 tape library

Big data offers vast opportunities for business insight, but you need the right technology to help you manage and use that data. IBM cloud solutions can help you harness the power of big data while reducing costs and enabling a secure environment.

The next-generation IBM TS4500 tape library is designed to help midsized and large enterprises meet cloud storage challenges, including data volume growth, rising storage footprint costs, data migration efforts and the increased complexity of IT training and management as staff resources shrink.

TS4500 answers those business needs by incorporating the latest generation of industry-leading LTO technology that will help organizations handle the growing data demands of modern tape use cases like big data, cloud, media and entertainment, ultra high-definition editing, digital video surveillance, Internet of Things (IoT), active file archiving and, of course, backup.

TS4500 delivers the density that today's data growth requires—along with the efficiency and manageability to grow with business needs while preserving your existing investments in IBM tape library products. You can achieve both a low per-terabyte cost and high density, with up to 8.76 PB of data in a single 10 square-foot library using LTO Ultrium 8 cartridges or 12.37 PB with 3592 cartridges.

TS4500 provides advanced capabilities for integrated tape drive and media management, delivered within a single-pane-of-glass management console. The TS4500 graphical user interface (GUI) is based on the unified interface used in other IBM storage solutions. It includes key features to help guide storage administrators in completing critical tasks. For example, you can monitor a tape library via persistent, at-a-glance library utilization and health status indicators.

IBM TS4500 features such as automatic control-path and data-path failover, tape-drive encryption, dual robotic accessors and WORM media support improved management and help to reduce risk in the cloud.

In addition, IBM TS4500 now supports IBM z14, the latest generation of IBM Z servers. Mainframe administrators can trust TS4500 to help reduce floorspace costs and increase overall capacity.

Figure 1. IBM TS4500 tape library

Figure 2. Inside TS4500 tape library

Automates solutions for cloud environments

TS4500 is a tape drive integration leader, with features including a persistent worldwide name, multipath architecture, drive/media exception reporting, remote drive/media management and host-based path failover. TS4500 L25, D25 and S25 frames support the IBM TS1160, TS1155, IBM TS1150, and IBM TS1140 tape drives, while TS4500 L55, D55 and S55 frames support LTO Ultrium 8, 7, 6 and 5 tape drives. LTO Ultrium tape drives and TS1160, TS1155, TS1150 and TS1140 tape drives can be mixed within the TS4500 library, frame by frame. The L-frame and D-frame models help boost efficiency with improved hot-swappable drive packaging. All of the frames include high-density (HD) slot technology that can greatly increase a library's total capacity.

TS4500 frame models can be placed in any active position, so the library can grow from both the right and the left side of the first L frame for floorspace flexibility. A dual-accessor option can help increase mount performance and overall system reliability and availability. Accessors can be serviced at the ends of the library, eliminating the need for a dedicated service bay frame.

A top-rack offering can also provide 10U of rack space on top of the library for Fibre Channel switches, tape data movers or IBM Spectrum Archive nodes.

Delivers capacity on demand

The TS4500 library frame provides a more flexible upgrade path for users who want to expand their tape storage as their needs grow. Capacity-on-demand configurations for TS4500 L-frame models include an entry-level configuration, an intermediate configuration and a base-capacity configuration. All models also support HD capacity-on-demand configurations.

Includes advanced features

TS4500 is designed with advanced features to deliver cutting-edge performance and long-term value. For example, the Advanced Library Management System (ALMS) feature supports dynamic storage management, enabling you to create and change logical libraries and configure any drive into any logical library. TS4500 also offers automatic control-path and data-path failover to help improve business continuity and disaster recovery, and policy-based automatic media verification can help minimize data risk.

Centralizes management of tape resources

IBM offers a wide range of management software options for TS4500. The management software options include:

- **IBM Spectrum Archive**—Allows users and applications to directly access files and directories stored on tape
- **IBM TS4500 command-line interface (CLI)**—Provides access to TS4500 library management commands
- **Rocket Servergraph Professional**—Enables administrators to monitor and report on storage devices
- **IBM Tape System Library Manager**—Allows multi-library environments to be managed as a single system
- **IBM Security Key Lifecycle Manager**—Simplifies encryption key management with an intuitive user interface

IBM TS4500 tape library at a glance

Table 3. IBM TS4500 tape library at a glance	
Frame definition	• **L25**—Base frame for TS1160, TS1155, TS1150, and TS1140 (3592) drives and cartridges—includes 32 input/output (I/O) slots • **D25**—Drive-capable and storage expansion frame for TS1160, TS1155, TS1150 and TS1140 (3592) drives and cartridges • **S25**—Storage-only expansion frame for 3592 cartridges • **L55**—Base frame for LTO drives and cartridges—includes 36 I/O slots • **D55**—Drive-capable and storage expansion frame for LTO drives and cartridges • **S55**—Storage-only expansion frame for LTO cartridges
Tape drive types	TS1160, TS1155, TS1150, and TS1140 (3592), LTO Ultrium 8, 7, 6 and 5 tape drives
Number of frames per library	One base frame, up to 17 expansion frames with maximum of 7 Dx5 frames
Number of drives	• Up to 16 per frame (up to 12 in frame 1) • Up to 128 per library
Number of tape cartridges	• **L25**—up to 660 (up to 550 in frame 1) • **D25**—up to 740 (up to 590 in frame 1) • **S25**—up to 1,000 (up to 798 in frame 1) • Total supported per library: up to 17,550 • **L55**—up to 882 (up to 730 in frame 1) • **D55**—up to 970 (up to 774 in frame 1) • **S55**—up to 1,320 (up to 1,054 in frame 1) • Total supported per library: up to 23,170
Capacity*	• 3592 advanced cartridges: up to 351 PB per library (1,053 PB with 3:1 compression) • LTO Ultrium 8 cartridges: up to 278 PB per library (up to 695 PB with 2.5:1 compression)
Operating systems support	See the IBM System Storage Interoperation Center
*Capacity depends on drives installed, number and type of cartridges used, and compression ratio achieved. Listed capacity is physical. Usable capacity may be less.	

TS4500 tape library structure

TS4500 tape library frames

The TS4500 tape library is built from a single frame model that is called the base frame. The scalability of the library allows an increase in capacity by adding up to 17 more frames, called expansion frames. The

frames join side by side and can grow to the left or to the right of the base frame. All frames are supported by a single accessor.

The tape library supports second-generation high-density (HD2) frames. Like the first-generation HD frames, HD2 frames offer increased capacity without increasing frame size or required floor space by using high-density storage slots for tape cartridges. In addition, HD2 frames provide the following enhancements.

- Can be installed in the leftmost position of the library (frame number 1)
- Drive-capable HD2 frames support up to 16 HD2-compatible tape drives when positioned as frame number 2 or higher.

Note: Non-HD2 frames cannot be upgraded to HD2 frames.

Related information

"Increasing capacity" on page 54
Install capacity on demand (CoD) features to increase the cartridge capacity of frames in the TS4500 tape library.

TS4500 tape library frame models

The L25 and L55 (Lx5) frames and D25 and D55 (Dx5) frames are HD2 drive-capable frames. They contain high-density cartridge storage slots, and slots to house up to 16 tape drives. The S25 and S55 (Sx5) frames are HD2 storage-only frames. They contain high-density cartridge storage slots, but no tape drives. All HD frames provide internal LED lighting.

Table 4 on page 5 lists the frames that are supported by the library and their specific media type and capacity. Mixed media configurations within a single frame are not supported.

Table 4. TS4500 tape library frame models

Frame Model	Type	Media type	Capacity		Other
			Frame Position 1	Frame Position 2+	
L25	Base frame	3592	Up to 12 tape drives and 550 storage slots	Up to 16 tape drives and 660 storage slots	• Equipped with two 16 slot I/O stations • Optionally equipped with top rack (Model TR1)
L55	Base frame	LTO	Up to 12 tape drives and 730 storage slots	Up to 16 tape drives and 882 storage slots	• Equipped with two 18 slot I/O stations • Optionally equipped with top rack (Model TR1)
D25	Expansion frame	3592	Up to 12 tape drives and 590 storage slots	Up to 16 tape drives and 740 storage slots	• Optionally equipped with two 16 slot I/O stations • Optionally equipped with top rack (Model TR1) • Limited to any combination of seven D25 and D55 frames

Table 4. TS4500 tape library frame models (continued)

Frame Model	Type	Media type	Capacity		Other
			Frame Position 1	Frame Position 2+	
D55	Expansion frame	LTO	Up to 12 tape drives and 774 storage slots	Up to 16 tape drives and 970 storage slots	• Optionally equipped with two 18 slot I/O stations • Optionally equipped with top rack (Model TR1) • Limited to any combination of seven D25 and D55 frames
S25	Storage-only expansion frame	3592	798 storage slots	1000 storage slots	• Optionally equipped with top rack (Model TR1)
S55	Storage-only expansion frame	LTO	1054 storage slots	1320 storage slots	• Optionally equipped with top rack (Model TR1)
S24	Storage-only expansion frame	3592	Unsupported	1000 storage slots	• Requires a TS4500 control upgrade • Cannot be installed to the left of an Lx5 frame • Cannot be installed as the rightmost frame in a dual accessor tape library
S54	Storage-only expansion frame	LTO	Unsupported	1320 storage slots	• Requires a TS4500 control upgrade • Cannot be installed to the left of an Lx5 frame • Cannot be installed as the rightmost frame in a dual accessor tape library

Related information

“Increasing capacity” on page 54
Install capacity on demand (CoD) features to increase the cartridge capacity of frames in the TS4500 tape library.

High-density technology

The TS4500 tape library offers high-density (HD), drive-capable and storage-only frame models that are designed to greatly increase storage capacity without increasing frame size or required floor space.

HD slots contain tape cartridges in a tiered architecture. The cartridge immediately accessible in the HD slot is a Tier 1 cartridge. Behind that is Tier 2. The maximum tier in an LTO HD slot is Tier 5. The maximum tier in a 3592 HD slot is Tier 4 because the 3592 tape cartridge is slightly longer than the LTO cartridge. The single-deep slots on the door side of HD frames are referred to as Tier 0 slots. On the left, Figure 3 on page 7 shows the inside of an HD frame from the side. On the right, Figure 3 on page 7 shows a top-down view of one row of an HD frame with cartridges in Tiers 0 (door side), 1, 2, and 3.

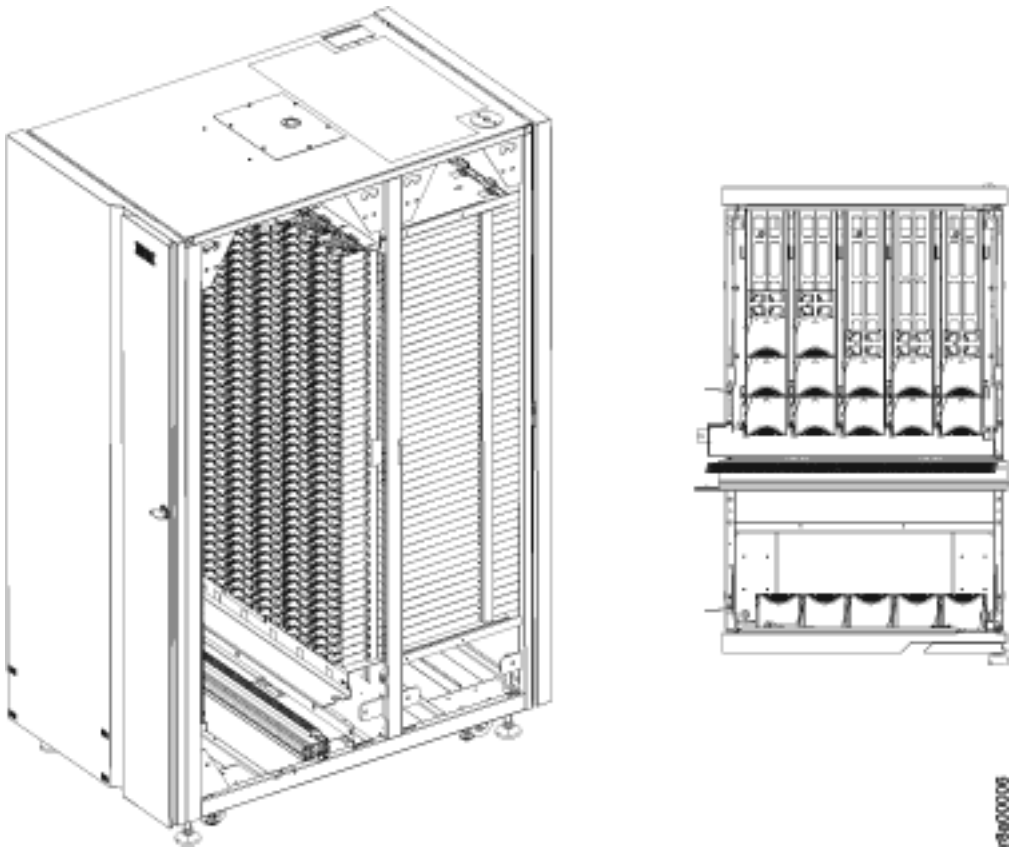


Figure 3. The HD frame (left) and top-down view of row in an HD frame (right)

All HD slots are black. The location of the cartridge retention latch differentiates LTO HD slots from 3592 HD slots. The cartridge retention latch is on the left side of LTO HD slots and on the right side of 3592 HD slots.

Attention: The HD slots have a constant force spring for maintaining forward pressure on the tape cartridges. Use caution when you are inserting or removing cartridges from HD slots.

Note: The cartridge count should not exceed 99% of the reported library slot capacity. Unused slots are required for shuffle operations.

In HD frames, the cartridge accessor runs a shuffle operation to access the cartridges that are stored in Tier 2 and beyond. A shuffle is the process of moving cartridges in lower tiers into the gripper (or other available slots) to access cartridges in higher tiers (Tier 2 or greater). To reduce shuffle operations and take advantage of repeated accesses of certain cartridges, the role of cartridge cache is assigned to all single-deep (Tier 0) slots in an HD library. To maintain efficient shuffle operations, the library uses load balancing to store cartridges across all HD slots in the library string. In other words, all HD slots are filled to a minimum tier level until that tier is full across the library. For more information about HD frames and library performance, see “High-Density Capacity on Demand” on page 55.

Second-generation HD (HD2) frames provide the following enhancements:

- Can be installed in the leftmost library position (frame position 1).
- Offer drive-capable models that support up to 16 HD2-compatible tape drives when in frame position 2 or higher.

Note:

- Non-HD2 frames cannot be upgraded to HD2 frames.
- The Lx5 frame cannot be the leftmost frame in a dual accessor library.

Top rack

The top rack, 3584 Model TR1, provides an extra 10U of rack space on any frame in a library without requiring more floor space.

The optional top rack (Figure 4 on page 8) reduces the storage footprint. It also simplifies cabling by providing extra rack space above the library for power distribution units, Fibre Channel switches, tape data movers, or IBM Linear Tape File System (LTFS) nodes.

Figure 4. TS4500 with top rack installed

A top rack is installed in the field by an IBM service representative on one or more frames of a TS4500 tape library. The top rack, and any components that are housed in the rack, are supported and serviced independently of the TS4500 tape library.

Feature code 1750, top rack end covers, is required for the left and right ends of one or more adjacent top racks. This feature is only required for the first top rack that is ordered when multiple top racks are ordered for adjacent frames.

Feature code 1751, power distribution unit (PDU), can optionally be ordered for any top rack. Up to two of FC 1751 can be ordered for any top rack. The first PDU does not use any of the 10U rack space. A second PDU, for redundancy, uses 1U of rack space. One power cord feature, 9954 through 9959 or 9966, is required for each PDU that is ordered.

Related information

“Feature codes for the TS4500” on page 93
Order feature codes to install components in library frames or to enhance the capacity or capabilities of the library.

Dual accessors and integrated service bays

When an optional second accessor is installed, the TS4500 tape library features high availability (HA), which enhances library performance. The extra accessor enables the library to operate without disruption if any component of one accessor fails. The integrated service bays reduce unusable service space by 40% compared to the TS3500 service bays. The default Maximum Capacity setting of the Elastic Capacity feature eliminates the remaining unusable service space.

If the library is installed with the optional second accessor, cartridge mount performance is also optimized. (A "mount" occurs when the accessor removes a cartridge from a drive, returns it to its storage slot, collects another cartridge from a random storage slot, moves it, and loads it into the drive.) The second accessor is part of feature code 1442.

When dual accessors are installed and an attached host issues a command for cartridge movement, the library automatically determines which accessor to mount cartridge in the most timely manner. Depending on the settings, if the library's primary accessor fails, the second accessor assumes control and eliminates system outage or the need for operator immediate intervention.

If you already have an installed TS4500 tape library and you want to add a second accessor, your IBM service representative can add the accessor. Converting from a single accessor to a dual accessor disrupts the operations of the library.

The second accessor ships inside a Dx5 or Sx5 frame. You can place that frame anywhere in the library string. However, the B accessor is always installed as the right-most accessor.

Dual Accessor Settings

You have three options to choose from. Each option changes the zones within which each accessor operates.

Dual active

Both accessors are online and active, and fulfill requests for media cartridges that fall within each accessor's preferred zone. In this option, the library is divided into two equally sized zones. While both accessors are active, the A accessor services the left zone and the B accessor services the right.

Accessor A Only

Only the A accessor is active and fulfills requests for media. The B accessor is online but parked in Service Bay-B. If the A accessor goes down, then the B accessor becomes active. In this option, the preferred zone for the A accessor includes the entire library with the exception of the area for Service Bay-B.

Accessor B Only

Only the B accessor is active and fulfills requests for media. The A accessor is online but parked in Service Bay-A. If the B accessor goes down, then the A accessor becomes active. In this option, the preferred zone for the B accessor includes the entire library with the exception of the area for Service Bay-A.

Service bays

Accessors are serviced through the side doors at the ends of the library. All front doors remain closed during accessor service, eliminating the need for dedicated service bay frames.

As you view the library from the front, Service Bay A is in the leftmost frame and it spans columns 3 - 8. Service Bay-A is where the A accessor moves to when it is placed in service. Service Bay-B is in the rightmost frame and it spans columns 5 - 10. Service Bay-B is where the B accessor moves to when it is placed in service. Integrated service bays reduce the number of unused storage columns in a dual accessor library from 22 to 14. While an accessor is in service, the media columns in that area are not available to the second accessor.

In frame one, the location of the I/O stations fall within the service bay area. Therefore, only Dx5 frames without the I/O station and Sx5 frames are supported as frame one in a dual accessor configuration. The rightmost frame can be an Lx5, Dx5, or Sx5 model.

Related concepts

“Elastic capacity” on page 40
In a dual-accessor configuration, the TS4500 tape library contains limited access columns that you can use for special situations. You can use these columns to store least recently used data cartridges, or as a temporary overflow area. The use of the limited access columns (Elastic Capacity) allows dual-accessor customers to achieve the same storage capacity as if the library was single accessor.

Components of the TS4500 tape library

The TS4500 tape library consists of one or more library frames, and other components for powering the library and installed tape drives and for handling and storing tape cartridges.

Refer to Figure 5 on page 11 to view the location of each component.

1 Library frames
The base frame (Lx5 models) and the expansion frames (Dx5 and Sx5 models) are the building blocks of the library. Each frame contains a rail system, high-density cartridge storage slots, and internal LED lighting. The Lx5 and Dx5 frames also contain slots for up to 16 tape drives.

Note: The LED lighting in the HD frames is specifically designed for use only in the TS4500 tape library and is not suitable for other applications

2 Rail system
The assembly on which the cartridge accessor moves through the library. The system includes the top and bottom rails.

3 Cartridge accessor
The assembly that moves tape cartridges between storage slots, tape drives, and the I/O stations.

4 Accessor controller
A circuit board that facilitates all accessor motion requests (such as calibrations, moves, and inventory updates).

5 Cartridge storage slots
Single-deep cells that are mounted on the door of the frame each store one tape cartridge. High-density cells inside of the frame each store 4 (3592) or 5 (LTO) tape cartridges. Mixed media (a combination of 3592 and LTO tape cartridges) is not supported within individual frames or within the TS4500 tape library.

6 IBM LTO or 3592 tape drives
One or more units that are mounted in the frame that read and write the data that is stored on tape cartridges. IBM LTO tape drives and 3592 tape drives cannot be mixed in the same frame. IBM tape drives use LTO tape cartridges; 3592 tape drives use IBM 3592 tape cartridges.

7 Front door
The front door of any frame. The single-deep cartridge storage slots on the inside of the door are referred to as Tier 0 slots. Two I/O stations are installed on the front door of the base frame. Two extra I/O stations can optionally be installed on the front door of any Dx5 frame. The library's front door has a key lock. The key lock is the same for every front door, and the keys are shipped with the library.

Note: The side doors of the base frames (Lx5) also have a key lock, which is the same key lock that is used for the front door.

8 Door safety switch
One or more devices in each frame that shuts down the motion power to the cartridge accessor whenever the front door is opened.

9 I/O stations
Two cartridge compartments on the front door of the base frame that enable the insertion or removal of tape cartridges without the library performing a re-inventory of the frame. Two extra I/O stations can optionally be installed on any Dx5 expansion frames.

TS4500 integrated management console (IMC) (Not shown)
At either end of the library, the IMC includes an LCD screen and keyboard with touchpad to access the TS4500 management GUI. The IMC is also used by IBM service representatives to perform service functions.

10 Power cable hole
A covered opening for a power cable that must attach to an outlet mounted above the library.

11 Fibre Channel cable hole
A covered opening for Fibre Channel cables that must be routed above the library.

12 TS4500 frame control assembly

An assembly of components that facilitate Ethernet communication between the drives in a frame and the accessor controller. The frame control assembly is standard on all base frames (Lx5) and optional on any Dx5 expansion frames. The assembly includes one library controller card (LCC) and two power supplies, both of which can provide power to the library and all drives in a frame.

13 Patch panel

A panel that houses the cable connections for the tape drives.

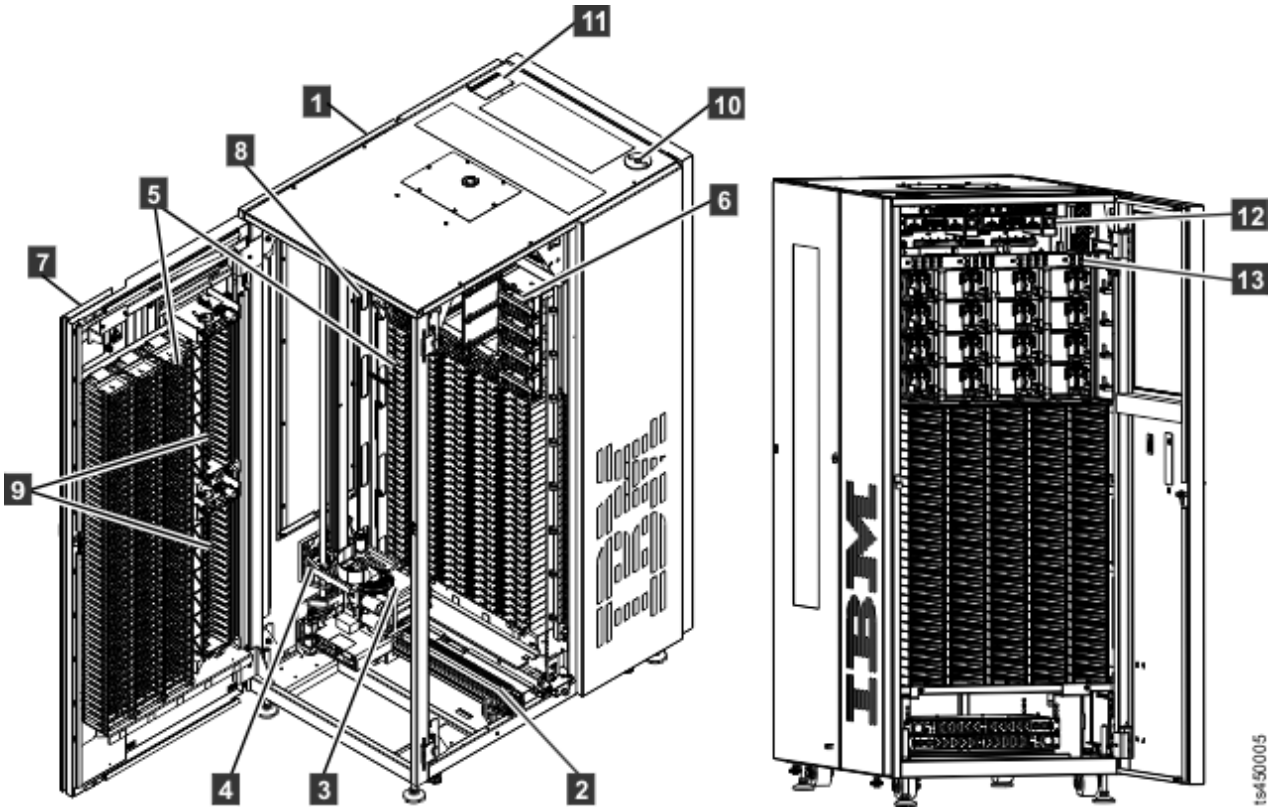


Figure 5. Components of the TS4500 tape library. The front of an Lx5 frame is shown on the left. The rear of an Lx5 frame is shown on the right.

Related information

"TS4500 tape library structure" on page 4

Display panel

The display panel on the base frame houses the library power and pause buttons and displays indicators of library status.

Expansion frames that have optional I/O stations that are installed also have a display panel. However, the panel on expansion frames does not include the library power or reset buttons.

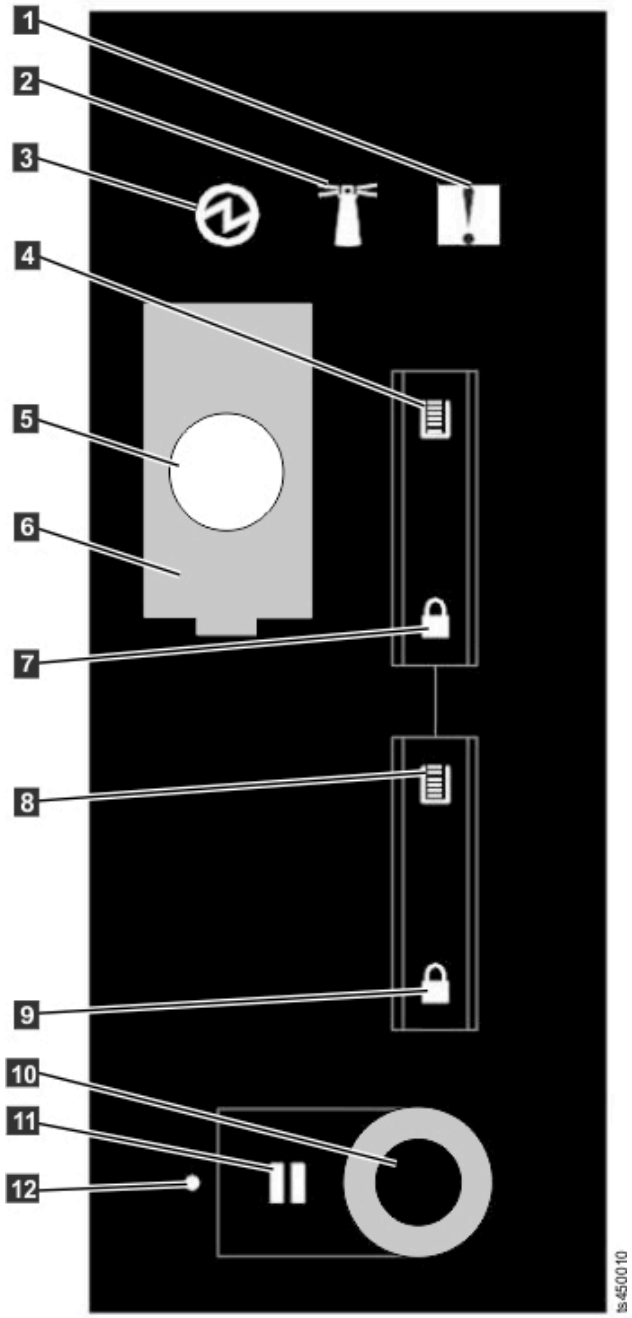


Figure 6. Display panel

#	Component	#	Component
1	Warning indicator (yellow)	2	Library beacon (blue)
3	Power indicator (green)	4	Upper I/O station capacity indicator
5	Power button	6	Power button cover
7	Upper I/O station lock indicator	8	Lower I/O station capacity indicator
9	Lower I/O station lock indicator	10	Pause button (pauses the library for 60 seconds or as long as a frame door is open)
11	Pause indicator (white)	12	Access Recovery button

Integrated management console

The integrated management console (IMC) is a built-in platform for tools that are used to manage the TS4500 tape library. The IMC, which includes an LCD screen and a keyboard with touchpad, can be mounted on either end of your TS4500 tape library.

Normally, a library controller card (LCC) and power source are required within the end frame or an adjacent frame. Optionally, feature code FC 2737 (IMC separate power source) allows for the IMC to be mounted on a non-powered end frame, that is more than one frame away from a powered frame. This feature can be installed during the installation of expansion frames in an initial library installation, or later when more expansion frames are added to an existing library.

The IMC comes preinstalled with a system console application, which is a set of software tools that is used for local service and remote support of the attached TS4500 tape library. The system console application enables the IMC to provide service console capabilities, such as broadband call home.

The TS4500 management GUI runs on a web browser in kiosk mode on the IMC. Kiosk mode means that the menu bar, address bar, and stop and reload buttons of the browser are disabled. In addition, it is not possible to use bookmarks or multiple browser windows.

Related information

"Remote support" on page 56
Remote support for the TS4500 tape library involves the use of a Call Home feature to detect and solve problems. Also, remote support requires several important security functions.

TS4500 management GUI Users page help
TS4500 management GUI Roles page help

I/O stations

Insert or remove cartridges with the input/output (I/O) stations while the TS4500 tape library is performing other operations without requiring an inventory.

The base frames (models L25 and L55) come with two I/O stations. Each I/O station has a cartridge magazine that allows cartridges to be loaded without interrupting the operation of the library. The cartridge magazine for LTO can hold up to 18 cartridges. The cartridge magazine for 3592 can hold up to 16 cartridges. On libraries with LTO and 3592 frames, the Lx5 frame I/O Stations can be used for both types of magazines or the first Dx5 frame (different from the Lx5) can have I/O station shipped with the magazines for the different drive type. Magazines for different media types can be ordered using FC 1628 for LTO, and FC 1629 for 3592.

Two extra I/O stations can be installed in any Dx5 expansion frame by ordering feature code 1652. This feature installs two I/O stations in one expansion frame. Each additional pair of I/O stations increases the maximum insert/eject throughput for the library. The total cartridge capacity for expansion frames with two I/O stations is reduced by 80 cartridges for model D25 and by 88 cartridges for model D55. Storage-only frames (models Sx5) do not support I/O stations.

You can remotely use the I/O station action menu, available from the **System** page of the TS4500 management GUI, to open and close the I/O station doors. At the library, you can press the eject button (9 in Figure 7 on page 14) to open and close the doors. When the doors are open, it is possible to manually remove and replace the cartridge magazine to insert or remove cartridges. When the doors are closed, the cartridge accessor can access the cartridges. The lock status LED next to the eject button (also 7 in Figure 7 on page 14) indicates that the I/O station is locked because the accessor could be inserting or removing cartridges. Do not attempt to open the station when the lock status indicator is illuminated.

Notes:

- Use the eject button (9 in Figure 7 on page 14) or the management GUI to open and close the I/O station doors. Do not attempt to open the doors manually.
- If there is an obstruction in the I/O station, the doors automatically reopen.
- Always keep a cartridge magazine, even if the magazine is empty.

Each I/O station slot has a unique address to indicate its physical location. The I/O station slot address consists of two values: a frame number and a row number.

Figure 7 on page 14 shows the location of the I/O stations and display panel. Table 5 on page 14 identifies each icon.

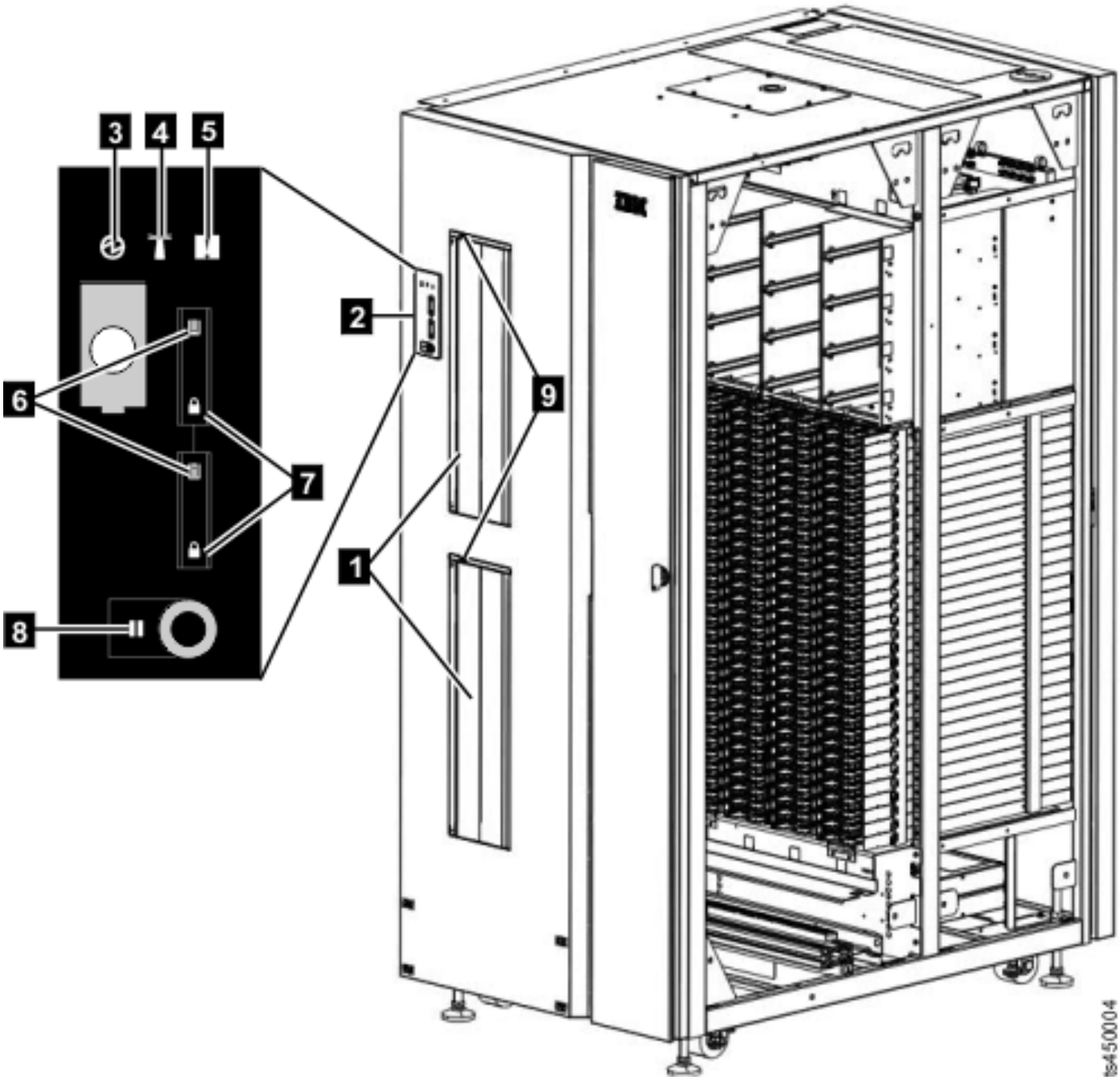


Figure 7. Location of I/O stations and display panel on an Lx5 frame

Table 5. I/O stations and display panel

#	Component	#	Component
1	I/O stations	6	I/O capacity indicator
2	Display panel	7	Lock status indicator
3	Power indicator (green)	8	Pause indicator (white)
4	Library beacon (blue)	9	Eject button

Table 5. I/O stations and display panel (continued)

#	Component	#	Component
5	Warning indicator (yellow)		

Related information

TS4500 management GUI System page help

“Cartridge magazine” on page 15

The cartridge magazine is used to load and unload one or more tape cartridges independent of the TS4500 tape library.

Inserting tape cartridges

Cartridge magazine

The cartridge magazine is used to load and unload one or more tape cartridges independent of the TS4500 tape library.

The base frame of the TS4500 tape library comes with two I/O stations. Any Dx5 expansion frame can optionally have two I/O stations installed. A removable cartridge magazine is installed in each I/O station and is used to insert or remove cartridges from the station. The cartridge magazine is accessed by opening the I/O station doors using either the eject button above the station or the TS4500 management GUI.

The cartridge magazines are media-specific. Table 6 on page 15 lists the dimensions and weight of each magazine. A bar code label at the top of the magazine is scanned by the cartridge accessor and indicates to the library whether the magazine is for LTO or 3592 cartridges. The LTO magazine holds up to 18 cartridges. The 3592 magazine holds up to 16 cartridges. A serial number label, affixed to the bottom of the magazine, is used for identification.

Table 6. Cartridge magazine physical specifications

Specification	3592 cartridge magazine	LTO cartridge magazine
Dimensions	Width: 127 mm (5 in) Height: 523 mm (20.6 in) Depth: 137 mm (5.4 in)	Width: 127 mm (5 in) Height: 523 mm (20.6 in) Depth: 160 mm (6.3 in)
Maximum weight (full of cartridges)	5.24 kg (11.6 lb)	5.14 kg (11.4 lb)
Minimum weight (no cartridges)	1.1 kg (2.5 lb)	1 kg (2.2 lb)

The magazine is always seated in the I/O station so that the handles are accessible when the I/O station doors are open. The magazine must also be positioned so that the bar code labels on the magazine and cartridges face inside the library and can be read by cartridge accessor. An up arrow and "THIS SIDE UP" engraving indicate how the magazine must be inserted into the I/O station. In addition, guide ribs on the top and bottom prevent the magazine from being inserted upside down.

The handles on the cartridge magazine are used to insert and remove the magazine, or to carry it during transport. The magazine safety lock retains cartridges in their slots and prevents them from falling out while the magazine is carried. When a magazine is removed from an I/O station, it is necessary to engage the safety lock until the magazine is placed on an accessible surface. It is then necessary to unlock the magazine to insert or remove cartridges. Attempting to insert or remove cartridges while the magazine safety lock is engaged might damage the magazine or the cartridges. After a magazine is reinserted into an I/O station, it is necessary to unlock the magazine so that the accessor can retrieve cartridges.

A universal dust cover comes with each magazine and can be used for shipping cartridges in the magazine. The bar code labels are visible through the clear cover.

Related information

Using I/O stations to insert cartridges

Rail assembly

This topic explains how the cartridge assessor moves through the TS4500 tape library on a rail assembly.

The cartridge accessor moves through the TS4500 tape library on a rail assembly. The system consists primarily of a main rail assembly and a support rail, and a trough for the power and control cable. The main rail assembly includes a main bearing way with a rack gear. Its support rail is an L-shaped rail that runs along the top of the frames and provides smooth transport for the cartridge accessor. The power and control cable is kept clear of the accessor in a covered trough at the bottom rear of the library.

Cartridge accessor

This topic explains how the cartridge accessor moves cartridges between storage slots, tape drives, and the I/O station of the TS4500 tape library.

The cartridge accessor moves cartridges between the storage slots, tape drives, and the I/O station of the TS4500 tape library. The accessor consists of several components:

X- and Y-axis motion assemblies
A group of parts that includes a controller (circuit board) for the Controller Area Network interface, servo motor, pinion drive gear, and lead screw. These assemblies provide the motive force to move the accessor side to side (on the X-axis) and up and down (on the Y-axis). The controller part of this assembly is referred to as the XY controller.

Pivot assembly
A group of parts that provides a mounting platform for the gripper mechanism and the bar code reader. The Pivot assembly is capable of 180° rotation about the vertical axis.

Optimized dual gripper
An electromechanical device (mounted on the pivot assembly) that gets or puts cartridges from or to a storage slot, tape drive, or I/O station. The gripper is independently controlled and can grip a single cartridge. There are two grippers on the pivot assembly (Gripper 1 and Gripper 2). The grippers are located in the dual-gripper transport mechanism.

In libraries that mix drive types, the optimized dual gripper can handle both Ultrium and 3592 tape cartridges.

Bar code scanner
A component that reads the bar code on a label that is affixed to a cartridge or to the rear of empty storage slots. The bar code scanner is mounted on the pivot assembly. It is used during inventories, audits, insertions, and inventory updates. An inventory update is a process that is invoked each time that you open a door. It determines whether cartridges were added to or removed from the library, or moved within the library.

Calibration sensor
A component that provides a means to locate certain positions within the library precisely during the calibration operation. The calibration sensor is mounted on the underside of Gripper 1 (for the optimized dual gripper, the sensor is mounted on the top of Gripper 2). All positions are calculated from these locating positions.

Library performance

The library performance values show the relative performance of the systems and are not meant to be absolute indicators of performance in your specific environment. Performance values, such as cartridge inventory times, mount performance, and cartridge move time, are obtained for the TS4500 tape library using specific measurements.

Performance values for the TS4500 tape library, whether measured on test systems or modeled through simulations, are based on a fixed set of workload assumptions to ensure accurate comparisons; however, the results are not evaluated in all production environments.

Some of the specific assumptions may not pertain to a given operating environment. Actual performance may vary. Accordingly, the performance information for this product does not constitute a performance

guarantee or warranty. Verify that the performance of the library is acceptable in your specific environment.

Inventory times

Various types of inventories are supported by the TS4500 tape library. The amount of time required to create the inventory for the library or a frame in the library varies with each type of inventory.

The tape library tracks the logical location of all of its elements by performing an automatic inventory as required. The automatic inventory improves application performance. You can also manually initiate an inventory, if necessary, from the **System** page of the TS4500 management GUI.

Table 7 on page 17 shows the typical time required for the tape library to inventory cartridges.

Table 7. Typical time required to inventory cartridges

Frame component	Typical time to inventory (in seconds)
Storage column (8 or 10 per frame)	6
Drive column (0-4 per frame)	6
I/O Station (0 or 2 per frame)	8

An inventory operation includes a check to determine whether each cartridge storage slot in the library is empty or full, and a scan of the bar code labels. An inventory occurs whenever you:

- Power on the tape library
- Issue the SCSI Initialize Element Status with Range command
- Close the front door after manually accessing the inventory. Only those frames whose doors were opened are inventoried.
- Initiate an inventory from the TS4500 management GUI

Inventory all tiers

A standard inventory is a scan of Tier 0 and Tier 1; however, at times it is necessary to inventory all tiers. This operation takes more time because it requires moving the cartridges to scan each bar code. For all inventory operations, tiers 2 and higher are only scanned when one of the following changes occurs:

- A Tier 1 cartridge bar code label has changed
- Enough Tier 1 bar code labels have changed in a column to warrant an inventory of the entire column
- **Scan all tiers** is selected when initiating a manual inventory from the TS4500 management GUI

Table 8 on page 17 shows the typical time required for the tape library to inventory all tiers during a bulk load.

Table 8. Typical time required to inventory all tiers

Frame component	Typical time to inventory all tiers (in seconds)
Full HD slot	15
Model L25/D25 column of full HD slots (0 - 5 per frame)	280
Model S24/S25 column of full HD slots (0 - 5 per frame)	415
Model L55/D55 column of full HD slots (0 - 5 per frame)	390
Model S54/S55 column of full HD slots (0 - 5 per frame)	580

Table 9 on page 18 provides typical inventory times for several example frame configurations.

Table 9. Typical time required to inventory a frame for example frame configurations			
	Typical time to inventory (in seconds)		
Frame configuration*	**No cartridges changed**	**One tier 1 cartridge changed**	**Initial bulk load**
Model S55 in frame position 1	48	63	2344
Model D55 with 3 drive columns and no I/O stations in frame position 1	66	81	1602
Model L25 with 4 drive columns and 2 I/O stations in frame position 2	88	103	1458
Model S25 in frame position 2	60	75	2105
*Assumes that the frame is 99% full.			

Mount performance

Mounts per hour is a measure of the overall capability of the cartridge accessor and tape drives. It is defined as the number of cartridges that the tape library can mount in one hour.

A mount, often called the demount and mount cycle, involves the following steps: (1) removing the cartridge from a drive; (2) returning it to a storage slot; (3) collecting another cartridge from a random storage slot; (4) moving it to the drive; and (5) loading the cartridge into the drive. Table 10 on page 18 shows the mount performance for a tape library with all mounts from Tier 0, which are the single-deep slots on the door side of the HD frame.

Table 10. Mount performance for a TS4500 tape library with all mounts coming from Tier 0		
	Maximum mounts per hour	
Library configuration	**Single accessor**	**Dual accessor**
4 frames	360	730
6 frames	315	720
8 frames	270	680
12 frames	220	620
18 frames	180	550
Specifications were produced from models, but are consistent with test results. The dual accessor data assumes that each cartridge is mounted in a drive that is located within the same library zone.		

Cartridge import and export performance

The cartridge import and export rates indicate the number of tape cartridges that can be imported and exported in an hour.

The import and export rates will vary depending on the following factors:

- How busy the accessor is with other activities (all activity is interleaved so that no activity can be "starved").
- How quickly the operators fill the I/O slots or empty the magazines from the I/O stations.
- How many operators are inserting cartridges or emptying the magazines.

The maximum rates listed in Table 11 on page 19 assume:

- Minimal mount/demount activity.

- Less than 90 seconds for the operator to introduce each magazine into the I/O station or empty each magazine from the I/O station.
- For dual-accessor libraries, two operators inserting magazines into both accessor zones or emptying magazines from both accessor zones simultaneously.

Table 11. Import and export performance for a TS4500 tape library

Maximum imports per hour		Maximum exports per hour (8 to 18 frames; exports from tier 0 and tier 1)
Single-accessor library (up to 8 frames)	**Dual-accessor library (8 to 18 frames)**	
Over 600 cartridges	Over 1200 cartridges	Over 1200 cartridges

Tape drives

The TS4500 tape library supports LTO and 3592 tape drives.

The HD2 frames of the TS4500 tape library support HD2-compatible models of the TS1140, TS1150, TS1155, TS1160, LTO 5, LTO 6, LTO 7, and LTO 8 tape drives.

Note: The non-HD2 and HD2-compatible models of these tape drives can be installed only in their respective non-HD2 or HD2 frames.

In a single accessor library, up to 12 drives can be installed in an Lx5 or Dx5 frame that is in frame position 1 (the leftmost frame) of the library. Also, up to 16 drives can be installed in each Lx5 or Dx5 frame that is in frame position 2 or higher.

No drives are installed in the storage-only frames (Models S25 and S55). You can identify a drive by examining the logo at the front of the drive canister or by inspecting the label at the rear of the drive canister.

You or your IBM service representative can update firmware for the tape drives without scheduling downtime. This function is available through the TS4500 management GUI or TS4500 command line interface (driveCodeUpdate command).

Related information

Updating drive firmware

driveCodeUpdate CLI command

Supported tape drives

The TS4500 tape library supports LTO and 3592 tape drives.

Table 12 on page 19 lists the supported LTO drives and Table 13 on page 20 lists the supported 3592 drives.

Table 12. Supported LTO tape drives

Type of drive	Speed of connectivity	Native data rate	Native capacity	Also known as	HD2-compatible model
IBM TS1080 Model 3588 F8S (single-mode fibre)	8 Gbps Fibre	360 MB/s	12 TB (10.91 TiB)	LTO 8 LTO Ultrium 8	IBM 3588 F8S
IBM TS1080	8 Gbps Fibre	360 MB/s	12 TB (10.91 TiB)	LTO 8 LTO Ultrium 8	IBM 3588 F8C

Table 12. Supported LTO tape drives (continued)

Type of drive	Speed of connectivity	Native data rate	Native capacity	Also known as	HD2-compatible model
IBM TS1070	8 Gbps Fibre	300 MB/s	6 TB (5.46 TiB)	LTO 7 LTO Ultrium 7	IBM 3588 F7C
IBM TS1060	8 Gbps Fibre	160 MB/s	2.5 TB (2.27 TiB)	LTO 6 LTO Ultrium 6	IBM 3588 F6C
IBM TS1050	8 Gbps Fibre	140 MB/s	1.5 TB (1.37 TiB)	LTO 5 LTO Ultrium 5	IBM 3588 F5C

Table 13. Supported 3592 tape drives

Type of drive	Speed of connectivity	Native data rate	Native capacity	Also known as	HD2-compatible model
IBM TS1160 Model 3592 60F	16 Gbps Fibre	400 MB/s	20 TB (18.19 TiB)[7] 15 TB (13.64 TiB)[5] 7 TB (6.37 TiB)[3] 5 TB (4.54 TiB)[6] 3 TB (2.73 TiB)[4] 900 GB (838.19 TB)[1]	IBM 3592 60F	IBM 3592 60F
IBM TS1160 Model 3592 60E	10 or 25 Gbps Ethernet	400 MB/s	20 TB (18.19 TiB)[7] 15 TB (13.64 TiB)[5] 7 TB (6.37 TiB)[3] 5 TB (4.54 TiB)[6] 3 TB (2.73 TiB)[4] 900 GB (838.19 TB)[1]	IBM 3592 60E	IBM 3592 60E
IBM TS1155 Model 3592 55F	8 Gbps Fibre	360 MB/s	15 TB (13.64 TiB)[5] 7 TB (6.37 TiB)[3] 3 TB (2.73 TiB)[4] 900 GB (838.19 TB)[1]	IBM 3592 55F	IBM 3592 55F
IBM TS1155 Model 3592 55E	10 Gbps Ethernet	360 MB/s	15 TB (13.64 TiB)[5] 7 TB (6.37 TiB)[3] 3 TB (2.73 TiB)[4] 900 GB (838.19 TB)[1]	IBM 3592 55E	IBM 3592 55E
IBM TS1150	8 Gbps Fibre	360 MB/s	10 TB (9.1 TiB)[5] 7 TB (6.37 TiB)[3] 2 TB (1.82 TiB)[4] 900 GB (838.19 TB)[1]	IBM 3592 EH8	IBM 3592 EH8
IBM TS1140	8 Gbps Fibre	250 MB/s	4 TB (3.6 TiB)[3] 1.6 TB (1.46 TiB)[2] 500 GB (.5 TB)[1]	IBM 3592 EH7	IBM 3592 EH7

Table 13. Supported 3592 tape drives (continued)					
Type of drive	**Speed of connectivity**	**Native data rate**	**Native capacity**	**Also known as**	**HD2-compatible model**
Native capacity varies with cartridge type: 1. with JK cartridge. 2. with JB/JX cartridge. 3. with JC/JY cartridge. 4. with JL cartridge. 5. with JD/JZ cartridge. 6. with JM cartridge. 7. with JE/JV cartridge.					

LTO tape drives

The TS4500 tape library supports LTO 5 and later LTO tape drives.

The LTO 5, LTO 6, LTO 7, and LTO 8 tape drives are dual-ported drives that facilitate 8 Gbps Fibre Channel connectivity. These drives are differentiated from other LTO drives by their machine type and model numbers. You can identify the LTO tape drives by the logo at the front of the drive or by the label at the rear of the drive's canister.

The following generations of HD2-compatible LTO drives are supported by the HD2 frames of the TS4500 tape library:

- IBM TS1080 Tape Drive (Model 3588 F8S, single-mode fibre)
- IBM TS1080 Tape Drive (Model 3588 F8C, multi-mode fibre)
- IBM TS1070 Tape Drive (Model 3588 F7C)
- IBM TS1060 Tape Drive (Model 3588 F6C)
- IBM TS1050 Tape Drive (Model 3588 F5C)

Note: Drive models 3588 F8A, F7A, F6A, and F5A are not supported by the HD2 frames of the TS4500 tape library.

LTO tape drives communicate with the tape library through an internal Ethernet interface. They also use the Statistical Analysis and Reporting System (SARS) to isolate failures between media and hardware.

LTO tape drives read and write non-WORM media, so you can load WORM-capable firmware on your tape drives and use any media that is supported by these drives. In this case, only the data that is written on WORM media is treated as WORM data. Data that is written on other types of media can be overwritten.

LTO tape drives do not read from or write to 3592 tape cartridges, and 3592 tape drives do not read or write to LTO tape cartridges. Refer to “Mixed media in drives” on page 34 for detailed information about cartridge and drive compatibility.

The LTO tape drives can read tapes that were written by non-IBM LTO drives. They also write to tapes that can be read by non-IBM LTO drives.

All supported generations of LTO tape drives and cartridges can be in the same frame.

When a cartridge is labeled according to IBM bar code label specifications, the last character of its volume serial (VOLSER) number indicates the first drive generation that supports the media. For example:

- 000764**L8** is an LTO 8 cartridge
- 000764**M8** is an LTO Ultrium 7 cartridge initialized as Type M media (M8)
- 000764**L7** is an LTO 7 cartridge

- 000764**L6** is an LTO 6 cartridge
- 000764**L5** is an LTO 5 cartridge

To enhance library performance, LTO tape drives include speed matching, channel calibration, and power management. Speed matching dynamically adjusts the drive's normal native (uncompressed) data rate to the slower data rate of a server. Channel calibration customizes each read/write data channel for optimum performance. The customization enables compensation for variations in the recording channel transfer function, media characteristics, and read/write head characteristics. Power management reduces the drive's power consumption during idle power periods.

To ensure that your tape drive conforms to IBM's specifications for reliability, use only IBM LTO tape cartridges. You can use other LTO-certified data cartridges, but they might not meet IBM standards of reliability.

Encryption

LTO 5 and later LTO tape drives are encryption capable, which means they can convert data into a cipher that ensures data security. The drive must first be encryption-enabled. Select one of two methods of encryption management (application-managed and library-managed encryption). Library-managed encryption requires the purchase of FC 1604 (Transparent LTO Encryption). A key is required to encrypt and decrypt the data. How a key is generated, maintained, controlled, and transmitted depends on the operating environment where the tape drive is installed. Some data management applications can also do key management. For an alternative solution, IBM provides a key manager that works with the keystore of your choice to accomplish all necessary key management tasks. There is no recovery for lost encryption keys. Refer to the IBM Encryption Key Manager and IBM Security Key Lifecycle Manager (formerly Tivoli® Key Lifecycle Manager) publications in Additional publications and resources in “Related information” on page xxi. To choose a method of encryption management, refer to “Managing encryption” on page 115.

Related information

“Mixed media in drives” on page 34
Not all cartridges that are supported by the TS4500 tape library are compatible with all drives. LTO cartridges are not supported by 3592 tape drives, and 3592 tape cartridges are not supported by LTO drives.

3592 tape drives

The TS4500 tape library supports the following 3592 tape drives:

- TS1160 (Models 60F and 60E)
- TS1155 (Models 55F and 55E)
- TS1150 (Models EH8 and E08*)
- TS1140 (Models EH7 and E07*)

*Models E07 and E08 are not supported by HD2 frames.

The following host attachment interface options are supported:

- Dual-port Fibre Channel, which provides flexibility in Open Systems environments because the drives can directly attach to Open Systems servers with Fibre Channel attachments. (Models EH7/E07, EH8/E08, 55F, and 60F.)
- Ethernet over optical fiber, which is optimized for cloud-based and hyper-scale environments. (Models 55E and 60E.)

The 3592 tape drive communicates with the tape library through an internal Ethernet interface and uses the Statistical Analysis and Reporting System to isolate failures between media and hardware.

The basic features of the supported 3592 tape drives are shown in Table 14 on page 23. Refer to “Drive performance” on page 26 for more 3592 tape drive performance specifications.

Table 14. Features of the 3592 tape drive

Feature	TS1160 tape drive		TS1155 tape drive		TS1150 tape drive	TS1140 tape drive
	Model 60F	**Model 60E**	**Model 55F**	**Model 55E**		
Native sustained data rate	400 MB/s (60F format)[3]	400 MB/s (60F format)[3]	360 MB/s (55F format)[2]	360 MB/s (55F format)[2]	360 MB/s (E08 format)	250 MB/s (E07 format)
Compressed sustained data rate (at maximum compression)[1]	1,200 MB/s (60F format)[3]	1,200 MB/s (60F format)[3]	700 MB/s (55F format)[2]	700 MB/s (55F format)[2]	700 MB/s (E08 format)	650 MB/s (E07 format)
Native capacity	JK cartridge: 900 GB (838.2 GiB) JL cartridge: 3 TB (2.73 TiB) JM cartridge: 5 TB (4.55 TiB) JC/JY cartridge: 7 TB (6.37 TiB) JD/JZ cartridge: 15 TB (13.64 TiB) JE/JV cartridge: 20 TB (18.19 TiB)	JK cartridge: 900 GB (838.2 GiB) JL cartridge: 3 TB (2.73 TiB) JM cartridge: 5 TB (4.55 TiB) JC/JY cartridge: 7 TB (6.37 TiB) JD/JZ cartridge: 15 TB (13.64 TiB) JE/JV cartridge: 20 TB (18.19 TiB)	JK cartridge: 900 GB (838.2 GiB) JL cartridge: 3 TB (2.73 TiB) JC/JY cartridge: 7 TB (6.37 TiB) JD/JZ cartridge: 15 TB (13.64 TiB)	JK cartridge: 900 GB (838.2 GiB) JL cartridge: 3 TB (2.73 TiB) JC/JY cartridge: 7 TB (6.37 TiB) JD/JZ cartridge: 15 TB (13.64 TiB)	JK cartridge: 900 GB (838.2 GiB) JL cartridge: 2 TB (1.82 TiB) JC/JY cartridge: 7 TB (6.37 TiB) JD/JZ cartridge: 10 TB (9.1 TiB)	JK cartridge: 500 GB (465.66 GiB) JB/JX cartridge: 1.6 TB (1.46 TiB) JC/JY cartridge: 4 TB (3.64 TiB)
Write-once-read-many (WORM) capability	Yes	Yes	Yes	Yes	Yes	Yes
Capacity scaling and short cartridge	Yes	Yes	Yes	Yes	Yes	Yes
Read/write capability	If encryption-enabled, reads and writes 60F encrypted format[3]	If encryption-enabled, reads and writes 60F encrypted format[3]	If encryption-enabled, reads and writes 55F encrypted format[2]	If encryption-enabled, reads and writes 55F encrypted format[2]	If encryption-enabled, reads and writes Model E08 encrypted format	If encryption-enabled, reads and writes Model E07 encrypted format
	Reads and writes 60F format[3]	Reads and writes 60F format[3]	Reads and writes 55F format[2]	Reads and writes 55F format[2]	Reads and writes Model E08 format	Reads and writes Model E07 format

Table 14. Features of the 3592 tape drive (continued)

Feature	TS1160 tape drive		TS1155 tape drive		TS1150 tape drive	TS1140 tape drive
	Model 60F	**Model 60E**	**Model 55F**	**Model 55E**		
Fibre Channel host (server) attachment interface	Supports dual-port, 16 Gbps Fibre Channel interface	Not supported	Supports dual-port, 8 Gbps Fibre Channel interface	Not supported	Supports dual-port, 8 Gbps Fibre Channel interface	Supports dual-port, 8 Gbps Fibre Channel interface
	Maximum interface burst transfer rate of 1,600 MB/s	Not supported	Maximum interface burst transfer rate of 800 MB/s	Not supported	Maximum interface burst transfer rate of 800 MB/s	Maximum interface burst transfer rate of 800 MB/s
	Supports N ports	Not supported	Supports N and L ports with auto-configure	Not supported	Supports N and L ports with auto-configure	Supports N and L ports with auto-configure
Ethernet host (server) attachment interface	Not supported	10 Gb or 25 Gb	Not supported	10 Gb (Model 55E)	Not supported	Not supported
Encryption-capable	Yes	Yes	Yes	Yes	Yes	Yes

Notes:

1. The compression ratio for the 3592 tape cartridges is 3:1.
2. The 55F format is the native format for both the Model 55F and Model 55E tape drives.
3. The 60F format is the native format for both the Model 60F and Model 60E tape drives.

The 3592 tape drives provide the following performance, capacity, and availability features:

N+1 power supplies
When installed in a TS4500 tape library frame, these power supplies increase drive availability in the event of a power failure.

Media reuse
The 3592 tape drives can reuse different types of tape and multiple densities (logical formats) across various drive generations. These logical formats can be divided into multiple sub-format options, such as segmentation and capacity scaling. For a matrix of read and write compatibility by cartridge and format type, refer to “Mixed media in drives” on page 34.

Speed matching
When the drives operate in a host environment where the net host data rate is less than the maximum drive native data rate, 3592 tape drives automatically perform dynamic speed matching to minimize backhitches. Dynamic speed matching adjusts the native data rate of the drive as closely as possible to the net host data rate (after data compressibility is factored out). A reduction in back-hitches improves system performance.

High resolution tape directory (HRTD)
The HRTD directory structure used by 3592 tape drives allows fast and consistent nominal and average access times for locate operations.

Channel calibration and dynamic adaptive equalization
To gain optimum performance, channel calibration allows the drive to automatically customize each read and write data channel. The customization compensates for variations in the recording channel transfer function, for media characteristics, and for read and write head characteristics. Initial

calibration settings are calculated and stored at the time of manufacture. For optimum error rate performance, the supported 3592 tape drives also use dynamic adaptive equalization hardware on an ongoing basis to adjust the read equalization response.

Recursive accumulating backhitchless flush

The supported 3592 tape drives use an algorithm called recursive accumulating backhitchless flush (or non-volatile caching). This algorithm increases the effective data rate performance from host servers that force explicit synchronize operations during write operations.

Backhitchless backspace

Backhitchless backspacing enables some backspace operations to be virtualized without physical back-hitching. If you write and overwrite multiple trailer labels, this firmware feature provides major performance improvements.

Capacity scaling

If you want to exchange capacity for improved access times, 3592 tape drives support multiple format options, such as scaling and segmentation modes. These tape drives can sense and report the scaling state of current medium by using the SCSI Mode Sense command and specifying Mode Page X'23'. Capacity scaling is only offered on the JB, JC, JD, and JE media types.

WORM

The 3592 tape drives support write-once-read-many (WORM) behaviors and format attributes. Four WORM cartridge types are supported: JX Extended WORM cartridge, JY Advanced Type C WORM cartridge, JZ Advanced Type D WORM cartridge, and JV Advanced Type E WORM cartridge. WORM cartridges are factory-formatted as WORM cartridges and cannot be converted to data cartridges. The 3592 tape drives allow append operations to data already on WORM cartridges, but do not allow data to be overwritten under any circumstances.

Constant Capacity-based and Maximum Capacity-based LEOT reporting

The 3592 tape drives use enhanced logic to report logical end-of-tape (LEOT) data. The drive is configured to report LEOT using either a constant capacity-based LEOT algorithm or a maximum capacity-based LEOT algorithm. These drives use the constant capacity-based LEOT reporting. Constant capacity-based LEOT reporting monitors the number of data sets (i.e., physical records) written to the medium and reports early-warning (EW) based on the number of data sets written to tape (i.e., the number of data sets to hold the advertised native capacity). This reduces the variation in the amount of data that is recorded before EW is returned. For applications that stop writing upon receipt of EW, a more consistent capacity is recorded to the medium. This process allows tape copies to finish without overflow a higher percentage of the time.

Enhanced format for recording error-correction codes (ECCs)

The logical formats of the 3592 tape drives offer error-correction-code capabilities of two orthogonal Reed-Solomon ECCs that protect the data on tape.

Drive mechanical and electrical reliability

The mechanisms of the 3592 tape drives are specified at a mean-cycles-between-failure rate of 300,000 cycles, which is the highest reliability rating in the industry. The mechanism contains special mechanical and electrical features to prevent damage to the media on power-down or reset. These features also prevent the dropping of the leader pin or other thread failures during similar interruptions. It also tolerates high vibration and shock environments without data loss or degraded operation.

Data compression

The 3592 tape drives use the data-compression method that is known as streaming lossless data compression algorithm or enhanced streaming lossless data compression algorithm depending on drive model.

Data buffer with read ahead feature

The 3592 tape drives include a data buffer of either 1 GiB or 2 GiB depending on model. Along with enabling performance characteristics in buffered Write and Read commands, the data buffer also supports a Read Ahead feature. When the drive processes a command to locate or read a block, the drive automatically continues to stream down the tape and read ahead until the data buffer is full. This feature allows subsequent Locate or Read commands to be fulfilled from the data buffer at faster speeds, rather than requiring access to the tape.

Offboard data string searching

The 3592 tape drives can search the data content of host server records for string matches. The function is called *offboard data string searching* because the data search workload can be done offboard from the host. Each drive performs a search at its own respective maximum data rate. This feature greatly reduces the amount of data transfer and host search times.

Encryption

All 3592 tape drives are encryption capable, which means they can convert data into a cipher that ensures data security. To encrypt data, the drive must be encryption-enabled by your selection of one of three methods of encryption management. A key is required to encrypt and decrypt the data. How a key is generated, maintained, controlled, and transmitted depends on the operating environment where the tape drives are installed. Some data management applications can do key management. For an alternative solution, IBM provides a key manager that works with the keystore of your choice to do all necessary key management tasks. There is no recovery for lost encryption keys.

For more information about encryption, see “Tape encryption overview” on page 114. Also, refer to the IBM Encryption Key Manager and IBM Security Key Lifecycle Manager (formerly Tivoli Key Lifecycle Manager) publications that are listed in topic in “Related information” on page xxi.

For information about supported cartridges, see “Tape cartridges” on page 37.

Related information

“Tape cartridges” on page 37
Libraries that are installed with LTO tape drives use LTO tape cartridges. Libraries that are installed with 3592 tape drives use 3592 tape cartridges.

“Mixed media in drives” on page 34
Not all cartridges that are supported by the TS4500 tape library are compatible with all drives. LTO cartridges are not supported by 3592 tape drives, and 3592 tape cartridges are not supported by LTO drives.

“Tape encryption overview” on page 114
The tape drives that are supported by the TS4500 tape library can encrypt data as it is written to a tape cartridge.

“Capacity scaling and segmentation” on page 142
The 3592 tape drive use capacity scaling and segmentation to place data in a designated section of tape to speed access and manage efficient capacity.

Additional publications and resources

Drive performance

Performance data for LTO and 3592 tape drives.

Performance specifications for LTO tape drives

Performance data for LTO tape drives.

Table 15. Performance specifications for LTO tape drives

Performance parameter	Tape drive			
	LTO 8	**LTO 7**	**LTO 6**	**LTO 5**
Sustained data rate (native)[1]	360 MB/ s (L8 media)	L8 media not supported	L8 media not supported	L8 media not supported
	300 MB/ s (M8 media)	M8 media not supported	M8 media not supported	M8 media not supported
	300 MB/ s (L7 media)	300 MB/ s (L7 media)	L7 media not supported	L7 media not supported
	L6 media not supported	160 MB/ s (L6 media)	160 MB/ s (L6 media)	L6 media not supported

Table 15. Performance specifications for LTO tape drives (continued)

Performance parameter	Tape drive			
	LTO 8	**LTO 7**	**LTO 6**	**LTO 5**
	L5 media not supported	140 MB/ s (L5 media)	140 MB/ s (L5 media)	140 MB/ s (L5 media)
	L4 media not supported	L4 media not supported	120 MB/ s (L4 media)	120 MB/ s (L4 media)
	L3 media not supported	L3 media not supported	L3 media not supported	80 MB/ s (L3 media)
Sustained data rate (L6, L7, and L8 media compressed at 2.5:1 compression; L5 and earlier media compressed at 2:1 compression)	750 MB/ s (L8 media)	L8 media not supported	L8 media not supported	L8 media not supported
	750 MB/ s (M8 media)	M8 media not supported	M8 media not supported	M8 media not supported
	750 MB/ s (L7 media)	750 MB/ s (L7 media)	L7 media not supported	L7 media not supported
	L6 media not supported	400 MB/ s (L6 media)	400 MB/ s (L6 media)	L6 media not supported
	L5 media not supported	280 MB/ s (L5 media)	280 MB/ s (L5 media)	280 MB/ s (L5 media)
	L4 media not supported	L4 media not supported	240 MB/ s (L4 media)	240 MB/ s (L4 media)
	L3 media not supported	L3 media not supported	L3 media not supported	160 MB/ s (L3 media)
Maximum sustained data rate (at maximum compression)	750 MB/s	750 MB/s	745 MB/s	745 MB/s
Burst data rate for Fibre Channel drives	800 MB/s	800 MB/s	800 MB/s	800 MB/s
Time to load, thread, and initialize a cartridge	15 seconds	15 seconds	12 seconds	12 seconds
Time to unload cartridge from load point	24 seconds	20 seconds	17 seconds	17 seconds
Average space record time from load point	59 seconds (L8/ M8/L7 media)	56 seconds (L7 media)	62 seconds (L6 media)	60 seconds (L5 media)

Note: All sustained data rates are dependent on the entire data path (from data source to host system to tape drive).

Performance specifications for 3592 tape drives
Performance data for 3592 tape drives.

Table 16. Performance specifications for 3592 tape drives

Performance parameter	TS1160 tape drive	TS1155 tape drive	TS1150 tape drive	TS1140 tape drive
Sustained data rate (native)[1]	400 MB/s (60F format)[3] 360 MB/s (55F format)[2] 360 MB/s (E08 format) 250 MB/s (E07 format)	360 MB/s (55F format)[2] 360 MB/s (E08 format) 250 MB/s (E07 format)	360 MB/s (E08 format) 250 MB/s (E07 format)	250 MB/s (E07 format)
Compressed sustained data rate (at maximum compression)	900 MB/s (60F format)[3] 750 MB/s (55F format)[2] 750 MB/s (E08 format) 650 MB/s (E07 format)	750 MB/s (55F format)[2] 750 MB/s (E08 format) 650 MB/s (E07 format)	750 MB/s (E08 format) 650 MB/s (E07 format)	650 MB/s (E07 format)
Burst data rate for Fibre Channel devices	1,600 MB/s	800 MB/s	800 MB/s	800 MB/s
Load-to-ready time				
- Initialized tape	12 seconds	12 seconds	12 seconds	15 seconds
- Uninitialized tape	415 seconds	415 seconds	415 seconds	26 seconds
Unload time: JE/JV/JM cartridge type				
- Tape not moved away from BOT during this mount	31 seconds	N/A	N/A	N/A
- Tape has been moved away from BOT during this mount	107 to 172[4] seconds	N/A	N/A	N/A
Unload time: JD/JZ/JL cartridge type				
- Tape not moved away from BOT during this mount	31 seconds	31 seconds	31 seconds	N/A
- Tape has been moved away from BOT during this mount	102 to 171[4] seconds	102 to 171[4] seconds	102 to 171[4] seconds	N/A
Unload time: JC/JY/JK cartridge type				
- With no encryption delay	36 seconds	36 seconds	36 seconds	36 seconds
- With delay to write wrapped key	44 seconds	44 seconds	44 seconds	44 seconds
Unload time: JB/JX cartridge type				
- With no encryption delay	N/A	N/A	N/A	24 seconds
- With delay to write wrapped key	N/A	N/A	N/A	31 seconds

Table 16. Performance specifications for 3592 tape drives (continued)

Performance parameter	TS1160 tape drive	TS1155 tape drive	TS1150 tape drive	TS1140 tape drive

Notes:

1. All sustained data rates are dependent on the entire data path (from data source to host system to tape drive). By using the built-in data-compression capability of the tape drives, you can achieve greater data rates than the native data transfer rate. However, the actual throughput is a function of many components, such as the host system processor, disk data rate, block size, data compression ratio, interconnect, and system or application software.
2. The 55F format is the native format for both the 3592 Model 55F and 3592 Model 55E.
3. The 60F format is the native format for both the 3592 Model 60F and 3592 Model 60E.
4. The amount of time added depends on the characteristics of how the tape has been used during the current mount. Prior to D3I5_44F and D3I4_916 the unload time was 284 seconds, even if the tape had not moved away from BOT.

Rewind times for 3592 tape drives
Rewind times for 3592 tape drives.

Table 17. Rewind times for 3592 tape drives

Cartridge type	Rewind time	Capacity setting	TS1160 tape drive	TS1155 tape drive	TS1150 tape drive	TS1140 tape drive
JB/JX	Maximum	Full, unscaled capacity (100%)	N/A	N/A	N/A	72 seconds
		Scaled capacity with 0x35 setting (20%)	N/A	N/A	N/A	24 seconds
	Average	Full, unscaled capacity (100%)	N/A	N/A	N/A	38 seconds
		Scaled capacity with 0x35 setting (20%)	N/A	N/A	N/A	15 seconds
JC/JY	Maximum	Full, unscaled capacity (100%)	76 seconds	76 seconds	76 seconds	76 seconds
		Scaled capacity with 0x35 setting (20%)	26 seconds	26 seconds	26 seconds	26 seconds
	Average	Full, unscaled capacity (100%)	42 seconds	42 seconds	42 seconds	42 seconds
		Scaled capacity with 0x35 setting (20%)	17 seconds	17 seconds	17 seconds	17 seconds
JD/JZ	Maximum	Full, unscaled capacity (100%)	94 seconds	94 seconds	94 seconds	N/A
		Scaled capacity with 0x35 setting (20%)	34 seconds	34 seconds	34 seconds	N/A
	Average	Full, unscaled capacity (100%)	50 seconds	50 seconds	50 seconds	N/A
		Scaled capacity with 0x35 setting (20%)	20 seconds	20 seconds	20 seconds	N/A

Table 17. Rewind times for 3592 tape drives (continued)

Cartridge type	Rewind time	Capacity setting	TS1160 tape drive	TS1155 tape drive	TS1150 tape drive	TS1140 tape drive
JE/JV	Maximum	Full, unscaled capacity (100%)	94 seconds	N/A	N/A	N/A
		Scaled capacity with 0x35 setting (20%)	34 seconds	N/A	N/A	N/A
	Average	Full, unscaled capacity (100%)	50 seconds	N/A	N/A	N/A
		Scaled capacity with 0x35 setting (20%)	20 seconds	N/A	N/A	N/A
JK	Maximum	Advanced Type C economy, short length	18 seconds	18 seconds	18 seconds	18 seconds
	Average	Advanced Type C economy, short length	11 seconds	11 seconds	11 seconds	11 seconds
JL	Maximum	Advanced Type D economy, short length	34 seconds	34 seconds	34 seconds	N/A
	Average	Advanced Type D economy, short length	20 seconds	20 seconds	20 seconds	N/A
JM	Maximum	Advanced Type E economy, short length	34 seconds	N/A	N/A	N/A
	Average	Advanced Type E economy, short length	20 seconds	N/A	N/A	N/A

Average block locate time from load point for 3592 tape drives

Average block locate time from load point for 3592 tape drives

Table 18. Average block locate time from load point for a 3592 tape cartridge in a 3592 tape drive

Cartridge	Setting	Average block locate time from load point[1]			
		TS1160 tape drive	TS1155 tape drive	TS1150 tape drive	TS1140 tape drive
JB	Full, unscaled capacity (100%)	N/A	N/A	N/A	37 seconds
	Scaled capacity with 0x35 setting (20%)	N/A	N/A	N/A	15 seconds
JC	Full, unscaled capacity (100%)	40 seconds	40 seconds	40 seconds	40 seconds
	Scaled capacity with 0x35 setting (20%)	12 seconds	12 seconds	12 seconds	12 seconds
JD	Full, unscaled capacity (100%)	45 seconds	45 seconds	45 seconds	N/A
	Scaled capacity with 0x35 setting (20%)	13 seconds	13 seconds	13 seconds	N/A
JE	Full, unscaled capacity (100%)	45 seconds	N/A	N/A	N/A

Table 18. Average block locate time from load point for a 3592 tape cartridge in a 3592 tape drive (continued)

Cartridge	Setting	Average block locate time from load point[1]			
		TS1160 tape drive	**TS1155 tape drive**	**TS1150 tape drive**	**TS1140 tape drive**
	Scaled capacity with 0x35 setting (20%)	13 seconds	N/A	N/A	N/A
JK	Advanced Type C economy	11 seconds	11 seconds	11 seconds	11 seconds
JL	Advanced Type D economy	13 seconds	13 seconds	13 seconds	N/A
JM	Advanced Type E economy	13 seconds	N/A	N/A	N/A
JV	Full, unscaled capacity (100%)	45 seconds	N/A	N/A	N/A
JX	Full, unscaled capacity (100%)	N/A	N/A	N/A	37 seconds
JY	Full, unscaled capacity (100%)	40 seconds	40 seconds	40 seconds	40 seconds
JZ	Full, unscaled capacity (100%)	45 seconds	45 seconds	45 seconds	N/A

Notes:

1. For an encrypted format, an additional 5 seconds might be required to obtain an encryption key to read the first block accessed on the cartridge.

For further information about data types supported by 3592 tape drives, see Table 14 on page 23. For further information about the capacity of each type of 3592 tape cartridge, see Table 23 on page 39.

Drive addresses

Tape drives are assigned two addresses – a physical address that indicates the drive's location in the library and a logical address that indicates the drive's location to the SCSI interface.

Physical addresses

The TS4500 tape library assigns each tape drive a unique address to indicate its physical location.

The physical address of each drive is displayed in the Location column of the Drives table in the management GUI. This column is displayed by default.

The physical address consists of three values:

Frame number
Represented as Fx, where F equals the frame and x equals its number. The leftmost frame in the library is always F1, regardless of whether it is a base frame or not. The frame numbers increment by one for each frame to the right of frame 1.

Column number
Represented as Cy, where C equals the column and y equals its number. Columns 1 - 4 are available for drives; however, if the frame is in position 1 (the leftmost frame of the library), only columns 2 - 4 are available.

Row number
Represented as Rz, where R equals the row and z equals its number. Rows 1 - 4 are available for drives. Regardless of whether drives are installed, the row numbering is the same for every frame.

For example, F7,C1,R1.

Related information

Drives

Logical addresses

The TS4500 tape library assigns each drive a SCSI element address that defines a logical location in the library to the SCSI interface.

The logical address of each drive is displayed in the Element Address column of the Drives table in the management GUI. This column is hidden by default.

The logical address is represented as xxxx(yyyh), where xxxx is a decimal value and yyyh is a hexadecimal value. It is assigned and used by the application when the server processes SCSI commands. The SCSI element address for a drive is unique to the location of the drive; it does not vary based on other drives in the library.

Related information

Drives

Control path drives

A control path is a logical path to the TS4500 tape library.

A control path is the path for SCSI Medium Changer commands sent by a server to control a specific logical library. The TS4500 tape library has no direct SCSI connection to a server. When a server communicates with the library, it sends the communication by way of an LTO or 3592 tape drive. The LTO or 3592 tape drive is designated as a control path.

Methods of cleaning drives

Automatic cleaning of tape drives is enabled by default. However, it is also possible to initiate manual or host cleaning.

Notes:

- It is the operator's responsibility to monitor cleaning cartridge usage.
- Automatic cleaning is always enabled with the Advanced Library Management System (ALMS).

The head of every tape drive in the tape library must be kept clean to prevent errors that are caused by contamination. To help you keep the drives clean, IBM provides a cleaning cartridge with the library. Whenever a drive determines that it needs to be cleaned, it alerts you with a message on the library's display or host console. The library uses the cleaning cartridge to clean the drive with whatever cleaning method that you choose. In all methods, cleaning is performed after the data cartridge is unloaded from the drive and before the next load.

It is the operator’s responsibility to monitor cleaning cartridge usage and replace cleaning cartridges as necessary. The tape library provides multiple ways to monitor and manage cleaning cartridges. If SNMP traps are enabled, a trap is generated when a cleaning cartridge expires. It is also possible to use the TS4500 management GUI to monitor the cleaning cycles that remain on a cleaning cartridge and to enable a setting that automatically ejects expired cleaning cartridges.

Three methods of cleaning are available:

Automatic cleaning

Automatic cleaning enables the library to automatically respond to any tape drive's request for cleaning and to begin the cleaning process. The cleaning process is transparent to any host application that uses the library. Automatic cleaning is required and cannot be disabled.

Manual cleaning

Manual cleaning requires that you select a menu option from the TS4500 management GUI to clean one or more of the tape drives. Manual cleaning is always supported.

Host cleaning

Host cleaning enables the backup application to define and control the cleaning process. Automatic and manual cleaning utilize the CLNxxx VOLSER. Host-based cleaning uses a cartridge defined within the backup application, which can have a non-CLNxxx VOLSER, to clean drives. For more information, see the section about cleaning in your application software's documentation.

Mixed drives in a logical library

The TS4500 tape library supports several combinations of drives, with certain limitations.

The TS4500 tape library supports a mixture of LTO drive types in a logical library. However, the tape library does not support a mixture of LTO and 3592 tape drives in a logical library. Some independent software vendors (ISVs) support mixed drive types within logical libraries; others do not. Some ISVs that support mixed drive types do so with restrictions. For details, contact your ISV.

If the ISV support does not exist or does not meet your requirements, the TS4500 tape library provides another option to protect your investment by partitioning the tape drives into separate logical libraries. You can customize the partition to any number of slots by using menus.

Figure 8 on page 33 shows examples of methods for mixing LTO drive types in a logical library.

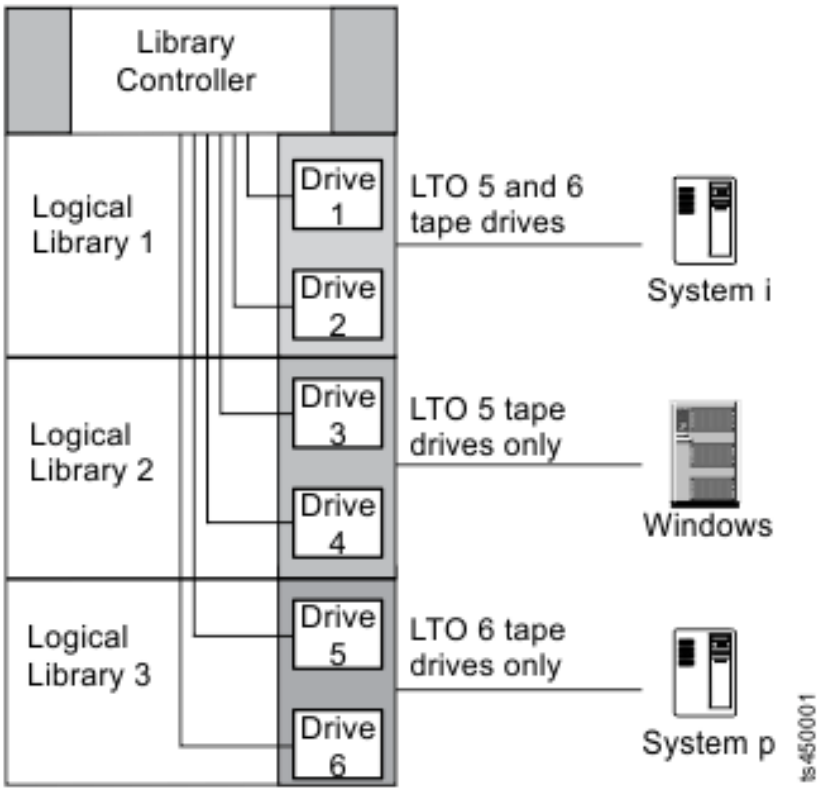


Figure 8. Examples of methods for mixing LTO drive types in a logical library

Mixed drives in frames

You can mix some drives in a TS4500 tape library frame.

Table 19 on page 33 summarizes drive combinations that are compatible in the physical frames of the TS4500 tape library.

Note: No drives are installed in the storage-only frames (models S25 and S55).

Table 19. Mixing drives in the physical frames of the TS4500 tape library

Drive types	Models L25 and D25	Models L55 and D55
LTO 8 (Model 3588 F8S)	No	Yes

Table 19. Mixing drives in the physical frames of the TS4500 tape library (continued)		
Drive types	**Models L25 and D25**	**Models L55 and D55**
LTO 8 (Model 3588 F8C)	No	Yes
LTO 8 (Model 3588 F8A)	No	No
LTO 7 (Model 3588 F7C)	No	Yes
LTO 7 (Model 3588 F7A)	No	No
LTO 6 (Model 3588 F6C)	No	Yes
LTO 6 (Model 3588 F6A)	No	No
LTO 5 (Model 3588 F5C)	No	Yes
LTO 5 (Model 3588 F5A)	No	No
TS1160 (Model 3592 60E/60F)	Yes	No
TS1155 (Model 3592 55E/55F)	Yes	No
TS1150 (Model 3592 EH8)	Yes	No
TS1140 (Model 3592 EH7)	Yes	No

Mixed media in drives

Not all cartridges that are supported by the TS4500 tape library are compatible with all drives. LTO cartridges are not supported by 3592 tape drives, and 3592 tape cartridges are not supported by LTO drives.

When labeled according to IBM bar code label specifications, the last character of the volume serial (VOLSER) number of an LTO cartridge indicates the first drive generation that supports the media. For example:

- 000764L8 is an LTO 8 cartridge
- 000764M8 is an LTO M8 cartridge
- 000764L7 is an LTO 7 cartridge
- 000764L6 is an LTO 6 cartridge
- 000764L5 is an LTO 5 cartridge

On a 3592 tape cartridge, the IBM product label represents whether it is a read/write (R/W) cartridge or a write-once-read-many (WORM) cartridge. In addition, the last 2 characters of the VOLSER indicate the media type.

Note: Each bar code must be unique across the entire physical library.

Cartridges that are compatible with LTO tape drives

Table 20 on page 34 summarizes the cartridges that are compatible with the LTO tape drives that are supported by the tape library.

Table 20. Cartridges that are compatible with LTO tape drives				
Cartridge type	**Drive type[1]**			
	LTO 8	**LTO 7**	**LTO 6**	**LTO 5**
12 TB LTO 8 Data Cartridge (xxxxxxL8)	R/W	Not compatible	Not compatible	Not compatible

Table 20. Cartridges that are compatible with LTO tape drives (continued)

Cartridge type	Drive type[1]			
	LTO 8	**LTO 7**	**LTO 6**	**LTO 5**
12 TB LTO 8 WORM Cartridge (xxxxxxLY)	R/W	Not compatible	Not compatible	Not compatible
9 TB LTO M8 Data Cartridge (xxxxxxxM8)[2]	R/W	Not compatible	Not compatible	Not compatible
6 TB LTO 7 Data Cartridge (xxxxxxL7)	R/W	R/W	Not compatible	Not compatible
6 TB LTO 7 WORM Cartridge (xxxxxxLX)	R/W	R/W	Not compatible	Not compatible
2.5 TB LTO 6 Data Cartridge (xxxxxxL6)	Not compatible	R/W	R/W	Not compatible
2.5 TB LTO 6 WORM Cartridge (xxxxxxLW)	Not compatible	R/W	R/W	Not compatible
1.5 TB LTO 5 Data Cartridge (xxxxxxL5)	Not compatible	Read only	R/W	R/W
1.5 TB LTO 5 WORM Cartridge (xxxxxxLV)	Not compatible	Read only	R/W	R/W
800 GB LTO 4 Data Cartridge (xxxxxxL4)	Not compatible	Not compatible	Read only	R/W
800 GB LTO 4 WORM Cartridge (xxxxxxLU)	Not compatible	Not compatible	Read only	R/W
400 GB LTO 3 Data Cartridge (xxxxxxL3)	Not compatible	Not compatible	Not compatible	Read only
400 GB LTO 3 WORM Cartridge (xxxxxxLT)	Not compatible	Not compatible	Not compatible	Read only

Notes:

1. The drive rejects any command to load unsupported media and returns a sense key of 3 and an extra sense code/additional sense code qualifier of 30/01.
2. Uninitialized M8 media and preinitialized M8 media are both supported with a minimum LTO 8 tape drive firmware level of HB82 and a minimum library firmware level 1.4.1.2. The usage of M8 media with prior firmware levels may result in a permanent reduction in the capacity of the M8 media from 9 TB to 6 TB (native).

Cartridges that are compatible with 3592 tape drives

Table 21 on page 36 summarizes the cartridges that are compatible with the 3592 tape drives that are supported by the tape library.

- (-) Not supported
- (RW) Read Write
- (RO) Read Only

Table 21. Cartridges that are compatible with 3592 tape drives

Media	Recording format	TS1160 tape drive		TS1155 tape drive		TS1150 tape drive		TS1140 tape drive	
		Encryption enabled	Encryption not enabled	Encryption enabled	Encryption not enabled	Encryption enabled	Encryption not enabled	Encryption enabled	Encryption not enabled
JE, JM, JV[1]	Encrypted 60F	RW	Reformat	-	-	-	-	-	-
	60F	RW	RW	-	-	-	-	-	-
JD, JL, JZ[1]	Encrypted 55F	RW	Reformat	RW	Reformat	-	-	-	-
	55F	RW	RW	RW	RW	-	-	-	-
	Encrypted E08	RW	Reformat	RW	Reformat	RW	Reformat	-	-
	E08	RW	RW	RW	RW	RW	RW	-	-
JC, JK, JY[1]	Encrypted E08	RW	Reformat	RW	Reformat	RW	Reformat	-	-
	E08	RW	RW	RW	RW	RW	RW	-	-
	Encrypted E07	RO	Reformat	RO	Reformat	RW	Reformat	RW	Reformat
	E07	RO	RO	RO	RO	RW	RW	RW	RW
JB, JX[1]	Encrypted E07	-	-	-	-	-	-	RW	Reformat
	E07	-	-	-	-	-	-	RW	RW
	Encrypted E06	-	-	-	-	-	-	RW	Reformat
	E06	-	-	-	-	-	-	RW	RW
	Encrypted E05	-	-	-	-	-	-	RO	Reformat
	E05	-	-	-	-	-	-	RO	RO
JA	Encrypted E06	-	-	-	-	-	-	RO	Reformat
	E06	-	-	-	-	-	-	RO	RO
	Encrypted E05	-	-	-	-	-	-	RO	Reformat
	E05	-	-	-	-	-	-	RO	RO
	J1A	-	-	-	-	-	-	RO	RO

Notes:

1. WORM tapes can be reformatted only if they are initialized and labeled. If data exists on the tape, reformatting is not allowed.

Tape cartridges

Libraries that are installed with LTO tape drives use LTO tape cartridges. Libraries that are installed with 3592 tape drives use 3592 tape cartridges.

Note: Management and handling of tape cartridges is a customer function and responsibility.

Mixed media configurations are supported, meaning that a tape library can contain a mix of 3592 and LTO tape cartridges. Certain restrictions apply to the use of tape cartridges with drives. For more information about media and drive compatibility, refer to the topic *Mixing media in drives* in the **Related information** section.

Related information

"Mixed media in drives" on page 34
Not all cartridges that are supported by the TS4500 tape library are compatible with all drives. LTO cartridges are not supported by 3592 tape drives, and 3592 tape cartridges are not supported by LTO drives.

"Overview of LTO tape drive media" on page 118
Subject to certain restrictions, the supported LTO tape drives use the following cartridge types.

"Overview of 3592 tape drive media" on page 139
The 3592 tape drive uses ten different data cartridge types, plus a cleaning cartridge and a diagnostic (CE) cartridge.

Tape cartridge types

The TS4500 tape library supports data or scratch cartridges, cleaning cartridges, and diagnostic/CE cartridges.

Data or scratch cartridge

A tape cartridge that is designed to receive information that is recorded to it by a tape drive. A scratch cartridge is a data cartridge whose tape no longer contains useful information and can be overwritten. To ensure that your tape library conforms to IBM's specifications for reliability, use only IBM LTO data cartridges in LTO tape drives and IBM 3592 tape cartridge in 3592 tape drives. You can use other LTO- or 3592-certified media, but they might not meet the standards of reliability that are established by IBM. If you are using mixed drive types, place only LTO tape cartridges into LTO frames; similarly, place 3592 tape cartridges into 3592 frames.

Cleaning cartridge

A tape cartridge that is used by the library to clean the heads of its tape drives. Use only the IBM LTO cleaning cartridge or an IBM-approved cleaning cartridge to clean an LTO tape drive. Use only the IBM 3592 cleaning cartridge or an IBM-approved cleaning cartridge to clean a 3592 tape drive. After you insert cleaning cartridges, they remain unassigned. You cannot assign them to a particular logical library, since they belong to the entire library.

Cleaning cartridges are identified by a volume serial (VOLSER) number that begins with a prefix of CLN for LTO and 3592 cleaning cartridges.

LTO diagnostic or 3592 CE cartridge

A tape cartridge used by an IBM Service Representative to service the tape library. The cartridge is installed when the library is installed – one for each type of drive used in the library (LTO and/or 3592).

Capacity of supported LTO tape cartridges

Libraries that are installed with LTO tape drives use LTO tape cartridges.

Table 22 on page 38 shows the capacity of supported LTO tape cartridges.

Table 22. Capacity of supported LTO tape cartridges

Supported tape cartridges	Native capacity	Compressed capacity[1, 2]
12 TB LTO 8 Data Cartridge (xxxxxxL8)	12 TB (10.91 TiB)	30 TB (27.93 TiB)
12 TB LTO 8 WORM Cartridge (xxxxxxLY)	12 TB (10.91 TiB)	30 TB (27.93 TiB)
9 TB LTO M8 Data Cartridge (xxxxxxxM8) [3]	9 TB (8.18 TiB)	22.5 TB (20.46 TiB)
6 TB LTO 7 Data Cartridge (xxxxxxL7)	6 TB (5.45 TiB)	15 TB (13.32 TiB)
6 TB LTO 7 WORM Cartridge (xxxxxxLX)	6 TB (5.45 TiB)	15 TB (13.32 TiB)
2.5 TB LTO 6 Data Cartridge (xxxxxxL6)	2.5 TB (2.27 TiB)	6.25 TB (5.68 TiB)
2.5 TB LTO 6 WORM Cartridge (xxxxxxLW)	2.5 TB (2.27 TiB)	6.25 TB (5.68 TiB)
1.5 TB LTO 5 Data Cartridge (xxxxxxL5)	1.5 TB (1.36 TiB)	3 TB (2.73 TiB)
1.5 TB LTO 5 WORM Cartridge (xxxxxxLV)	1.5 TB (1.36 TiB)	3 TB (2.73 TiB)
800 GB LTO 4 Data Cartridge (xxxxxxL4)	800 GB (745.06 GiB)	1600 GB (1490.12 GiB)
800 GB LTO 4 WORM Cartridge (xxxxxxLU)	800 GB (745.06 GiB)	1600 GB (1490.12 GiB)
400 GB LTO 3 Data Cartridge (xxxxxxL3)	400 GB (372.53 GiB)	800 GB (745.06 GiB)
400 GB LTO 3 WORM Cartridge (xxxxxxLT)	400 GB (372.53 GiB)	800 GB (745.06 GiB)

Notes:

1. The compressed capacity for the LTO 6, LTO 7, and LTO 8 cartridges uses a 2.5:1 compression ratio.
2. The compressed capacity for the LTO 3, LTO 4, and LTO 5 cartridges use a 2:1 compression ratio.
3. Uninitialized M8 media and preinitialized M8 media are both supported with a minimum LTO 8 tape drive firmware level of HB82 and a minimum library firmware level 1.4.1.2. The usage of M8 media with prior firmware levels may result in a permanent reduction in the capacity of the M8 media from 9 TB to 6 TB (native).

Related information

“Mixed media in drives” on page 34
Not all cartridges that are supported by the TS4500 tape library are compatible with all drives. LTO cartridges are not supported by 3592 tape drives, and 3592 tape cartridges are not supported by LTO drives.

“Overview of LTO tape drive media” on page 118

Subject to certain restrictions, the supported LTO tape drives use the following cartridge types.

Capacity of supported 3592 tape cartridges

Libraries that are installed with 3592 tape drives use 3592 tape cartridges.

Table 23 on page 39 shows the capacity of supported 3592 tape cartridges.

Table 23. Capacity of supported 3592 tape cartridges

3592 tape cartridge	Cartridge type	Native capacity	Compressed capacity (compression ratio 3:1)
60F tape drive format	JE, JV[1]	20 TB (18.19 TiB)	60 TB (54.57 TiB)
	JM	5 TB (4.55 TiB)	15 TB (13.64 TiB)
	JD, JZ[1]	15 TB (13.64 TiB)	45 TB (40.2 TiB)
	JL	3 TB (2.72 TiB)	9 TB (8.18 TiB)
	JC, JY[1]	7 TB (6.37 TiB)	21 TB (19.1 TiB)
	JK	1.3 TB (1.18 TiB)	3.9 TB (3.54 TiB)
55F tape drive format	JD, JZ[1]	15 TB (13.64 TiB)	45 TB (40.93 TiB)
	JL	3 TB (2.73 TiB)	9 TB (8.19 TiB)
	JC, JY[1]	7 TB (6.37 TiB)	21 TB (19.1 TiB)
	JK	900 GB (838.19 GiB)	2.7 TB (2.46 TiB)
E08 tape drive format	JD, JZ[1]	10 TB (9.1 TiB)	30 TB (27.3 TiB)
	JL	2 TB (1.82 TiB)	6 TB (5.46 TiB)
	JC, JY[1]	7 TB (6.37 TiB)	21 TB (19.1 TiB)
	JK	900 GB (838.19 GiB)	2.7 TB (2.46 TiB)
E07 tape drive format	JC, JY[1]	4 TB (3.64 TiB)	12 TB (10.91 TiB)
	JB, JX[1]	1.6 TB (1.46 TiB)	4.8 TB (4.37 TiB)
	JK	500 GB (465.66 GiB)	1.5 TB (1.36 TiB)

Notes:

1. Write-once-read-many (WORM) cartridge type.

Related information

“Mixed media in drives” on page 34
Not all cartridges that are supported by the TS4500 tape library are compatible with all drives. LTO cartridges are not supported by 3592 tape drives, and 3592 tape cartridges are not supported by LTO drives.

“Overview of 3592 tape drive media” on page 139

The 3592 tape drive uses ten different data cartridge types, plus a cleaning cartridge and a diagnostic (CE) cartridge.

Automatic media verification

The TS4500 tape library supports policy-based automatic media verification to verify that your tape cartridges are readable.

The verification process is controlled at the logical library level. Media verification is set up to run automatically on a set date, but you can verify individual cartridges before the set date. Logical libraries that use AME or SME encryption cannot use media verification.

You can set the recurring schedule for media verification by day, months, or years. Cartridges that are in the process of verification are still available for media access. If the library receives a request for information on a cartridge that is being verified, the verification is suspended and the cartridge is released to fill the request. When the cartridge is no longer needed, verification is resumed.

The move and eject actions are disabled for cartridges in the verification process. You have to first stop the verification process before you can move or eject a cartridge that is being verified.

Enabling Media Verification

The first step to using media verification is selecting at least one tape drive in your library as a media verification drive. You should have at least two drives to ensure that there are no false positives due to a faulty tape drive. Tapes that fail verification are retried on the second drive, if available, before they are reported as faulty.

Once you selected the verification drives, go to the **Cartridges by Logical Libraries** page in the management GUI. Right-click on the logical library to enable media verification and set the verification schedule.

When media verification is enabled on a logical library for the first time, all the cartridges become due for verification on the same date. The initial queue for media verification might take up to several months to be established. This depends on the number of cartridges, how full they are, and the number of media verification drives. Once a cartridge is verified, the next verification date is based on the time period set in the verification policy.

Related information

Table 6

Elastic capacity

In a dual-accessor configuration, the TS4500 tape library contains limited access columns that you can use for special situations. You can use these columns to store least recently used data cartridges, or as a temporary overflow area. The use of the limited access columns (Elastic Capacity) allows dual-accessor customers to achieve the same storage capacity as if the library was single accessor.

Elastic Capacity Settings

Go to **Settings** > **Library** > **Advanced** in the TS4500 tape library GUI to modify the Elastic Capacity settings. Choose one of the three options for Elastic Capacity.

Use for maximum capacity

Use this setting to store media cartridges in the limited access (Elastic Capacity) columns. When the dual-access area (the cartridge slots that both A and B accessors can reach) exceeds the usage threshold, the least recently used cartridges are move into the Elastic Capacity area. The default usage threshold is 98%.

Use for temporary overflow

Use this setting to temporarily store media cartridges in the limited access (Elastic Capacity) columns. When the dual-access area is 100% full, new cartridges that are imported from the I/O stations are moved to the Elastic Capacity areas.

Do not use

Choose this setting if you do not want any media cartridges stored in the Elastic Capacity areas.

Limited Access

The Elastic Capacity slots are limited access when an accessor is placed in service. When the A accessor is in the Integrated Service Bay A (see 1 in Figure 9 on page 41), the B accessor cannot reach columns 3-8 in that frame. The only cartridges the B accessor can access are in column 9 (see 3 in Figure 9 on page 41) and column 10 on the door-side.

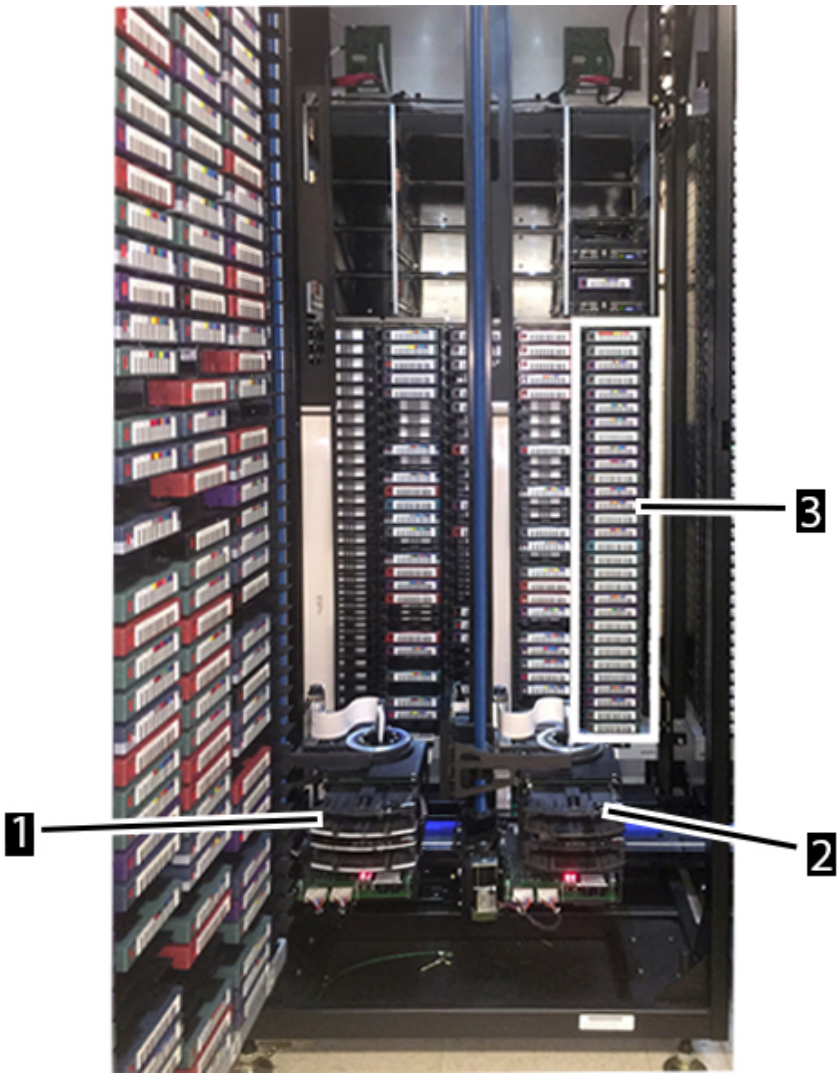


Figure 9. A-accessor in Service Bay A

When the B accessor is in the Integrated Service Bay B (See 2 in Figure 10 on page 42), the A accessor cannot reach columns 5-10 in that frame. The only cartridges the A accessor can reach are in columns 1, 3 1 and door-side columns 2 and 4.

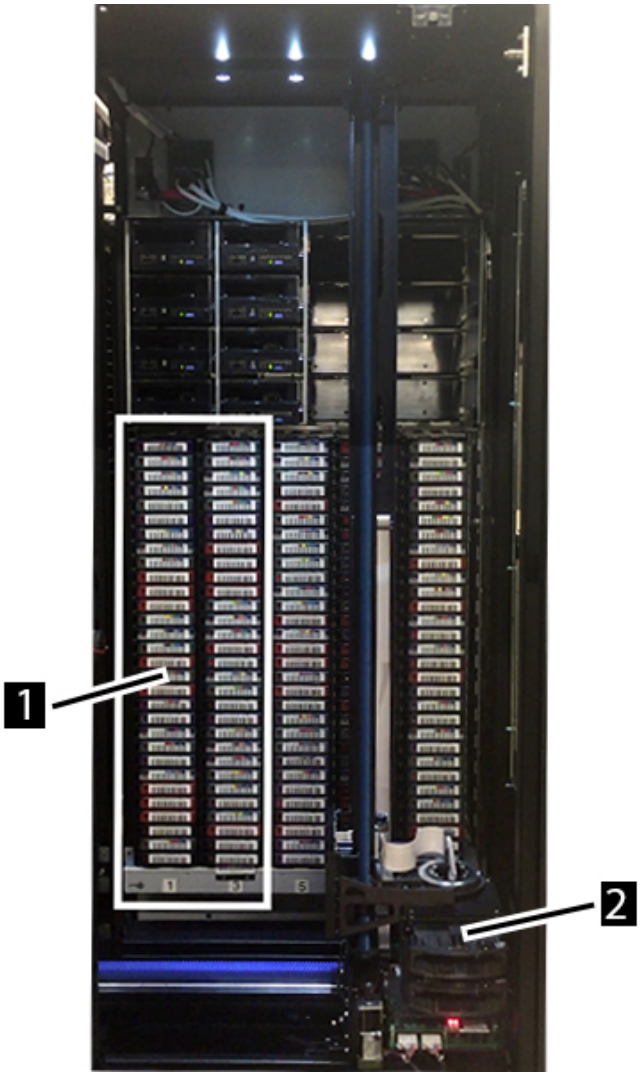


Figure 10. B-accessor in Service Bay B

Cartridge Movement

The movement of cartridges into the Elastic Capacity area is automated by the library firmware. The movement of cartridges from the Elastic Capacity area is not automated by the library firmware - that movement occurs when requested by the application, GUI, or CLI.

TS7700 backend switch support

A TS4500 tape library can be connected to a TS7700 system using two 16 Gb fibre channel switches. The switches can be installed in the bottom of the TS4500 frame, or in a TR1 rack mounted above the TS4500.

Supported device drivers

IBM provides device driver support for the LTO and 3592 tape drives, and the robotics in the TS4500 tape library.

IBM maintains the current levels of device drivers and driver documentation on Fix Central. Follow these steps to access this material.

1. From the **Fix Central** web page, select **Select product**.
2. Select **System Storage** from the Product Group list.

3. Select **Tape systems** from the System Storage list.
4. Select **Tape drivers and software** from the Tape systems list.
5. Select **Tape device drivers** from the Tape drivers and software list.
6. Select the appropriate operating system from the Platform list and click **Continue**.
7. Select the appropriate driver from the list.

Refer to the IBM Tape Device Drivers Installation and User's Guide for more information.

Communication with TSLM

The IBM Tape System Library Manager (TSLM) provides a resource management layer between applications such as Tivoli Storage Manager and the tape library hardware.

Essentially, TSLM decouples tape resources from applications. Decoupling simplifies both the aggregation and the sharing of tape resources.

TSLM provides the following benefits:

- Consolidated, mainframe-class media management services
- Centralized repository, access control, and administration
- Management beyond physical library boundaries
  - Access multiple TS3500 or TS4500 tape libraries as a single library image.
  - The libraries can be separate (at SAN distances) or connected in a shuttle complex (TS3500 tape library only)
- Dynamic sharing of resources across heterogeneous application boundaries
- Security features to allow or prevent application access to tapes
  - Helps to enable common scratch pool and private pools for every application
  - Secures the usage and visibility
- Policy-based drive and cartridge allocation
- Policy-based media-lifecycle management
- 3494 Emulation
  - Emulation of an IBM 3494 library on top of an attached IBM TS3500 or TS4500 tape library.

For more information about TSLM, see the *IBM Tape System Library Manager User's Guide* (GA32-2208).

Compatible servers and software

The TS4500 tape library is supported by a wide variety of servers, operating systems, and adapters. There are several ways to determine the servers and software that support the TS4500 tape library.

These attachments can change throughout the lifecycle of the product. To determine the current list of compatibility components, perform one of the following actions:

- Visit the web:
  - For a list of compatible software, operating systems, and servers for LTO and 3592 tape drives, download the Independent Software Vendor (ISV) Matrix from the TS4500 Tape Library web page.
  - For complete IBM storage interoperability information for the TS4500 tape library in a storage area network (SAN) configuration, refer to the IBM System Storage Interoperation Center (SSIC). The SSIC has details on supported operating systems, servers, switches, and adapters.
- Contact your IBM sales representative.

Notes:

1. IBM does not provide application software with the TS4500 tape library. To order software, contact your IBM sales representative, IBM business partner, or an independent software provider.

2. If you attach your library to a non-IBM platform with non-IBM software, contact your software vendor for a matrix of compatible hardware, software, firmware revisions, and adapter cards.

Attachment interfaces

The TS4500 tape library uses the Fibre Channel interface for data transmission with attached tape drives and the Gigabit Ethernet interface for library communications.

The TS4500 tape library supports the Fibre Channel interface and the following device types:

- SCSI Medium Changer Device (tape library)
- SCSI Sequential Access Device (tape drive)

The Gigabit Ethernet interface is supported in either auto negotiation or fixed modes of 10 Mbps, 100 Mbps, and 1 Gbps using half or full duplex. The following TCP/IP protocols are supported:

IPv4 and IPv6 support
The TS4500 tape library supports internet protocol (IP) addresses in both IPv4 and IPv6 format. Both the TS4500 integrated management console (IMC) and the TS4500 management GUI allow the definition of IPv4 and IPv6 addresses. The key proxy determines the IP version used and presents the correct IP address and parameters to the IP Stack.

Simple Network Management Protocol (SNMP)
SNMP traps are supported for drive and library events. SNMP management query functionality is supported by using a standard Management Information Base (MIB).

Hyper Text Transfer Protocol (HTTP)
An embedded web server provides a web user interface for library management and query capabilities.

Secure Socket Layer (SSL)
The TS4500 tape library supports SSL, a protocol for transmitting private documents through the internet.

Proprietary command set for communicating with the IBM Encryption Key Manager or IBM Security Lifecycle Key Manager (formerly the Tivoli Key Lifecycle Manager)

Simple Mail Transfer Protocol (SMTP)
The TS4500 tape library supports SMTP for sending email alerts.

Network Time Protocol (NTP)
The TS4500 tape library supports NTP for external time-and-date synchronization.

Lightweight Directory Access Protocol (LDAP)
The TS4500 tape library supports LDAP for centralized authentication.

Domain Name System (DNS)
The TS4500 tape library supports DNS for flexible IP addressing.

Fibre Channel interface

Several information resources are available to help users of drives that use a Fibre Channel interface.

Attention: This product contains an assembly that complies with the performance standards set by the United States Food and Drug Administration for a Class One Laser Product. This laser assembly is registered with the Department of Health and Human Services and is in compliance with IEC825.

For drives that use a Fibre Channel interface, the following information is available:

- For a list of compatible software, operating systems, and servers for LTO and 3592 tape drives, download the Independent Software Vendor (ISV) Matrix from the TS4500 Tape Library web page.

- For complete IBM storage interoperability information for the TS4500 tape library in a storage area network (SAN) configuration, refer to the IBM System Storage Interoperation Center (SSIC). The SSIC has details on supported operating systems, servers, switches, and adapters.

Fibre Channel technology combines the best features of traditional input/output interfaces with the best features of networking interfaces. The technology offers a transport mechanism for delivering commands, and provides high performance by allowing processing to be done in the hardware.

You can establish Fibre Channel connections between Fibre Channel ports that are in the tape library, one or more servers, and the connecting network. The network can consist of such elements as switches, hubs, bridges, and repeaters.

Library sharing

The TS4500 tape library can be configured into one or more logical libraries that can be shared by multiple applications.

The guided setup for the TS4500 tape library allows a single application to operate the library. Often, however, it is advantageous to be able to share a single library between heterogeneous or homogeneous applications. Some applications (and some servers) do not allow for sharing a library between systems. With the TS4500 tape library, however, you can create configurations that enable the library to process commands from multiple heterogeneous applications (such as an IBM System p application and a Windows application) and multiple homogeneous applications (for example, the same application run by several System p servers).

Use the TS4500 management GUI to perform the following actions:

- Configure the library so that it is partitioned into separate logical libraries that independently communicate with separate applications through separate control paths. This configuration (see example 1 in Figure 11 on page 46) requires no special capabilities from the server or application.
- Configure any single logical library (including the entire physical library) so that it is shared by two or more servers that are running the same application. Depending on the capabilities of the server and application, there are several ways to set up this type of configuration. Three typical ways include:
  - Configuring one server (mainframe host) to communicate with the library through a single control path; all other servers send requests to that server through a network (see example 2 in Figure 11 on page 46). This configuration is used by Tivoli® Storage Manager (TSM).
  - Configuring all of the servers to communicate with the library through a single, common control path (see example 3 in Figure 11 on page 46). This configuration is used in high-availability environments such as High-Availability Cluster Multi-Processing (HACMP) from IBM and Systems Management Server and Clustered Server Environments from Microsoft. Multi-initiator configurations are only supported by certain adapters and independent software vendors (ISVs). Check with your ISV.
  - Configuring a single logical library to communicate with multiple servers through multiple control paths. This configuration (see example 4 in Figure 11 on page 46) requires that you add control paths. It is used by Backup, Recovery, and Media Services.

Your library configuration is not limited to the examples shown in Figure 11 on page 46. Many configurations are possible, and you can design them according to your business needs.

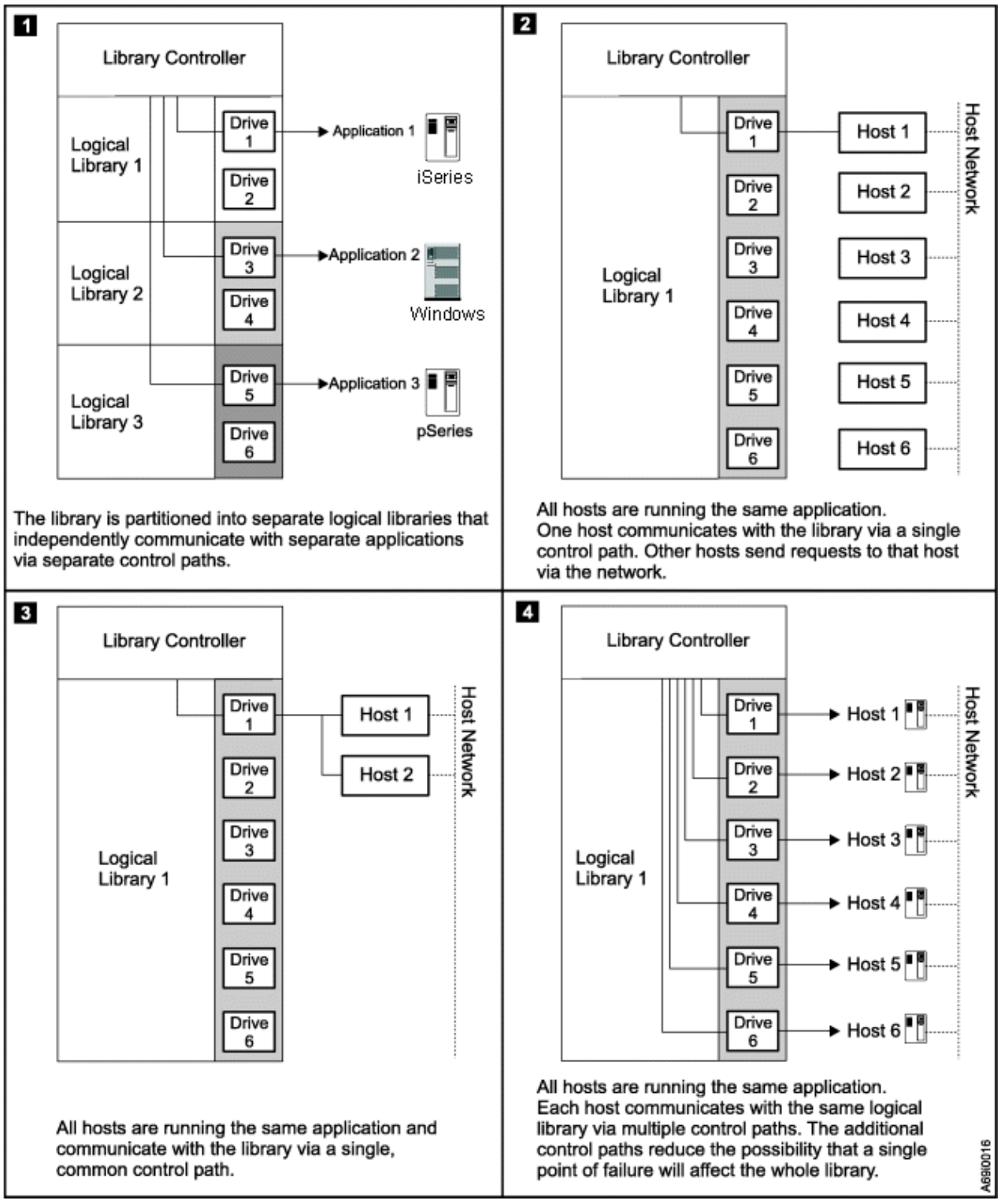


Figure 11. Examples of configurations for sharing an TS4500 tape library

Multipath architecture

The multipath architecture feature of the TS4500 tape library allows Open Systems applications to share the robotics of the library.

The TS4500 tape library features storage area network (SAN) ready multipath architecture. This architecture allows homogeneous or heterogeneous Open Systems applications to share the library's robotics without middleware or a dedicated server (host) acting as a library manager. The SAN-ready multipath architecture makes sharing possible by partitioning the library's storage slots and tape drives

into logical libraries. Servers can then run separate applications for each logical library. This partitioning capability extends the potential centralization of storage that the SAN enables. Partitioning also provides investment protection if your application does not support the mixing of drive generations and media in the same logical library.

The multipath architecture of the TS4500 tape library is designed to provide the capability to share the library robotics. The sharing is accomplished first by partitioning the library into as many as 192 logical libraries (up to the number of drives installed). Then, each logical library is assigned its own separate and distinct drives, storage slots, and control paths. Input/output (I/O) slots are shared on a first-come-first-serve basis. This type of partitioning is designed to allow heterogeneous applications to share the library robotics independent of each other. Cartridges under library control are not shared between logical libraries, nor are they allowed to be moved between logical libraries. An example of heterogeneous sharing is a Microsoft Windows application that is using the drive and storage slots of one logical library, while a UNIX application uses the drive and slots of another logical library. Logical libraries can also be used for separating LTO 5 tape drives and cartridges from LTO 6, LTO 7, LTO 8, or 3592 tape drives and cartridges, for applications that do not support mixing the drives in the same logical library.

Whether partitioned or not, the TS4500 tape library is certified for SAN solutions (such as LAN-free backup).

The multipath architecture allows for more than one control path to be configured for any one logical library. A control path is a logical path into the library through which a server sends standard SCSI Medium Changer commands to control the logical library. Multiple control paths reduce the possibility of a failure in one control path to cause the entire library to become unavailable. Use of the control path failover feature further reduces that possibility.

Related information

“Control path drives” on page 32
A control path is a logical path to the TS4500 tape library.

Multiple logical libraries

The TS4500 tape library supports multiple libraries to share the physical library between applications, or to support mixed drive types for any application.

You can create multiple logical libraries by partitioning the library’s tape drives and tape cartridges into two or more logical libraries. Each logical library consists of:

- Tape drives
- Tape cartridges in storage slots
- Tape cartridges in input/output (I/O) slots

Each logical library has its own control path. A control path is a logical path into the library through which a server sends standard SCSI Medium Changer commands to control the logical library. For frames that contain LTO tape drives and frames that contain 3592 tape drive, each logical library control path is available to servers through logical unit number (LUN) 1 of the first drive that is defined within that logical library. A LUN is a number that is used by a server to identify a drive.

In a TS4500 tape library, a logical library shares empty storage slots, empty I/O slots, and the cartridge accessor on a first-come, first-served basis.

A frame that uses LTO tape drives can be partitioned into up to 12 logical libraries. A frame that uses 3592 tape drive can also be partitioned into up to 12 logical libraries.

Note: When you are naming logical libraries, developing an enterprise-wide library naming convention leads to easier management of the libraries.

With automatic cleaning, cleaning cartridges are shared between logical libraries, so any appropriate cleaning cartridge is used to clean a drive in any configured logical library.

Share libraries by using multiple logical libraries
Partition a tape library into multiple logical libraries to enable simultaneous data backup and restore tasks from different applications.

You can partition the library so that it processes:

- Commands from Application 1 (about Department A) in Logical Library 1
- Commands from Application 2 (about Department B) in Logical Library 2
- Commands from Application 3 (about Department C) in Logical Library 3

In this configuration, the tape drives and cartridges of each logical library are dedicated to that library and are not shared among other libraries. Commands that are issued by the applications travel to the library through three unique control paths. So, the data processing for Department A is confined to the tape drives and cartridges of Logical Library 1. Processing for Department B is confined to the tape drives and cartridges of Logical Library 2, and so forth.

Multiple logical libraries for mixed drive types
For applications that do not support mixed drive types and media within the same logical library, the TS4500 tape library can partition the applications.

The TS4500 tape library places the applications into multiple logical libraries to keep them separate.

For example, you can partition the following tape drives and their media into multiple and separate logical libraries:

- LTO 8
- LTO 7
- LTO 6
- LTO 5

Multiple control paths

You can configure any TS4500 tape library logical library to have multiple control paths.

With the TS4500 tape library, in addition to creating multiple logical libraries, you can configure any logical library to have more than one control path. When you configure more control paths, more library-sharing configurations and options are possible. Access to the logical library is on a first-come, first-served basis. Each control path for a logical library can accept commands while the library is in use by another control path.

Note: Microsoft Windows 2000 Removable Storage Manager (RSM) does not support multiple control paths within a logical library. To use this feature, disable RSM.

Enable or disable control path drives from the Drives page of the TS4500 management GUI.

Related information
TS4500 management GUI Drives page help

Multiple control paths for IBM i attachment
The use of control paths for IBM Power Systems running IBM i and the System i®, iSeries, and AS/400 servers is unique. In general, every IBM i, System i, and iSeries input/output processor (IOP) based adapter must "see" the control path that is associated with the drives to which it is connected.

The following list presents possible scenarios for IOP adapters that recognize the control paths with which they are associated.

- OS/400® V5R1 supports only one drive per IOP-based adapter and every drive requires a control path.
- For OS/400 V5R2 and later, the IOP-based adapter supports multiple drives per adapter, so that only one control path for the group of drives is required.
- For V6R1 and Power® 6 hardware using the IOP-less (Smart IOA), the adapter has two Fibre Channel ports and supports multiple devices per port. At least one control path is required per IOA and per set of drives within a library partition.

- For V7R1 and Power 6 or Power 7 hardware using the IOP-less (Smart IOA), the adapter has two Fibre Channel ports and supports multiple devices per port. At least one control path is required per IOA port and per set of drives within a library partition.

Multiple control paths for control path failover
The TS4500 tape library offers an optional control path failover feature.

The control path failover feature (feature code 1682) enables the host device driver to resend a command to a different control path for the same logical library.

Related information
"Control path failover, data path failover, and load balancing" on page 51
The path failover feature of the TS4500 tape library ensures the use of a redundant communication path when the primary path fails.

"Feature codes for the TS4500" on page 93
Order feature codes to install components in library frames or to enhance the capacity or capabilities of the library.

Advanced Library Management System

The Advanced Library Management System (ALMS) allows the locations of cartridges in the tape library to be virtualized.

ALMS is an extension of IBM's patented Multi-Path Architecture. With ALMS, the TS4500 tape library can virtualize locations of cartridges (called SCSI element addresses) while it maintains the native SAN attachment for the tape drives. ALMS enables logical libraries to consist of unique drives and ranges of volume serial (VOLSER) numbers, instead of fixed locations.

The TS4500 tape library comes with ALMS, so you can immediately start assigning tape drives to any logical library by using the TS4500 management GUI. Logical libraries can also be added, deleted, or easily changed without disruption. Storage capacity can be changed without impact to host applications.

ALMS offers dynamic management of cartridges, cartridge storage slots, tape drives, and logical libraries. It enables the tape library to achieve unprecedented levels of integration for functionality through dynamic partitioning, storage slot pooling, and flexible drive assignment. ALMS eliminates downtime when you add Capacity On Demand (CoD) or High Density Capacity on Demand (HD CoD) storage, add or remove logical libraries, or change logical library storage allocation. ALMS also reduces downtime when you add expansion frames, add or remove tape drives, or change logical drive allocation.

ALMS provides the following capabilities:

- Dynamic partitioning (storage slot pooling and flexible drive assignment)
- The ability to add or remove storage capacity to any host application
- The ability to configure drives or to configure storage capacity without taking the library offline
- Virtual I/O slots (always enabled) to automatically manage the movement of cartridges between I/O slots and storage slots

The sections that follow describe the capabilities of ALMS.

Related information
"Multipath architecture" on page 46
The multipath architecture feature of the TS4500 tape library allows Open Systems applications to share the robotics of the library.

"Multiple logical libraries" on page 47

The TS4500 tape library supports multiple libraries to share the physical library between applications, or to support mixed drive types for any application.

Storage slot pooling

Storage slots are a shared resource in the TS4500 tape library.

The Advanced Library Management System (ALMS) allows logical libraries to be added or deleted without disrupting operation. All storage slots are pooled (available on a first-come, first-served basis) to each logical library based on cartridge insert operations. They are a shared resource such that changes to the capacity allocation for each logical library can occur without downtime or administrator involvement. The minimum logical library has a name and can be thought of as a file folder that has no contents. Drives are assigned to the logical library from the Drive Assignment screen of the Tape Library Specialist web interface**Drives** page of the TS4500 management GUI. Cartridges are assigned to the logical library based on their volume serial (VOLSER) numbers and by using one of the following methods, which are listed in priority order:

- Migration of static partitioning to dynamic partitioning (requires web enablement of ALMS)
- Cartridge assignment policy (automatic at the time of insertion)
- VOLSER ranges
- Software application move from the I/O station (based on the source application that issued the command)
- Manual assignment by an operator by using the TS4500 management GUI

The primary and backup copies of VOLSER assignment and physical location of cartridges are stored in nonvolatile random access memory (NVRAM).

Transparent addition or removal of storage capacity

The addition or removal of logical library capacity in the TS4500 tape library is transparent to any host application.

With the Advanced Library Management System (ALMS), you can change the quantity of storage slots accessible to all logical libraries by adding licensed capacity or by adding physical capacity. The change is transparent to each host application because the value in the `Maximum Number of Cartridges` field on the management GUI is not impacted by changes to the quantity of storage slots. The additional storage slots are new candidates for cartridges to be moved to upon insertion. This behavior allows the following two tasks to be performed independently and in either order:

- An administrator or service task to change the licensed or physical capacity of the library
- An administrator task to prepare the application to have access to more cartridges in their respective logical libraries by increasing the `Maximum Number of Cartridges` on the management GUI. Then, rediscovering the logical library at the application (for example, by restarting the application).

To modify the maximum number of cartridges for a logical library, access the management GUI and select **Library** > **Logical Libraries**.

Related information

Logical Libraries

Configuration of storage capacity without disruption

With the Advanced Library Management System (ALMS), the capacity expansion features can be enabled to increase storage capacity without disrupting library operations.

No downtime is required when you enable the base or intermediate capacity-on-demand features for models L25 and L55.

Also, no downtime is required when you enable the high-density capacity-on-demand features for models Lx5, Dx5, and Sx5.

Virtual I/O slots

Virtual I/O slots enhance the import and export capabilities of the library.

Virtual I/O slots are always enabled so that the library automatically queues all cartridge moves between the I/O station and the storage slots. This capability makes the process of adding and removing cartridges easier and faster.

The TS4500 tape library has I/O stations with cartridge magazines that can be used to import and export up to 144 cartridges at any time. The I/O slots are also known as import/export elements (IEEs). Virtual I/O slots increase the quantity of available I/O slots by allowing storage slots to appear to the host as I/O slots. These storage slots are also called virtual import/export elements (VIEEs). With virtual I/O slots, the library automatically moves cartridges from the I/O stations to the storage slots. This enhances the import and export performance, while also decoupling physical cartridge movement from the application. As a result, operator efficiency is increased.

With virtual I/O slots, the library has various mechanisms for selecting the best storage slot location for each inserted cartridge, and the best I/O station for each ejected cartridge. These mechanisms vary depending on the configuration of your library.

Power structure of the TS4500 tape library

This section introduces the power structure that is provided by the TS4500 tape library.

Frame control assembly (FCA)

What is included in the FCA?

For models L25, D25, L55, and D55, the library offers the TS4500 frame control assembly power structure, which combines drive power, library power, and AC power cord capabilities. Each Lx5 and Dx5 frame comes with two Back Plane Cards (BPCs) and two power supplies. Model Sx5 frames do not have their own power supply. They share power with either an Lx5 or Dx5 frame.

Redundancy provided by two or more frames with an FCA (control system)

For two or more frames that have an FCA control system, failure or repair of a particular part does not cause the entire system to fail. Nor does it require scheduled downtime for maintenance. For example, the replacement of any single failed power supply can be accomplished without affecting the operation of the library. The two redundant power supplies are fed directly by independent AC power cords that support only 220 V AC (110 V AC is not supported).

Note: AC power cords do not come standard with models L25, D25, L55, and D55. You must specify what type of AC power cord is to be shipped with the frame control assembly.

Control path failover, data path failover, and load balancing

The path failover feature of the TS4500 tape library ensures the use of a redundant communication path when the primary path fails.

Command failures and time outs are costly. You want your library to run smoothly and efficiently. To ensure continued processing, libraries that are equipped with Fibre Channel LTO and 3592 tape drive offer path failover and load balancing capabilities. These capabilities allow the IBM device driver to resend a command to an alternate path. The alternate path can include another host bus adapter (HBA), Storage Area Network (SAN), or library control path drive. The device driver initiates error recovery and continues the operation on the alternate path without interrupting the application. Path failover and load balancing are built-in features that are enabled by using a purchased license key.

Two types of path failover capabilities exist: *control path failover (CPF)* and *data path failover (DPF)*. *Control* refers to the command set that controls the library (the SCSI Medium Changer command set on LUN 1 of the tape drives). *Data* refers to the command set that carries the customer data to and from

the tape drives (the SCSI-3 Stream Commands (SSC) device on LUN 0 of the tape drives). Path failover means the same thing in both. Path failover is where there is redundancy in the path from the application to the intended target (the library accessor or the drive mechanism, respectively), the device driver transparently fails over to another path in response to a break in the active path.

Both types of failover include host-side failover when configured with multiple HBA ports into a switch. But CPF includes target-side failover through the control paths that are enabled on more than one tape drive. DPF includes target-side failover for the dual-ported tape drives that are supported by the TS4500 tape library.

DPF includes load balancing of the HBAs because the channel is a data-intensive path (the control path carries very little data, so load balancing is not an issue). The dynamic load balancing support optimizes resources for devices that have physical connections to multiple HBAs in the same machine. When an application opens a device that has multiple HBA paths configured, the device driver determines which path has the HBA with the lowest usage and assigns that path to the application. When another application opens a different device with multiple HBA paths, the device driver again determines the path with the lowest HBA usage and assigns that path to the second application. The device driver updates the usage on the HBA assigned to the application when the device is closed. Dynamic load balancing uses all HBAs whenever possible and balances the load between them to optimize the resources in the machine.

Both CPF and DPF require the use of the IBM device driver. They are supported exclusively with products that bear the IBM logo on the operating systems that is indicated in Table 24 on page 52.

Table 24 on page 52 summarizes the differences between CPF, DPF, and load balancing.

Table 24. Differences between CPF and DPF

Characteristic	CPF	DPF and Load Balancing for Ultrium 2 and later tape drivesDPF and Load Balancing for LTO tape drives	DPF and Load Balancing for 3592 tape drives
Device type	SMC[1]	SSC[2]	SSC
LUN[3]	LUN 1	LUN 0	LUN 0
Host-side failover	Yes	Yes	Yes
Target-side failover	Yes	Yes[6]	Yes
IBM device driver required	Yes	Yes	Yes
Operating systems supported	AIX®, SuSE Linux, Red Hat Enterprise Linux, Solaris, Windows, HP-UX, Asian UX	AIX, SuSE Linux, Red Hat Enterprise Linux, Solaris, Windows[4](DPF only), Asian UX	AIX, SuSE Linux, Red Hat Enterprise Linux, Solaris, Windows[4] (DPF only), HP-UX, Asian UX
Order feature to obtain license key	Yes	Yes[55, 7]	No
SCSI attachment supported	Yes	No	No
Fibre Channel attachment supported	Yes	Yes	Yes

Table 24. Differences between CPF and DPF (continued)

Characteristic	CPF	DPF and Load Balancing for Ultrium 2 and later tape drivesDPF and Load Balancing for LTO tape drives	DPF and Load Balancing for 3592 tape drives

Notes:

1. SMC = SCSI-3 Medium Changer Specification (library)
2. SSC = SCSI-3 Stream Commands (drive)
3. LUN = logical unit number
4. Load balancing is not supported on Windows
5. LTO 4 and later tape drives do not require license keys at the host when you are configuring Data Path Failover.

The path failover feature can be ordered from the factory, or you can order them as field upgradesit as a field upgrade. The path failover feature (FC 1682) is activated with a license key that you enter on the TS4500 management GUI. To order features, contact your IBM Sales Representative.

For more information about using these features, see the *IBM Tape Device Drivers Installation and User's Guide*.

Related information

"Feature codes for the TS4500" on page 93
Order feature codes to install components in library frames or to enhance the capacity or capabilities of the library.

Library Control Card failover

The TS4500 tape library allows for automatic Library Control Card (LCC) failover.

The main control center of the TS4500 tape library is the LCC. In addition to the base L-frame, each D-frame with a Frame Control Assembly has an LCC. For libraries with multiple LCCs, the library firmware performs automatic LCC failover.

When the TS4500 tape library powers up, one LCC is chosen to be the primary control card. Any other LCCs that are present in the library are used as cache LCCs. Should the primary LCC becomes degraded, the library firmware will automatically choose one of the cache LCCs to assume the primary role without interrupting library operations.

VOLSER ranges

Volume serial (VOLSER) ranges are used to assign cartridges to specific logical libraries in the TS4500 tape library.

Tape cartridges are identified by the VOLSER number on the bar code label that is affixed to each cartridge. The TS4500 tape library uses VOLSER ranges to assign cartridges to one or more logical libraries. When you insert a cartridge into the library and its VOLSER is within a logical library's range, the cartridge is assigned to that logical library. For example, you create a logical library that is called LogicalLibrary1 for VOLSERs that range from ABC000 to ABC999 (a library of LTO drives). When you insert a cartridge with VOLSER ABC123, the library recognizes that VOLSER as belonging to the range and assigns it to LogicalLibrary1.

When the library detects a new, unassigned cartridge, the library reads the VOLSER and assigns the cartridge to the correct logical library. If the VOLSER does not match any of the VOLSER ranges, the

cartridge is available to be imported into any logical library of the same media type. The assignment is then determined by the first application to import the cartridge.

Within a physical TS4500 tape library, a maximum of 300 VOLSER ranges can be created between all logical libraries.

VOLSER ranges are created during the initial library configuration. However, you can assign new, or modify existing, ranges from the Logical Libraries page of the TS4500 management GUI.

Related information

TS4500 management GUI Logical Libraries page help

Increasing capacity

Install capacity on demand (CoD) features to increase the cartridge capacity of frames in the TS4500 tape library.

In the TS4500 tape library, the physical capacity, or total storage slots, is composed of licensed and unlicensed capacity. When the number of assigned cartridges reaches the licensed capacity, more cartridges cannot be assigned to a logical library until one of the following actions occurs:

- A cartridge is removed
- A CoD feature is purchased
- More slots or frames are added to the library

The Intermediate, Base, and High-Density Capacity-on-Demand features provide license keys so that you can enable more storage slots in the frames of the TS4500 tape library. For more information, see “Frame capacity” on page 112.

Monitor the capacity utilization of frames and the library from the TS4500 management GUI.

Related information

“Feature codes for the TS4500” on page 93
Order feature codes to install components in library frames or to enhance the capacity or capabilities of the library.

“Frame capacity” on page 112
The cartridge capacity of the frames of the TS4500 tape library varies depending on whether the frame has I/O stations, tape drives, or any of the available capacity on demand features that increase the amount of licensed capacity of the frame.

Intermediate and Base Capacity on Demand

Use the Intermediate and Base Capacity on Demand (CoD) features to increase the initial (entry) capacity of the base frames (models L25 and L55) of the TS4500 tape library.

The initial (entry) capacity of the L25 and L55 frames is 100 storage slots. You can purchase CoD features to increase the amount of available licensed capacity.

The Intermediate CoD feature (FC 1643) adds 100 slots, increasing the usable capacity of the L25 and L55 frames to 200 slots. The Base CoD feature (FC 1644) adds 200 slots, increasing the usable capacity of the L25 and L55 frames to 400 slots. FC 1644 is referred to as Full CoD with the TS4500 tape library.

For more information about these licensed features, see “Feature codes for the TS4500” on page 93. For more information about the capacities of library frames in various positions and configurations, see “Frame capacity” on page 112.

Related information

“Feature codes for the TS4500” on page 93
Order feature codes to install components in library frames or to enhance the capacity or capabilities of the library.

“Frame capacity” on page 112

The cartridge capacity of the frames of the TS4500 tape library varies depending on whether the frame has I/O stations, tape drives, or any of the available capacity on demand features that increase the amount of licensed capacity of the frame.

High-Density Capacity on Demand

Use the High Density (HD) Capacity on Demand (CoD) license key to enable the full high-density capacity of the Lx5, Dx5, and Sx5 frames in the TS4500 tape library. Enabling the CoD on the TS4500 is a non-disruptive process.

The initial (entry) capacity of the Lx5 frames is 100 slots. The Intermediate and Base CoD features can increase the usable capacity up to 400 slots. The HD CoD features add anywhere from 150 to more than 450 more slots, depending on frame position and configuration. The Base CoD feature (FC 1644) is a prerequisite for installing an HD CoD feature on an Lx5 frame.

The initial (entry) capacity of the Dx5 frames is 500 slots. The initial (entry) capacity of the S25 frame is 600 slots and of the S55 frame is 660 slots. The HD CoD features can add anywhere 50 - 660 more slots, depending on frame position and configuration.

Table 25 on page 55 shows potential capacities by frame model.

Table 25. HD CoD capacity

Frame model	Frame position	
	Position 1 (leftmost frame)	Position 2+
L25	+150 slots	+260 slots
L55	+330 slots	+482 slots
D25	+90 slots	+240 slots
D25 with I/O stations	+50 slots	+160 slots
D55	+274 slots	+470 slots
D55 with I/O stations	+230 slots	+382 slots
S25	+198 slots	+400 slots
S55	+394 slots	+660 slots

For more information about HD technology, see “High-density technology” on page 6. For more information about these licensed features, see “Feature codes for the TS4500” on page 93. For more information about maximum frame capacities in various configurations, see “Frame capacity” on page 112.

Related information

“High-density technology” on page 6
The TS4500 tape library offers high-density (HD), drive-capable and storage-only frame models that are designed to greatly increase storage capacity without increasing frame size or required floor space.

“Feature codes for the TS4500” on page 93
Order feature codes to install components in library frames or to enhance the capacity or capabilities of the library.

“Frame capacity” on page 112

The cartridge capacity of the frames of the TS4500 tape library varies depending on whether the frame has I/O stations, tape drives, or any of the available capacity on demand features that increase the amount of licensed capacity of the frame.

Command-line interface

Use the command-line interface (CLI) program to access tape library functions outside of the GUI interface.

For detailed information about each CLI command, refer to the CLI commands reference section.

For detailed information about each CLI command, refer to the command-line interface reference section in the IBM TS4500 customer online documentation in the IBM Knowledge Center.

Related information

TS4500 tape library CLI commands

Remote support

Remote support for the TS4500 tape library involves the use of a Call Home feature to detect and solve problems. Also, remote support requires several important security functions.

Optional remote support is available for the TS4500 tape library through its Call Home capability. The Call Home feature uses the integrated management console (IMC) to report failures that are detected by the library or a tape drive. When a failure is detected, Call Home sends detailed error information to IBM (home). The IBM service representative can then prepare an action plan to handle the problem before hand. The library might also periodically send support information (such as configuration, library and drive code versions, and error logs) to IBM.

The Call Home feature has three different, but related, capabilities: Problem Call Home, Heartbeat Call Home, and Test Call Home. The tape library sends data files that might be helpful to Support Center personnel for all three types of Call Home. These data files include library error logs and configuration information, such as the Machine Reported Product Data (MRPD) log. The MRPD file contains the following information about the machine (library):

- The number of frames and drives
- The model and serial number of each frame
- The type and serial number of each drive
- The code version of the library and each drive
- Any machine-detectable features such as additional I/O stations, capacity expansion

If a Problem Call Home is initiated, the library also sends the tape library logs and drive logs that are related to the problem.

Problem Call Home
The tape library or one of its drives detects a problem and the library initiates a Call Home operation. This Call Home operation creates a Problem Management Record (PMR) in the IBM Remote Technical Assistance Information Network (RETAIN). This is a single page of text data. It helps the support center or service representative determine an action plan and a list of parts (called field replaceable units or FRUs).

Heartbeat Call Home
The tape library sends the Heartbeat Call Home on a scheduled basis to ensure proper Call Home function. By default, the Heartbeat Call Home is sent once per week, 1 hour after a power cycle, and 1 hour after a code update is complete.

Test Call Home
When servicing the library, the service representative can issue a Test Call Home operation to RETAIN from the TS4500 management GUI. The library allows the service representative to include drive

dumps in the Test Call Home for analysis. In this way, a drive dump can be accessed by Support Center personnel through the Call Home database.

Remote support through a system console

A system console is a service tool through which the TS4500 tape library provides remote support.

The integrated management console (IMC) can be used as a service console with the TS4500 tape library. Similar in function to the TSSC, the IMC comes installed with a set of software tools that helps both local service and remote support of the attached TS4500 tape library. Table 26 on page 57 lists the system console features that can be ordered for the library.

Table 26. System console and remote support features

Feature Code	Supported Models	Customer-Setup Unit (CSU)	Description
This is a standard feature.	L25, L55	No	Integrated Management Console (IMC)
2704	L25, L55	No	Console Expansion 26 Port Enet Switch/ Rackmount
2715	L25, L55	No	TS3000 system console (TSSC) Attachment

The method that is used by the library for Call Home support is a broadband connection that uses the Electronic Customer Care (ECC) Call Home function through the system console.

To perform an ECC Call Home operation through a system console, the TS4500 tape library sends Call Home information across a private Ethernet connection to the system console. The system console then performs the ECC Call Home operation and sends the information to the IBM Remote Technical Assistance Information Network (RETAIN) through the system console's Ethernet (broadband) connection.

For remote support through a system console, the TS4500 tape library needs a minimum of two Ethernet ports: one attached to your network for use by your administrator and one attached to the private system console network for remote support.

The IMC is preconfigured for remote support with the TS4500 tape library. The IMC also comes equipped with an RJ45 port that can be used to connect an external network cable for remote support.

Table 27 on page 57 presents the capabilities of remote support with a system console.

Note: All of the listed capabilities do not apply to every product type. For example, the TS4500 tape library does not use wellness checking, daily log file storage, or code image broadcast.

Table 27. Remote support capabilities

Location	Event	Support
Customer site	Call Home events	• Error initiated • Heartbeat (regular interval) • Test

Table 27. Remote support capabilities (continued)		
Location	**Event**	**Support**
	System console support capability	• Error-initiated problem reporting for up to 43 subsystems • Staged, error-specific data gathering • Subsystem and system console heartbeat reporting • Wellness checking • Log file storage (daily) • Code image and documentation repository (from media and RETAIN Fix Distribution Library)
	System console and remote support service tools	• Code image broadcast • Call home event log review • End-of-call completion report
IBM support	System console remote access	• Authenticated, secure remote access • Simultaneous call in and call home • Data transmission (TCP/IP) supported
	IBM call home database	• 24/7 access by IBM support staff • Error analysis and search capability

Remote support security

This topic is currently under review.

Security concerns when you use the TS4500 management GUI

The TS4500 tape library has remote support security through a system console when you use the management GUI.

The management GUI does not allow any access to customer data, and it does not allow FTP or TELNET type operations. It provides those functions that are allowed coded in the library firmware. The only files that it can offload are library logs, drive logs, and certain usage and error statistics files. It cannot be used to read or write a customer cartridge or otherwise access customer data.

You can use the management GUI to set up an administrator password. No-one without the password can use the management GUI to do anything to the library. The management GUI also provides several levels of access through various preset roles.

For more information, see the IBM TS4500 customer online documentation in the IBM Knowledge Center.

The following list presents potential security concerns when you are using the management GUI:

- A Management GUI user might move a cartridge from one location to another within the library. This change in position might confuse a host application, or make the cartridge unavailable by moving it to a different partition.
- A user might reconfigure the library and possibly cause problems at the hosts because of changes in partitioning or device IDs.
- A remote user might update the library or drive firmware. However, since the library and drives ignore any firmware they do not recognize, the only exposure is to loading older firmware.

These security concerns can be addressed by using the password, user role, and authentication features that are provided by the management GUI, and also by enabling SNMP audit logging. When SNMP audit logging is enabled, the library sends notifications when certain events occur in the library.

Library monitoring and querying

The TS4500 tape library provides several way to monitor library status and query the library for operating details.

TapeAlert support

The TS4500 tape library is compatible with TapeAlert technology, which provides error and diagnostic information about the drives and the library to the host application.

The library provides this error and diagnostic information as TapeAlert flags that are reported to the application by the SCSI LOG SENSE command.

For a list of the TapeAlert flags for the drives and the library, refer to TapeAlert Flags in the TS4500 KC.

SNMP requests

The TS4500 tape library allows requests from an SNMP manager running systems management software, such as Netview®.

IBM maintains a management information base (MIB) that contains configuration data for all IBM tape libraries. This allows you to gather configuration data for all IBM tape libraries being managed – local or remote, regardless of model – in a single operation.

The `Get`, `GetNext`, and `GetBulk` SNMP requests are supported. `Set` requests are not supported.

The following configuration data can be queried:

- Frame or system configuration (frame or module)
- Logical libraries
- Drive configuration
- Library configuration
- VPD note card
- Call home configuration
- SNMP
- Key manager
- Drive encryption
- SMTP configuration
- Time configuration
- User roles
- Role access level
- LDAP configuration
- Ethernet configuration

Related information

Using SNMP to monitor and query a library

SNMP messaging

The Simple Network Management Protocol (SNMP) enables the tape library to exchange information over a TCP/IP local area network with an SNMP manager running systems management software, such as NetView®.

SNMP allows alerts (called traps) to be sent to an SNMP manager. Using the information that is supplied in each SNMP trap, the monitoring software can alert operations staff of possible problems or operator interventions that occur. Monitoring programs (such as NetView) can be used to send email or pager notifications when they receive an SNMP trap. For more information, see your NetView documentation or the manual for your network management application.

Occasionally, the tape library might encounter situations that you want to know about. These situations can be conditions that affect library performance, such as an open door that causes the library to stop. You might also want to log user actions, such as a cartridge move or export that is initiated from the TS4500 management GUI. SNMP messages can alert you of these conditions.

The monitoring server must be loaded with systems management software that can receive and process the trap. SNMP supports a get and get-response mechanism for an operator to gather more information about a problem or query the library about its status. Through an SNMP manager, the operator issues a "get" to request information about the library. A get-response is the information that is provided in response to the get. This type of support generally requires an up-to-date library Management Information Base (MIB). The library's MIB contains units of information that specifically describe an aspect of a system, such as the system name, hardware number, or communications configuration.

IBM provides the MIBs that are supported by the library. They include:

- IBM 3584 MIB for Version 2c traps
- Storage Networking Industry Association (SNIA) Storage Media Library (SML) MIB Version 1.12

Library settings cannot be changed with SNMP. Settings are changed by using the TS4500 management GUI.

Figure 12 on page 60 shows the flow of SNMP communication from the library over the Ethernet LAN to an SNMP monitoring server.

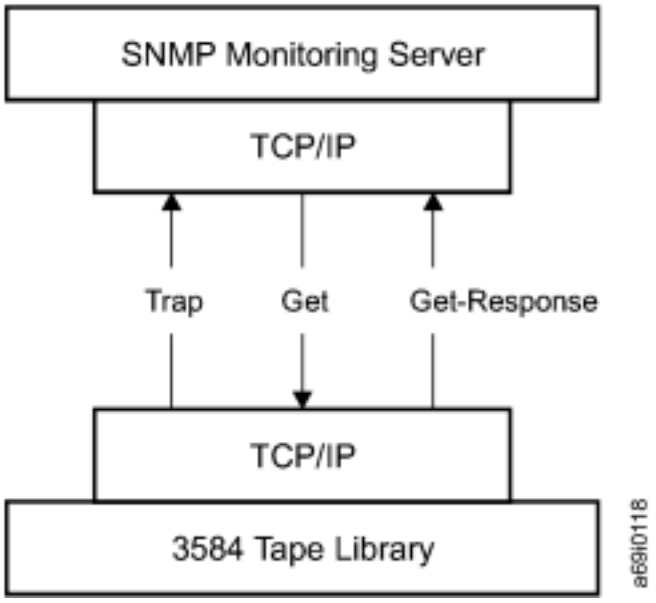


Figure 12. SNMP messaging system

Additional information is available in the *Implementing IBM Tape in Linux and Windows* Redbook. Also, see the *Implementing IBM Tape in Unix Systems* Redbook.

Related information

Using SNMP to monitor and query a library

SNMP audit logging

SNMP audit logging provides logging information about specific TS4500 tape library user actions.

The tape library provides various interfaces that allow a user to configure different library or drive settings, move cartridges within or out of the library, and other actions. In addition, the tape library provides notifications, in the form of SNMP traps, that provide a log of when certain activities take place. With SNMP traps, you have more capabilities for monitoring these activities and the physical security of the library.

SNMP audit logging sends the log information over a TCP/IP local area network to an SNMP manager, just as SNMP traps are sent for library alerts.

The following events are logged when SNMP audit logging is enabled:

- Login attempts, whether granted or denied
- Logouts (timeout, logout, or force logout)
- Any configuration change
- Any data or cleaning cartridge move that is initiated from a library user interface
- Any code load operation (library or drive) initiated from a library user interface and not associated with an FRU replacement
- Any prepare or finish service procedure that is initiated from a library user interface, including set storage slot offline or online
- Any drive serial number change not associated with an FRU replacement
- Any drive power cycle that is initiated from a library user interface
- Any node card reset that is initiated from a library user interface

Notes:

- Door open events are logged whether or not SNMP Audit Logging is enabled.

The following information is provided in the logs for each of these events:

- Machine type, model, and serial number of the reporting machine
- The user name that initiated the event
- Level of severity
- Trap ID
- Description of the event

Secure Socket Layer (SSL) functions

The TS4500 tape library supports secure socket layer (SSL), which is a protocol for transmitting private documents across the Internet.

To enable or disable SSL, go to the management GUI and select **Settings** > **Security** and click the **HTTPS** tab.

Related information

Secure Communications

Remote authentication

The TS4500 tape library supports remote authentication of user credentials using LDAP (with optional RACF authentication) or Kerberos.

When remote authentication is enabled, the tape library passes user authentication requests to the remote authentication server. The authentication server authenticates the user's ID and password. If they are valid, the tape library assigns the user a role based on the user's group membership on the authentication server.

When remote authentication is enabled, you can perform the following security tasks on multiple systems from a single interface:

- Add and remove users
- Reset or change passwords
- Assign, change, or delete user group assignments
- Respond to new security requirements. For instance, password rules can be changed in one location without reconfiguring multiple systems. By comparison, when you use local authentication, each individual system maintains an internal database of user IDs, with corresponding passwords and roles.

Related information

Managing remote users

Roles

Remote authentication

IPv6 functionality

The TS4500 tape library supports internet protocol (IP) addresses in IPv4 and IPv6 formats.

Internet protocol version 6 (IPv6) is designed to allow the Internet to grow steadily, both in terms of the number of hosts connected and the total amount of data traffic transmitted. The TS4500 management GUI allows the definition of IPv4 and IPv6 addresses. The Key Proxy determines the IP version used and presents the correct IP address and parameters to the IP Stack.

IPv4 and IPv6 address formats

Octets or segments, or a combination of both, make up Internet Protocol version 4 (IPv4) and Internet Protocol version 6 (IPv6) addresses.

An IPv4 address has the format x.x.x.x, where *x* is called an *octet* and must be a decimal value between 0 and 255. Octets are separated by periods. An IPv4 address must contain three periods and four octets. The following examples are valid IPv4 addresses:

- 1.2.3.4
- 01.102.103.104

An IPv6 address can have either of the following two formats:

- Normal - Pure IPv6 format
- Dual - IPv6 plus IPv4 formats

An IPv6 (normal) address has the format y:y:y:y:y:y:y:y, where *y* is called a *segment* and can be any hexadecimal value between 0 and FFFF. The segments are separated by colons, not periods. An IPv6 normal address must have eight segments; however, a short form notation can be used in the TS4500 management GUI for segments that are zero, or those that have leading zeros.

The following are examples of valid IPv6 (normal) addresses:

- 2001:db8:3333:4444:5555:6666:7777:8888
- 2001:db8:3333:4444:CCCC:DDDD:EEEE:FFFF

- :: (implies all 8 segments are zero)
- 2001:db8:: (implies that the last six segments are zero)
- ::1234:5678 (implies that the first six segments are zero)
- 2001:db8::1234:5678 (implies that the middle four segments are zero)
- 2001:0db8:0001:0000:0000:0ab9:C0A8:0102 (This can be compressed to eliminate leading zeros, as follows: 2001:db8:1::ab9:C0A8:102)

An IPv6 (dual) address combines an IPv6 and an IPv4 address and has the following format: y:y:y:y:y:y:x.x.x.x. The IPv6 portion of the address (indicated with y's) is always at the beginning, followed by the IPv4 portion (indicated with x's).

- In the IPv6 portion of the address, *y* is called a *segment* and can be any hexadecimal value between 0 and FFFF. The segments are separated by colons, not periods. The IPv6 portion of the address must have six segments but there is a short form notation for segments that are zero.
- In the IPv4 portion of the address *x* is called an *octet* and must be a decimal value between 0 and 255. The octets are separated by periods. The IPv4 portion of the address must contain three periods and four octets.

The following are examples of valid IPv6 (dual) addresses:

- 2001:db8:3333:4444:5555:6666:1.2.3.4
- ::11.22.33.44 (implies all six IPv6 segments are zero)
- 2001:db8::123.123.123.123 (implies that the last four IPv6 segments are zero)
- ::1234:5678:91.123.4.56 (implies that the first four IPv6 segments are zero)
- ::1234:5678:1.2.3.4 (implies that the first four IPv6 segments are zero)
- 2001:db8::1234:5678:5.6.7.8 (implies that the middle two IPv6 segments are zero)

Subnet masks (IPv4) and prefixes (IPv6)
Subnet masks (IPv4) and prefix lengths (IPv6) identify a range of IP addresses that are on the same network.

IPv4 subnet masks

All IP addresses are divided into portions. One part identifies the network (the network number) and the other part identifies the specific machine or host within the network (the host number). Subnet masks (IPv4) and prefixes (IPv6) identify the range of IP addresses that make up a subnet, or group of IP addresses on the same network. For example, a subnet can be used to identify all the machines in a building, department, geographic location, or on the same local area network (LAN).

Dividing an organization's network into subnets allows it to be connected to the Internet with a single shared network address. Subnet masks and prefixes are used when a host is attempting to communicate with another system. If the system is on the same network or subnet, it will attempt to find that address on the local link. If the system is on a different network, the packet is sent to a gateway which will then route the packet to the correct IP address. This is called Classless-InterDomain Routing (CIDR).

In IPv4, the subnet mask 255.255.255.0 is 32 bits and consists of four 8-bit octets. The address 10.10.10.0 with the subnet mask 255.255.255.0 means that the subnet is a range of IP addresses from 10.10.10.0 - 10.10.10.255.

The prefix-length in IPv6 is the equivalent of the subnet mask in IPv4. However, rather than being expressed in 4 octets like it is in IPv4, it is expressed as an integer between 1-128. For example: 2001:db8:abcd:0012::0/64 specifies a subnet with a range of IP addresses from **2001:db8:abcd:0012:**0000:0000:0000:0000 to **2001:db8:abcd:0012:**ffff:ffff:ffff:ffff. The portion in bold is called the network portion of the IP address, or the prefix. The non-bold portion is called the host portion of the IP address, since it identifies an individual host on the network.

IPv6 addresses

An IPv6 address is eight groupings of numbers:

- **Network address** - the first three groupings of numbers (first 48 bits) in the subnet mask
- **Subnet address** - the fourth grouping of numbers (the 49th through 64th bits) in the subnet mask
- **Device address** - the last four groupings of numbers (the last 64 bits) in the subnet mask

For example, in the IPv6 address 2001:db8:abcd:0012:0000:0000:0000:0000, the network address is 2001:db8:abcd and the subnet address is 12 (using the short form notation and eliminating the leading zeroes). Together, these two groupings are the IPv6 *prefix*. The device address in the example is 0000:0000:0000:0000.

Each device in the network has a unique device address, but the network address and subnet address portions of the IPv6 address are the same for every device in the network. So, the first four groupings of numbers in every IPv6 address remain constant, and the last four groupings of numbers vary with each device. You can simplify your list of devices by substituting a prefix-length in place of the device address portion of the IPv6 address. The prefix-length specifies a range of devices. It is expressed as a slash (/), followed by an integer between 1 and 128. For example, a prefix-length of /64 specified as 2001:db8:abcd:0012::/64 tells the system to divide the network into 64 subnetworks. Each subnetwork contains 1/64th of the devices on the network. Table 28 on page 64 shows the resulting network ranges for prefix lengths of IPv6 addresses.

Table 28. Network ranges for prefix lengths of IPv6 addresses

Expanded notation of IPv6 address at start of the range	IPv6 address (condensed notation)	IPv6 address with prefix length	Device range in subnetwork
2001:0DB8:ABCD:0012:0000:0000:0000:0000	2001:DB8:ABCD:12::	2001:db8:abcd:0012::0/64	2001:0DB8:ABCD:0012:0000:0000:0000:0000 - 2001:0DB8:ABCD:0012:FFFF:FFFF:FFFF:FFFF
2001:0DB8:ABCD:0012:0000:0000:0000:0000	2001:DB8:ABCD:12::	2001:db8:abcd:0012::0/80	2001:0DB8:ABCD:0012:0000:0000:0000:0000 - 2001:0DB8:ABCD:0012:0000:FFFF:FFFF:FFFF
2001:0DB8:ABCD:0012:0000:0000:0000:0000	2001:DB8:ABCD:12::	2001:db8:abcd:0012::0/96	2001:0DB8:ABCD:0012:0000:0000:0000:0000 - 2001:0DB8:ABCD:0012:0000:0000:FFFF:FFFF
2001:0DB8:ABCD:0012:0000:0000:0000:0000	2001:DB8:ABCD:12::	2001:db8:abcd:0012::0/112	2001:0DB8:ABCD:0012:0000:0000:0000:0000 - 2001:0DB8:ABCD:0012:0000:0000:0000:FFFF
2001:0DB8:ABCD:0012:0000:0000:0000:0000	2001:DB8:ABCD:12::	2001:db8:abcd:0012::0/128	2001:0DB8:ABCD:0012:0000:0000:0000:0000 - 2001:0DB8:ABCD:0012:0000:0000:0000:0000

Chapter 2. Planning

The TS4500 tape library requires an environment able to accommodate the appropriate height, weight, and width in addition to other physical specifications. Use the **Planning** section as a reference for the on-site requirements for optimum operation of the TS4500 tape library. The TS4500 tape library is installed by an IBM service representative.

Height and length of the frames of the library

This topic provides the height of TS4500 tape library frames to help plan for shipment and installation.

Each frame of the TS4500 tape library has a set of casters and four leveling jack screws. The casters and leveling jack screws that attach to the TS4500 tape library affect its height.

- The nominal height from the bottom of the jack screws to the top of the frame is 1840 mm (72.4 in.). This height can vary by ±40 mm (±1.6 in.).
- The shipping height of the library (on its casters and with jack screws raised and not including the pallet) is 1800 mm (70.9 in.).
- The height of a frame with a shuttle connection is 2 275 mm (89.57 in.).
- The height of a frame with a top rack is 2320 mm (91.34 in.).

For detailed information about the physical specifications of each library frame, refer to the topic about the frame model physical specifications. To calculate the length of your fully configured library, refer to the topic about clearance specifications for the library.

Frame model physical specifications

The physical specifications by frame model provide detailed information about the height and weight of frames in various configurations. Use this information when designing your tape library and planning for delivery and installation.

Physical specifications for frame models L25 and D25

Table 29. Physical characteristics of frame models L25 and D25

Physical characteristic	**Measurement**	
Height of L25 and D25 frames (on casters)	1800 mm (70.9 in)	
Height of L25 and D25 frames with top rack	2320 mm (91.34 in)	
Width of L25 frame with covers	782 mm (30.8 in)	
Width of L25 or D25 frame without covers[2]	725 mm (28.5 in)	
Depth of L25 or D25 frame (including front and rear doors)	1212 mm (47.72 in)	
	Position 1 (Leftmost frame)	**Position 2+**
Minimum weight of frame (with no tape drives or cartridges)[5, 6]	**L25:** 407.8 kg (899 lb) **D25**: 310.7 kg (685 lb)	**L25:** 407.8 kg (899 lb) **D25**: 310.7 kg (685 lb)

Table 29. Physical characteristics of frame models L25 and D25(continued)		
Physical characteristic	**Measurement**	
Maximum weight of frame (with maximum tape drives and cartridges)[3, 4, 5, 6]	**L25**: 586.5 kg (1 293 lb) **D25**: 500 kg (1 103 lb)	**L25** : 630.5 kg (1 390 lb) **D25**: 552.5 kg (1 218 lb)
Weight of top rack (empty)[1]	24.5 kg (54 lb)	
Weight of top rack [1]	109 kg (240 lb)	

Notes:

1. A top rack can optionally be installed on any HD2 frame. Side panels and PDUs are also optional. Each side panel adds 6.8 kg (15 lb). Each PDU adds 4.5 kg (10 lb).
2. With the air conditioner installed
3. Frame width only. Extra inter-frame spacing of 30 mm (1.2 in) is required.
4. The weight with drives and cartridges assumes a weight of 3.97 kg (8.75 lb) for a 3592 EH7 or 3592 EH8 tape drive and 0.24 kg (0.5 lb) for a standard 3592 tape cartridge. The actual weight of the frame varies, depending on the configuration and cartridge capacity. Listed weights are plus or minus 2.3 kg (5 lb).
5. Frames in position 1 (the leftmost frame in a library string) can have a maximum of 12 tape drives and 550 (L25) or 590 (D25) cartridges. Frames in positions 2+ can accommodate 16 tape drives and 660 (L25) or 740 (D25) cartridges.
6. Weights listed for the Lx5 frames include the accessor, IMC, side doors and side panels. After the initial library installation, these parts can be moved to other frames within the library string, which shifts some of the weight to other frames.

Physical specifications for frame models L55 and D55

Table 30. Physical characteristics of frame models L55 and D55		
Physical Characteristic	**Measurement**	
Height of L55 and D55 frames (on casters)	1 800 mm (70.9 in)	
Height of L55 and D55 frames with top rack	2 320 mm (91.34 in)	
Width of L55 frame with covers	782 mm (30.8 in)	
Width of L55 or D55 frame without covers[2]	725 mm (28.5 in)	
Depth of L55 or D55 frame (including front and rear doors)	1 212 mm (47.72 in)	
	Position 1 (Leftmost frame)	**Position 2+**
Minimum weight of frame (with no tape drives or cartridges)[5, 6]	**L55:** 410 kg (904 lb) **D55:** 316 kg (697 lb)	**L55:** 410 kg (904 lb) **D55:** 316 kg (697 lb)
Maximum weight of frame (with maximum tape drives and cartridges)[3, 4, 5, 6]	**L55**: 592 kg (1 305 lb) **D55**: 503.5 kg (1 110 lb)	**L55**: 637 kg (1 404 lb) **D55**: 557 kg (1 228 lb)
Weight of top rack (empty)[1]	24.5 kg (54 lb)	

Table 30. Physical characteristics of frame models L55 and D55(continued)

Physical Characteristic	Measurement

Notes:

1. A top rack can optionally be installed on any frame. Side panels and PDUs are also optional. Each side panel adds 6.8 kg (15 lb). Each PDU adds 4.5 kg (10 lb).
2. Frame width only. Additional inter frame spacing of 30 mm (1.2 in) is required.
3. The weight with drives and cartridges assumes a weight of 3.29 kg (7.25 lb) for an LTO tape drive and 0.2 kg (0.44 lb) for a standard LTO tape cartridge. The actual weight of the frame varies, depending on the configuration and cartridge capacity. Listed weights are plus or minus 2.3 kg (5 lb).
4. Frames in position 1 (the leftmost frame in a library string) can have a maximum of 12 tape drives and 730 (L55) or 774 (D55) cartridges. Frames in positions 2+ can accommodate 16 tape drives and 882 (L55) or 970 (D55) cartridges.
5. Weights listed for the Lx5 frames include the accessor, IMC, side doors and side panels. After the initial library installation, these parts can be moved to other frames within the library string, which shifts some of the weight to other frames.

Physical specifications for frame model S25

Table 31. Physical characteristics of frame model S25

Physical Characteristic	Measurement	
Height of S25 frame (on casters)	1 800 mm (70.9 in)	
Height of S25 with top rack	2 320 mm (91.34 in)	
Width of S25 frame with covers	782 mm (30.8 in)	
Width of S25 frame without covers[1]	725 mm (28.5 in)	
Depth of S25 frame (including front and rear doors)	1 212 mm (47.7 in)	
	Position 1 (Leftmost frame)	**Position 2+**
Minimum weight of frame (0 cartridges)	299 kg (660 lb)	299 kg (660 lb)
Maximum weight of frame (with 0 drives and maximum cartridges)[3, 4]	491.2 kg (1 083 lb)	540.2 kg (1 191 lb)
Weight of top rack (empty)[2]	24.5 kg (54 lb)	

Notes:

1. Frame width only. Additional inter frame spacing of 30 mm (1.2 in) is required.
2. A top rack can optionally be installed on any HD2 frame. Side panels and PDUs are also optional. Each side panel adds 6.8 kg (15 lb). Each PDU adds 4.5 kg (10 lb).
3. The weight with cartridges assumes a weight of .24 kg (0.5 lb) for a standard 3592 tape cartridge. The actual weight of the frame varies, depending on the configuration and cartridge capacity. Listed weights are plus or minus 2.3 kg (5 lb).
4. Frames in position 1 (the leftmost frame in a library string) can have a maximum of 798 cartridges. Frames in positions 2+ can accommodate 1 000 cartridges.

Physical specifications for frame model S55

Table 32. Physical characteristics of frame model S55

Physical Characteristic	Measurement	
Height of S55 frame (on casters)	1 800 mm (70.9 in)	
Height of S55 with top rack	2 320 mm (91.34 in)	
Width of frame with covers	782 mm (30.8 in)	
Width of frame without covers[1]	725 mm (28.5 in)	
Depth of S55 frame (including front and rear doors)	1 212 mm (47.7 in)	
	Position 1 (Leftmost frame)	**Position 2+**
Minimum weight of frame (with 0 cartridges)	304 kg (670 lb)	304 kg (670 lb)
Maximum weight of frame (with 0 drives and maximum cartridges)[3, 4]	509.4 kg (1 123 lb)	564 kg (1 244 lb)
Weight of top rack (empty)[2]	24.5 kg (54 lb)	

Notes:

1. Frame width only. Additional interframe spacing of 30 mm (1.2 in) is required.
2. A top rack can optionally be installed on any HD2 frame. Side panels and PDUs are also optional. Each side panel adds 6.8 kg (15 lb). Each PDU adds 4.5 kg (10 lb).
3. The weight with cartridges assumes a weight of .2 kg (0.44 lb) for a standard LTO tape cartridge. The actual weight of the frame varies, depending on the configuration and cartridge capacity. Listed weights are plus or minus 2.3 kg (5 lb).
4. Frames in position 1 (the leftmost frame in a library string) can have a maximum of 1 054 cartridges. Frames in positions 2+ can accommodate 1 320 cartridges.

Library placement

To ensure optimal performance, the TS4500 tape library must be placed in a location that meets certain requirements and environmental specifications.

To avoid damage to the library, tape drives, and tape media, place the tape library away from equipment that produces any of the following pollutants (such as laser printers, ultrasonic humidifiers, and ionizers):

- Airborne dust
- Particulate pollution
- Corrosive fumes

Refer to “Environmental specifications” on page 80 for detailed information about gaseous and particulate contamination.

Floor requirements

The TS4500 tape library must be placed on floor space that meets the following specifications. Use the list of allowable variances for floor stability, unevenness, and point load bearing qualities to determine where the TS4500 tape library is placed.

Install the library on a raised or solid floor. The floor must have a smooth surface and, if raised, must not have ventilation panels beneath the leveling jack screws. If carpeted, ensure that the carpet is approved for computer-room applications.

To accommodate unevenness in the floor, you can raise or lower the leveling jack-screws to the following specifications:

- Maximum allowable variance must not exceed 7 mm (.27 inches) per 76 mm (3 inches).
- Maximum out-of-level condition must not exceed 40 mm (1.6 inches) over the entire length and width of the library.

The floor on which the TS4500 tape library is installed must be able to support:

- Up to 5.0 kilograms per square centimeter (71.5 pounds per square inch) of point loads that are exerted by the leveling jack-screws.
- Up to 370 kilograms per square meter (75.8 pounds per square foot) of overall floor loading.

Note: The Top Rack (TR1) and the components in the Top Rack are not included in the floor loading requirements.

The number of point loads that is exerted depends on the number of frames that make up the library. The locations of the four point loads per frame are at the corners of each frame.

Delivery route

The TS4500 tape library must be delivered using a planned route. Check the delivery route that the library must travel from your loading dock to the installation location. Ensure that the library will fit through all doors, hallways, and elevators.

You must remove the library from the pallet and place it at the final location before you call your IBM Service Representative to arrange for the installation. Refer to the instructions on the shipping carton for correct unpacking procedures.

Because of the size and weight of this product, the transportation of this equipment must be performed by professional movers or riggers who are trained to handle large heavy objects. The IBM-authorized service provider will only perform minimal frame repositioning within the computer room, as needed, to perform required service actions.

Security

The equipment must be located so that access to the equipment can be controlled and monitored. Consider all of these recommended security measures when you are determining where to locate your TS4500 tape library.

Library location

You are responsible for the security of the TS4500 tape library, the cartridges that are contained within the library, and shelf-resident cartridges. To prevent unauthorized access to data, IBM recommends locating the TS4500 tape library and all shelf-resident cartridges in an area where access is controlled.

Locking mechanisms

The I/O stations have locking mechanisms that prevent you from opening an I/O station door when the accessor is manipulating cartridges in a station. The library's front door has a key lock. The key-lock is the same for every front door, and the keys are shipped with the library. The side doors of the base frames (Lx5) also have a key lock, which is the same key lock that is used for the front door. The library's rear door has a different key lock. The key lock is the same for every rear door and the keys are shipped with the library.

Onsite security measures

You are also responsible for evaluating, selecting, and implementing security features, administrative procedures, and appropriate controls in application systems and communication facilities.

Data security

Data security is accomplished through the TS4500 management GUI. For more information, see the IBM TS4500 customer online documentation in the IBM Knowledge Center. For more information about data security, see Access and Security.

Move restraints

The TS4500 tape library has several move restraints (adjustable points) that you can use to restrain the unit from potential movement (such as an earthquake). Use the diagram as a guide to help you locate the move restraints.

Restraining points are at the bottom of the unit (see 1 in Figure 13 on page 70). There are four restraining points at the bottom four corners of each frame. Affix restraints to each of the four points (two on each long side) and secure the library as needed. The restraint points provide threaded holes, thread size M10.

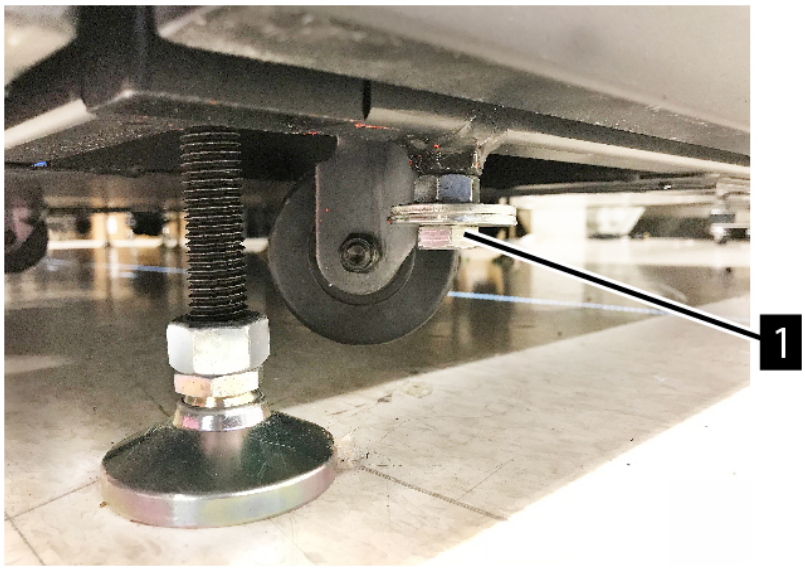


Figure 13. Location of restraining points

Additional library grounding (bonding)

You can attach additional grounding (bonding) wires to the TS4500 tape library frame.

The library is grounded to the grounding conductor of the AC power distribution of the building through the library power cords. However, you can provide additional grounding (bonding) of the library frames to the building. A grounding (bonding) conductor may be attached to any library frame at one of the 2

threaded holes (M6) at the bottom, back corners of the library frame. See 1 and 2 in Figure 14 on page 71.

The library frames are electrically bonded together by the accessor rail and the frame to frame mechanical connections. It is not necessary to bond every frame individually.

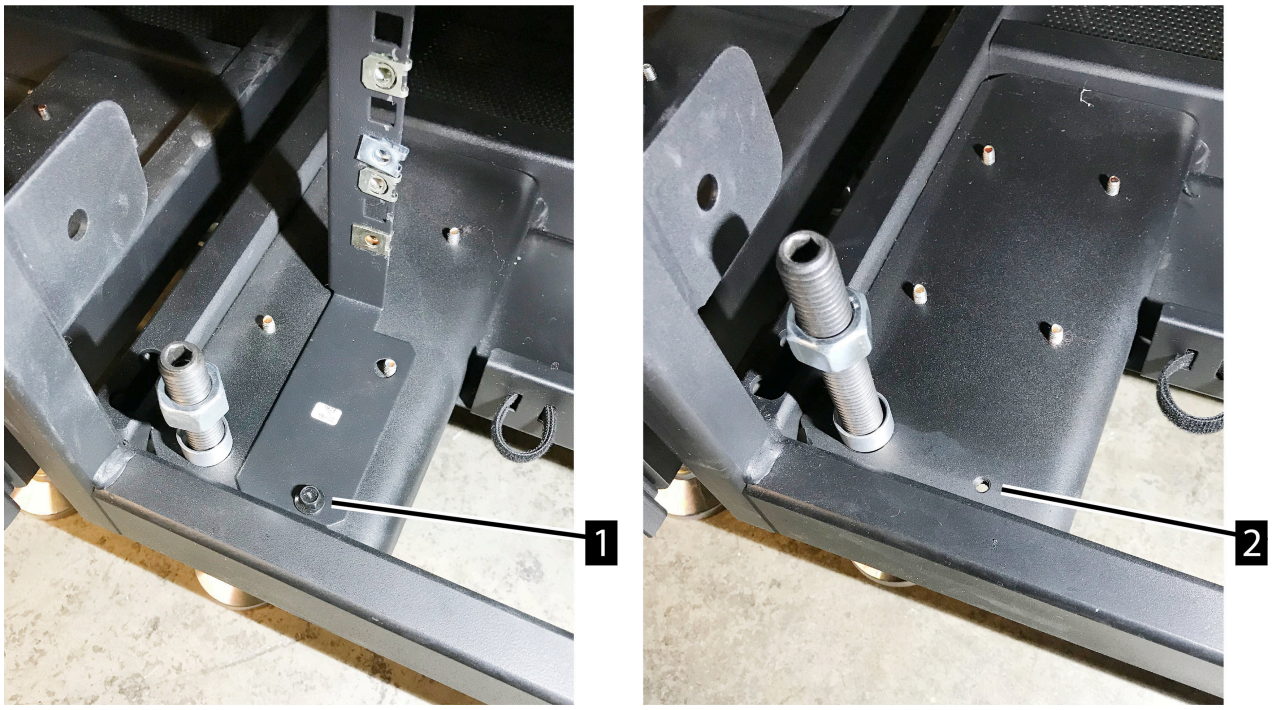


Figure 14. Location of grounding/bonding points

To install your additional grounding (bonding) wires:

1. If there is a mounting bracket installed in the frame (See 1 in Figure 14 on page 71). Remove the M6 screw and connect the grounding (bonding) wire.
2. If there is not a mounting bracket installed (See 2 in Figure 14 on page 71). Use an M6 screw to connect the bonding wire to the threaded M6 hole.

Clearance specifications for the library

Clearances are required around the tape library to enable access for you or IBM service representatives to use or work on the library. Use this information when you are determining the location and position of your library.

Plan for appropriate clearances around your tape library. For a single accessor library, you need a service clearance of a minimum of 762 mm (30 in) on the front and back of each frame, in addition to the side where the Integrated Management Console (IMC) is installed.

For a dual accessor library, you need a minimum of 762 mm (30 in) clearance on the front and back of each frame, in addition to both ends of the library string.

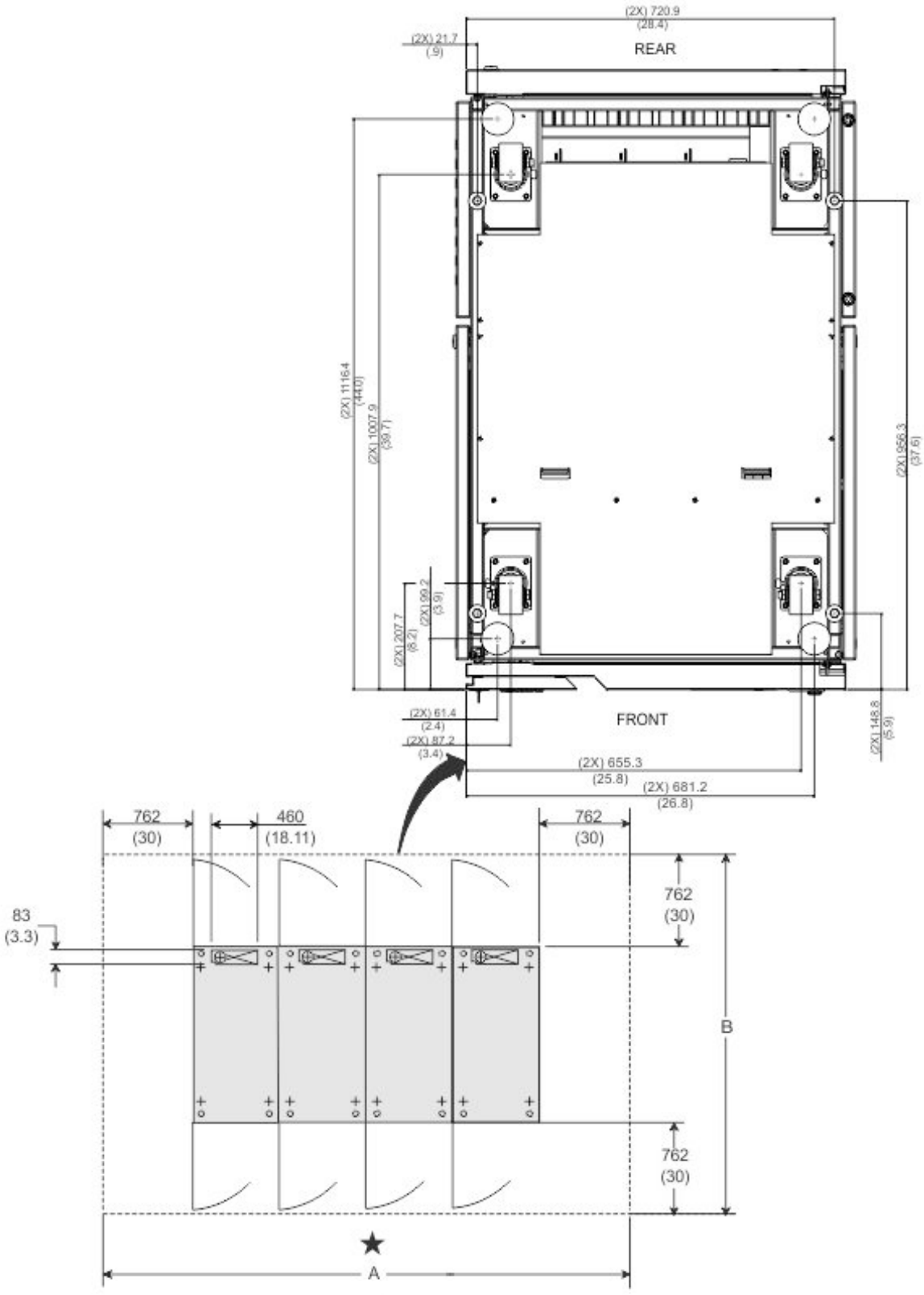
Ensure that service clearance space does not overlap into high-traffic walkways where service activity might impede pedestrian traffic. As you plan clearances, consider leaving extra room on either end of the library for future expansion.

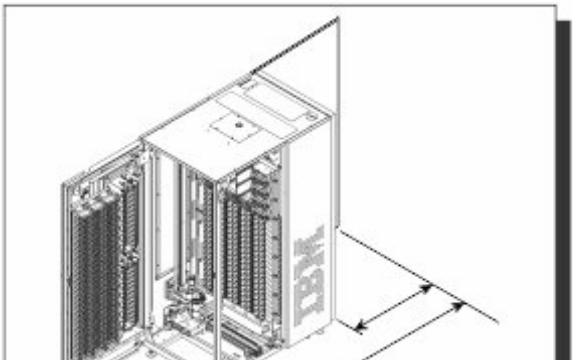
Table 33. TS4500 tape library footprint including service clearance

Number of Frames	Minimum Length of A in Figure 15 on page 73 (Single Accessor) (see Note 1)	Minimum Length of A in Figure 15 on page 73 (Dual Accessor)	Minimum Length of B in Figure 15 on page 73
1	1 544 mm (60.8 in.)	n/a	2 737 mm (107.8 in.)
2	2 298 mm (90.5 in.)	3 061 mm (120.5 in.)	2 737 mm (107.8 in.)
3	3 053 mm (120.2 in.)	3 815 mm (150.2 in.)	2 737 mm (107.8 in.)
4	3 808 mm (149.9 in.)	4 570 mm (179.9 in.)	2 737 mm (107.8 in.)
5	4 562 mm (179.6 in.)	5 324 mm (209.6 in.)	2 737 mm (107.8 in.)
6	5 317 mm (209.3 in.)	6 079 mm (239.3 in.)	2 737 mm (107.8 in.)
7	6 072 mm (239.0 in.)	6 834 mm (269 in.)	2 737 mm (107.8 in.)
8	6 826 mm (268.7 in.)	7 588 mm (298.7 in.)	2 737 mm (107.8 in.)
9	7 581 mm (298.5 in.)	8 343 mm (328.5 in.)	2 737 mm (107.8 in.)
10	8 335 mm (328.2 in.)	9 097 mm (358.2 in.)	2 737 mm (107.8 in.)
11	9 090 mm (357.9 in.)	9 852 mm (387.9 in.)	2 737 mm (107.8 in.)
12	9 845 mm (387.6 in.)	10 607 mm (417.6 in.)	2 737 mm (107.8 in.)
13	10 599 mm (417.3 in.)	11 361 mm (447.3 in.)	2 737 mm (107.8 in.)
14	11 354 mm (447.0 in.)	12 116 mm (477.0 in.)	2 737 mm (107.8 in.)
15	12 108 mm (476.7 in.)	12 870 mm (506.7 in.)	2 737 mm (107.8 in.)
16	12 863 mm (506.4 in.)	13 625 mm (536.4 in.)	2 737 mm (107.8 in.)
17	13 618 mm (536.1 in.)	14 380 mm (566.1 in.)	2 737 mm (107.8 in.)
18	14 372 mm (565.8 in.)	15 134 mm (595.8 in.)	2 737 mm (107.8 in.)

Note:

1. For libraries with service clearance on the right end only (as you face the front door): Visual access is required on the left end as determined by the local service team. This visual access allows an IBM service representative to see the two-character display on the left side of the cartridge accessor.





- ○ Leveling pad
- \+ Caster
- ⊕ Power cord exit
- Cable exit area
- ★ Operator side
- ◎ Move restraints

Cable routing

Normally, cables are routed through the rear openings at the bottom of the frame. If the library is being installed on a solid (non-raised) floor, your IBM Service Representative can route the Fibre Channel, Ethernet, and power cables through openings in the frame at the top of the library.

Fibre Channel cables and Ethernet cables are routed through the frame opening shown in 1 in Figure 16 on page 74. Power cables are routed through the frame opening shown in Figure 17 on page 75. This illustration also shows the cable restraint assembly used to hold the power cables in place.

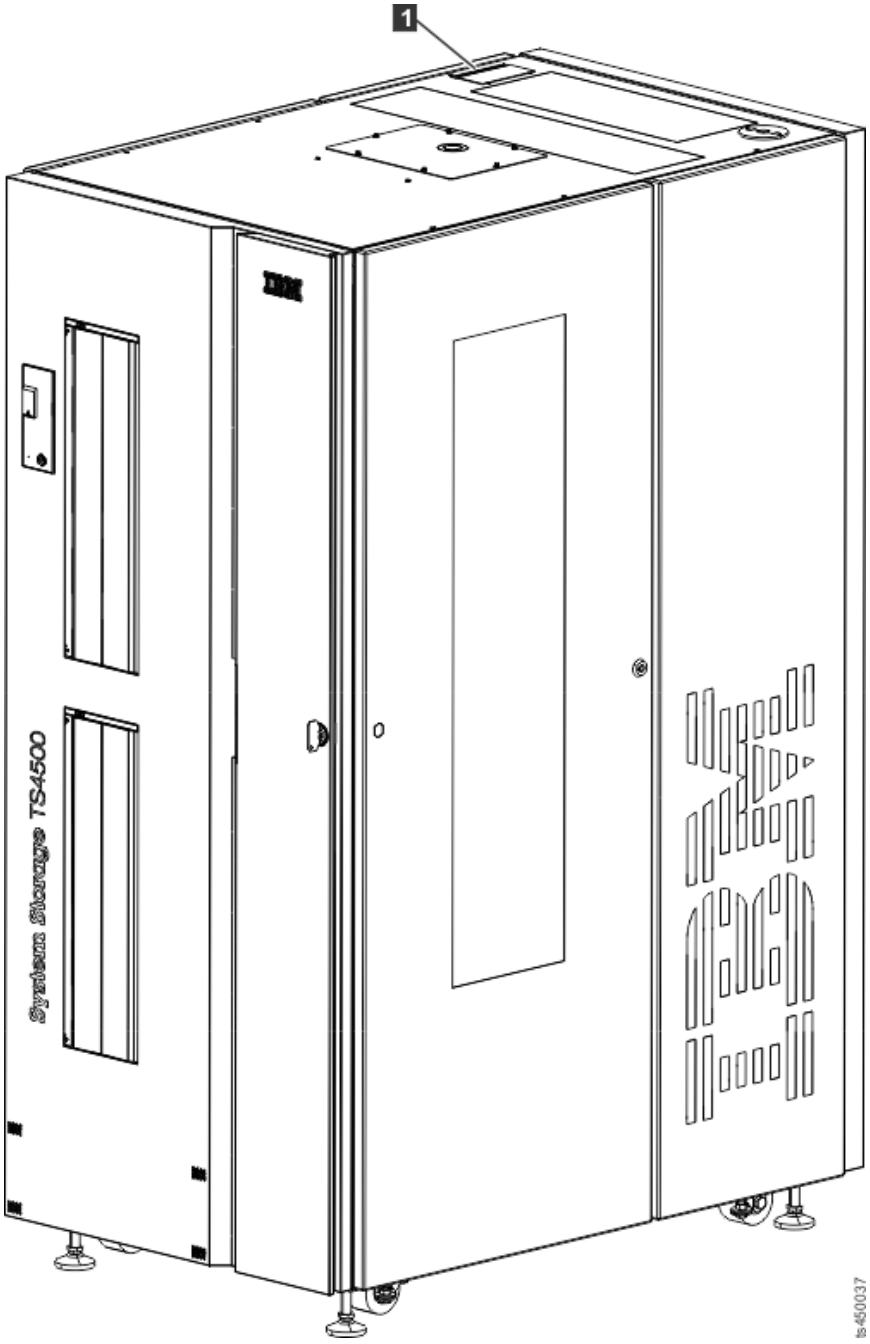


Figure 16. Access panel for Fibre Channel and Ethernet cable routing

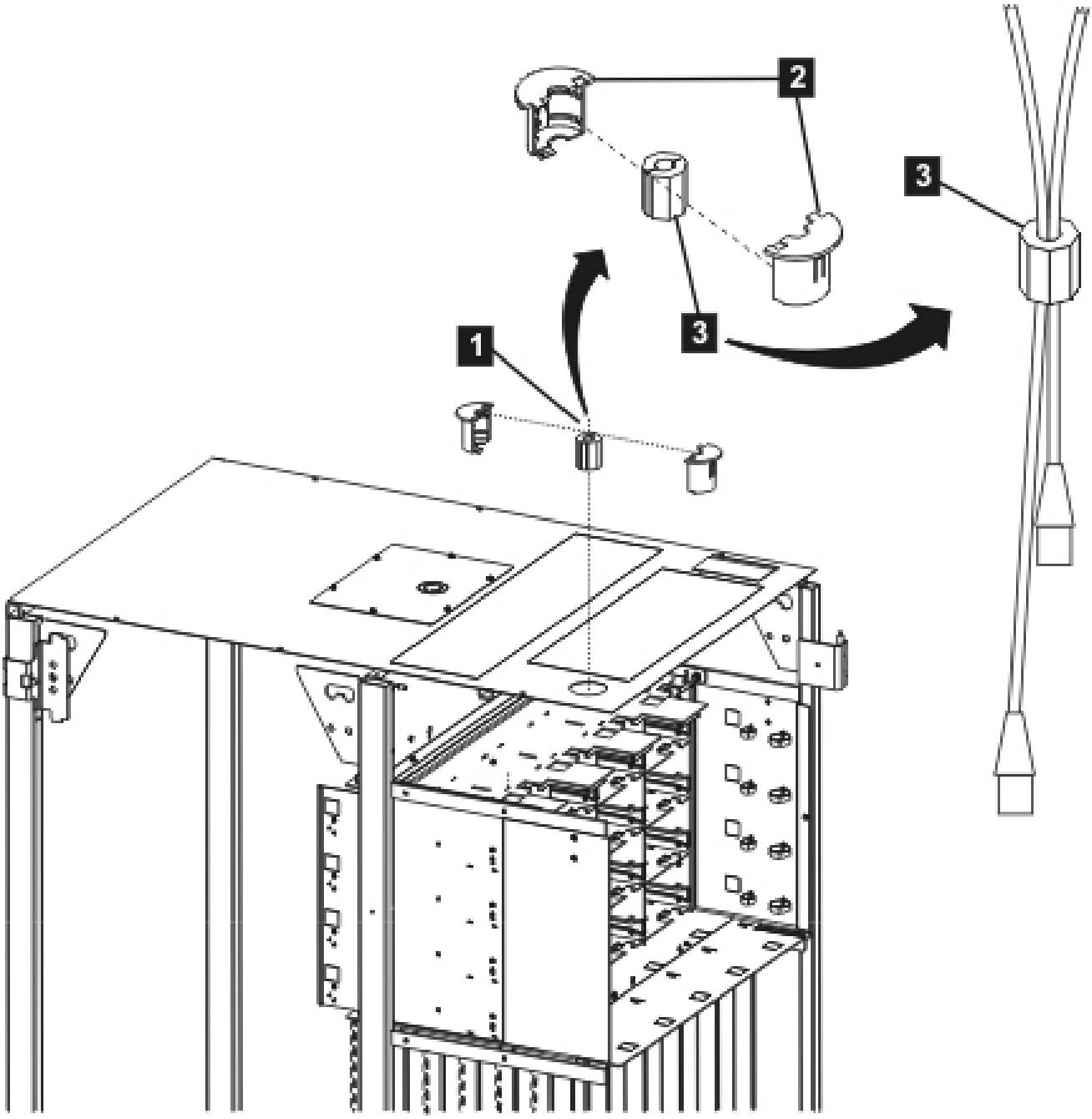


Figure 17. Opening in top of frame for power cables

Figure 18 on page 76 shows how the Fiber and Ethernet cables are routed through the openings on the top of the frame. However, you can also route the cables up from the bottom of the frame.

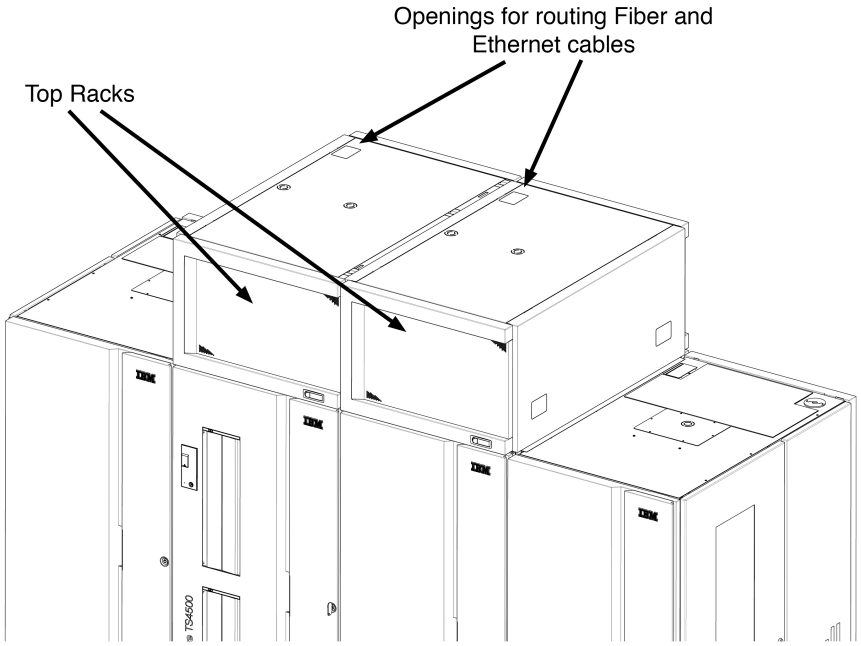


Figure 18. Access panel for Fibre Channel and Ethernet cable routing

Network connections

The TS4500 tape library provides support for an independent customer network. The Library Control Card (LCC) provides the Ethernet port A for the customer network. If a second, independent, customer network is required, Ethernet port A from an LCC on a D frame must be used. These connections allow remote viewing and management of the library. The customer network is also connected directly to the Tiny PC for remote support (Call Home) purposes.

Customer network Ethernet cables can be routed to the customer ports on the LCC and to the Tiny PC either up through the access hole in the bottom of the frame or through the access panel in the top of the frame. See Figure 19 on page 77.

If a top rack is going to be installed, the Ethernet cables are routed though the access panel in the top of the frame and then through the top rack. The Ethernet cables can also route through the access hole in the bottom of the frame. It is the customer's responsibility to provide the proper length Ethernet cable for this connectivity.

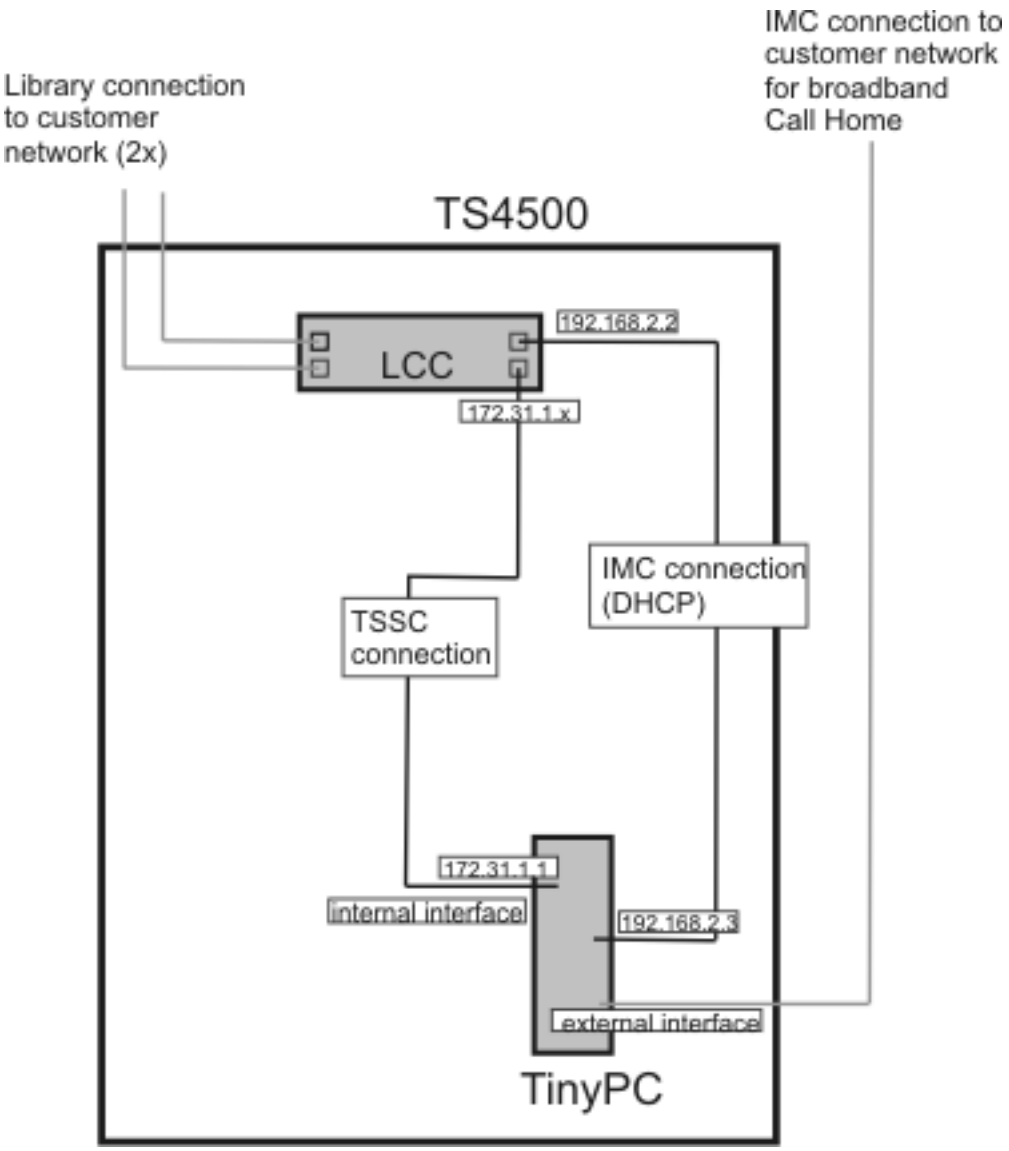


Figure 19. Customer network connections

Web cameras

A customer-supplied web camera can be mounted in a TS4500 tape library to visually monitor the location of the library's robotics. The mounting hardware must be installed by an IBM service representative.

A web camera can be installed in any frame, and the camera mount can be installed on the front or rear frame support. Feature code 1530, web camera mounting hardware, is required in order to install a web camera.

Camera size

The maximum camera dimensions can vary; however, no part of the camera should extend more than 60 mm (2.36 in.) from the center of the tripod mount (1/4-20 UNC threads). This ensures sufficient clearance (as shown in Figure 20 on page 78) so that accessor movement is not obstructed.

Note: The camera must be positioned at least 13 mm (0.5 in.) from the accessor to avoid possible collision (see Figure 20 on page 78).

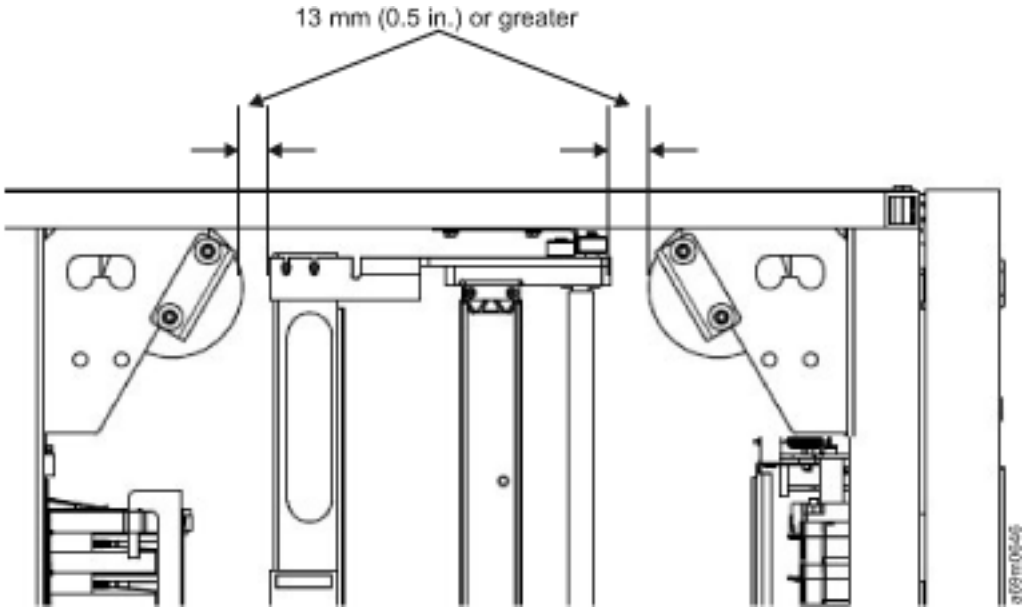


Figure 20. Camera clearance from accessor

Fire suppression

Each Dx5, Lx5, S25 frame in the TS4500 tape library has areas on the top where you can cut opening to install pipes, conduits, or other fire suppression parts.

A fire-suppression system is the responsibility of the customer

Attention: For advice about selecting a fire-suppression system that provides the correct level of coverage and protection, consult your insurance underwriter, and local fire marshal (or local building inspector).

IBM designs and manufactures equipment to internal and external standards that require certain environments for reliable operation. Because IBM does not test any equipment for compatibility with fire-suppression systems, IBM does not make compatibility claims of any kind nor does IBM provide recommendations on fire-suppression systems. The TS4500 tape library is constructed to allow third-party installation of fire-suppression equipment. When you are deciding whether to implement fire-suppression equipment, refer to local and national standards and regulations.

In a TS4500 tape library with Integrated Cooling, the top of the L25 and D25 frames are covered by the TR1 and the air conditioner. However, you can apply fire suppression piping through the top of the S25 frames. Figure 21 on page 79 shows the knockouts you can use to route your fire suppression piping into the frames.

See “Attachment of cables, wiring, and pipes between frames” on page 79 for how to route the fire suppression piping inside the library.

All water systems must be external to the library's frame, with mechanical support provided for piping.

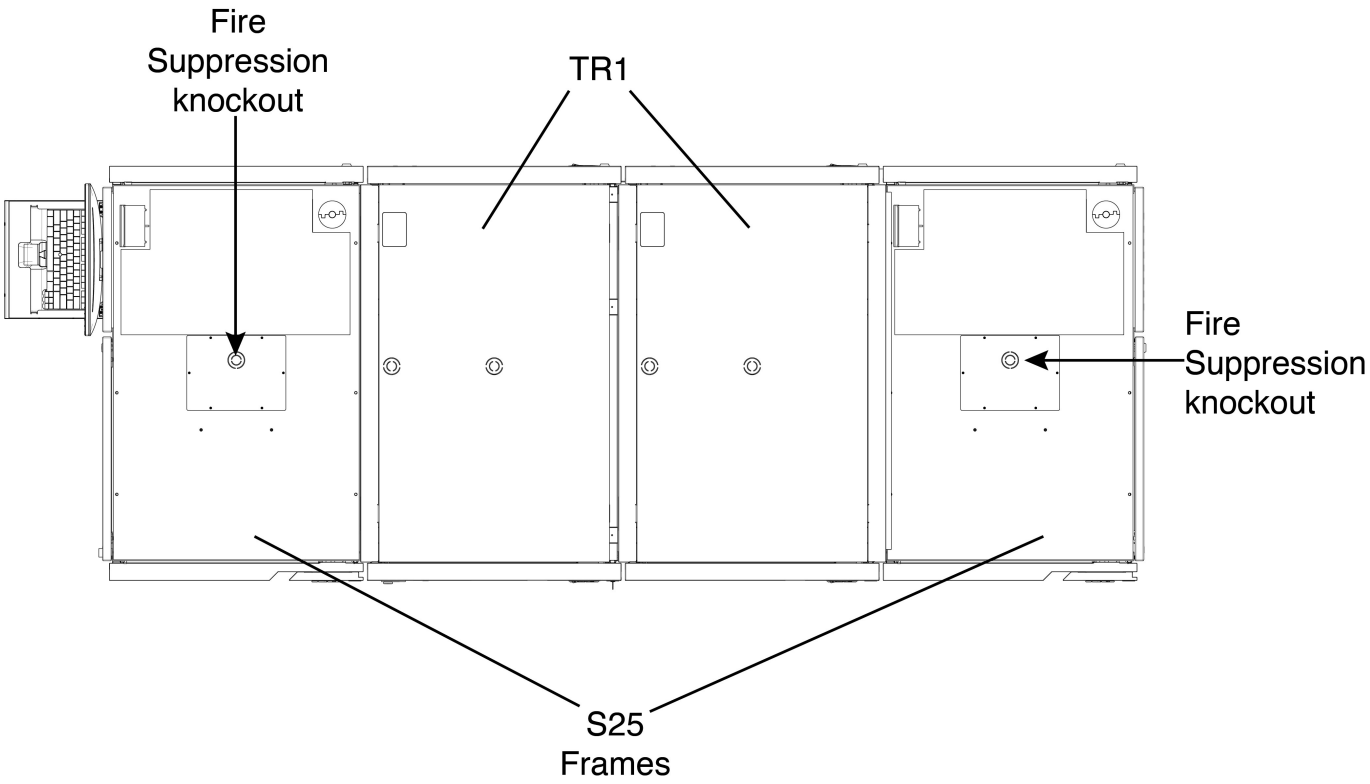


Figure 21. Allowable areas for routing fire-suppression equipment (top view of the library frames)

Attachment of cables, wiring, and pipes between frames

A side view of the area available to run cables, wiring, and pipes between frames of the TS4500 tape library is shown in Figure 22 on page 80. The area is a triangular section that is 81 mm (3.2 inches) wide by 140 mm (5.5 inches) long (see 1 in Figure 22 on page 80). All of the fire suppression tubing and equipment that routes between frames **must stay** within the area of the triangle section 1.

Inside a frame, all the fire suppression equipment **must stay** within the upper back portion of the frame. Figure 22 on page 80 illustrates this area with the four directional arrows and dotted line.

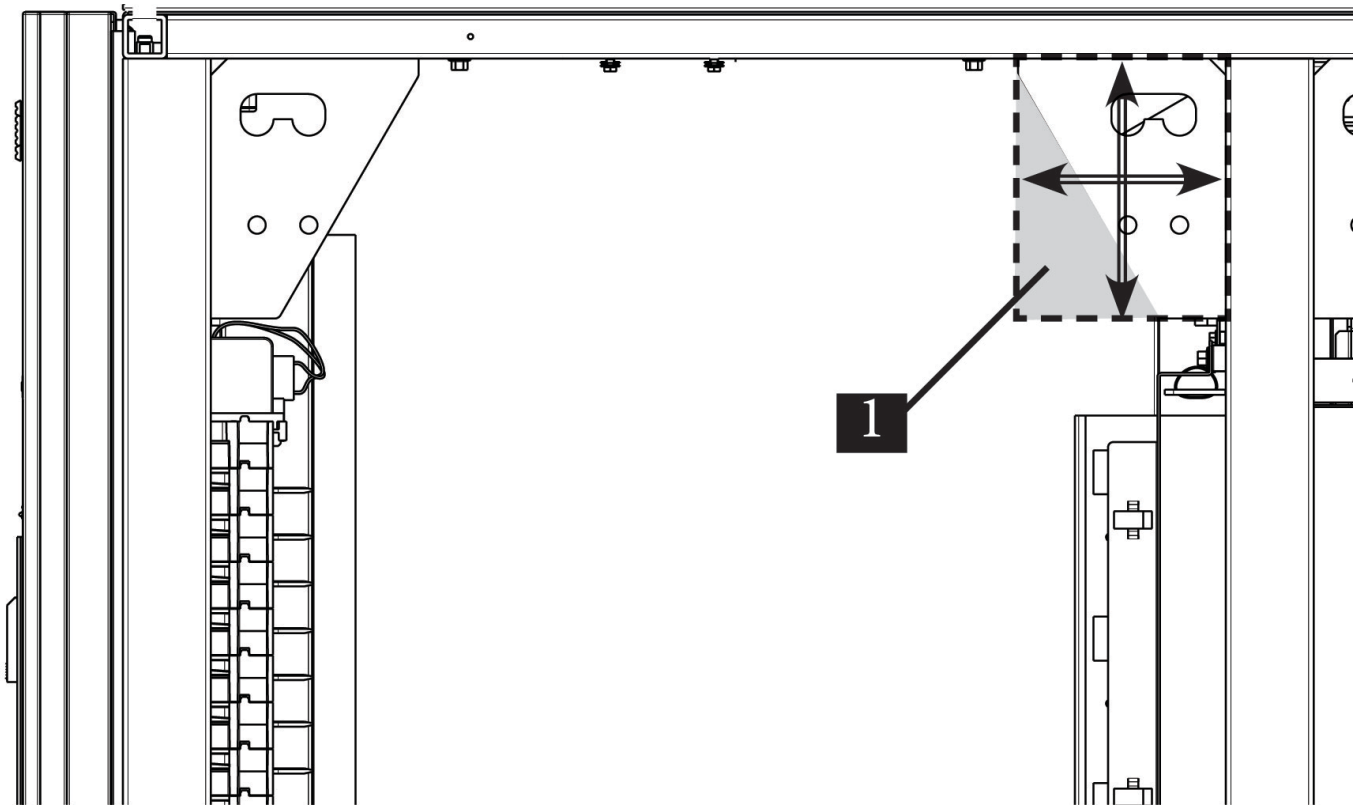


Figure 22. Location for routing fire-suppression equipment between frames

Route gaseous system piping with discharge nozzles inside the frames just below the top of the frame. Gas cylinders and control equipment must be external to the library. IBM does not supply heat or smoke detectors.

Environmental specifications

Refer to these environmental specifications to determine where to place the TS4500 tape library.

Table 34 on page 81 lists the recommended environmental specifications for the tape library when operating and when powered off. Figure 23 on page 81 is a psychrometric chart showing the allowable and recommended operating environments. Table 35 on page 82 provides guidelines for gas and particulate exposure.

Attention: The environments in Table 34 on page 81 refer to the hardware of the tape library and may lead to temperatures greater than allowable for the cartridges and media stored in the library. Refer to the following topics and adjust the operating environment for the library accordingly.

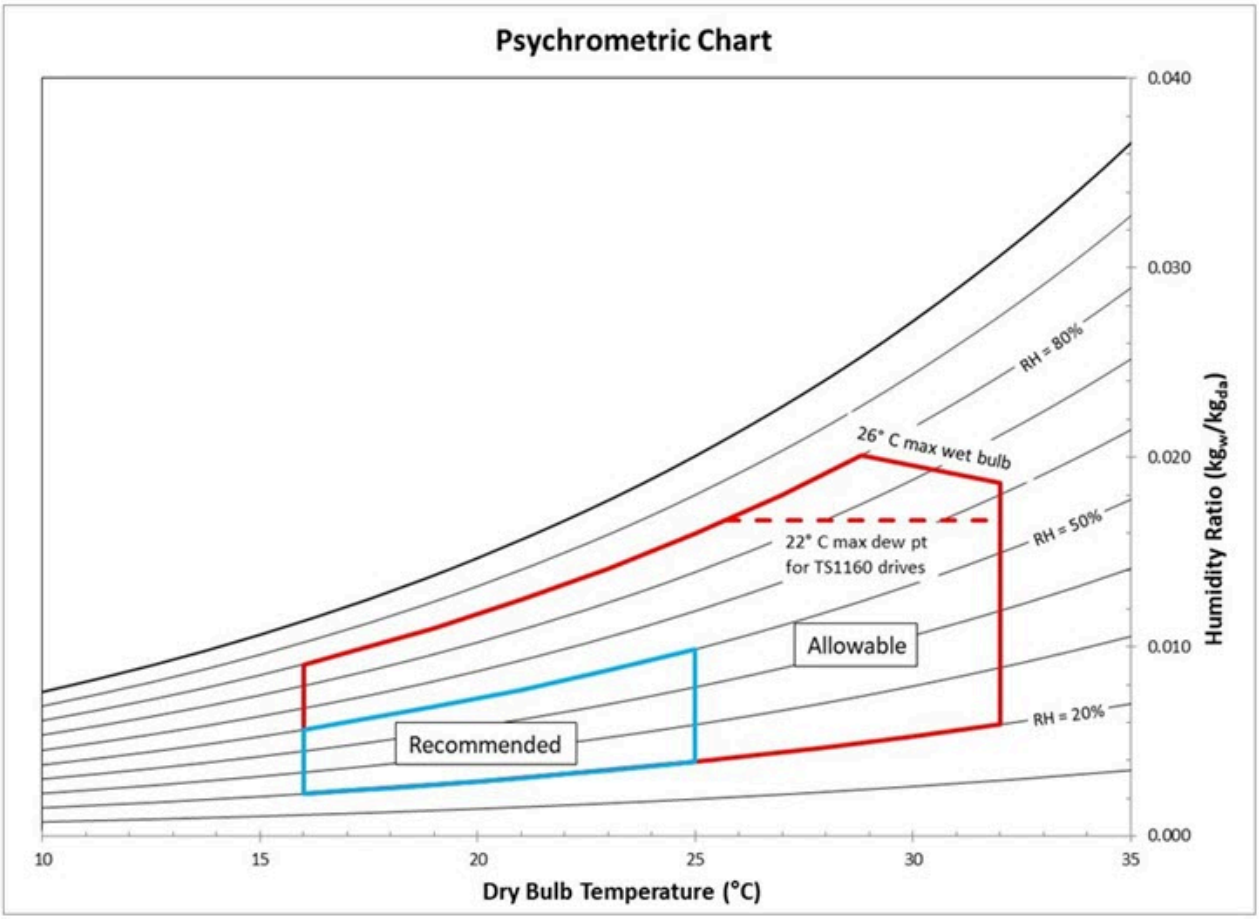
- "Environmental and shipping specifications for LTO tape cartridges" on page 135
- "Environmental and shipping specifications for IBM 3592 tape cartridges" on page 153

Table 34. Equipment environment specifications for the tape library

Product operation (equipment is powered on)									Product power off[1]		
Dry-bulb temperature			Humidity range, non-condensing			Maximum wet-bulb temperature[5]	Maximum dew point temperature[6]	Maximum elevation	Dry-bulb temperature	Relative humidity	Maximum wet-bulb temperature
Allowable[2]	Recommended[3]	Maximum rate of change	Allowable	Recommended	Maximum rate of change						
16 to 32°C (60 to 90°F)	16 to 25°C (60 to 77°F)	5°C/hour (9°F/hour)	20% to 80% RH	20% to 50% RH	5% RH/hour[4] with no condensation	26°C (79°F)	22°C (72°F)	3050 m (10,000 feet)	5 to 45°C (40 to 113°F)	8% to 80% RH	26°C (79°F)

Notes:

1. Product equipment is removed from the original shipping container and installed but not in use - for example, during repair, maintenance, or upgrade.
2. Derate maximum dry-bulb temperature 1°C/300 m above 900 m (1.8°F/1,000 feet above 3,000 feet).
3. Derate maximum recommended dry-bulb temperature 1°C/300 m above 1,800 m (1.8°F/1,000 feet above 6,000 feet).
4. For 3592 media, changes of up to 40% RH in 5 minutes are allowed as long as the 20% to 80% absolute limits are not exceeded.
5. Applies to LTO drive generations 1 through 8 and to legacy 3592 drives (TS1155 and prior generations).
6. Applies to TS1160 drives.



Notes:

- The chart is shown in SI (metric) units and a barometric pressure of 101.325 kPa (sea level).
- The recommended operating environment specifies a long-term operating environment that can result in the greatest reliability and energy efficiency.
- The allowable operating environment represents where the equipment has been tested to verify functionality. Due to the stresses that operating in the allowable envelope can place on the equipment, these envelopes should be used for short-term operation, not continuous operation (for example, in the case of a cooling failure).

Figure 23. Psychrometric chart showing recommended and allowable operating environments for the tape library

Table 35. Gas and particulate exposure	
Contaminate	**Requirement**
Gaseous contamination	Severity level G1 as per ANSI/ISA 71.04-1985,[1] which states that the reactivity rate of copper coupons shall be less than 300 Angstroms per month (Å/month, ≈ 0.0039 µg/cm² - hour weight gain).[2] In addition, the reactivity rate of silver coupons shall be less than 300 Å/month (≈ 0.0035 µg/cm² - hour weight gain).[3] The reactive monitoring of gaseous corrosivity should be conducted approximately 5 cm (2 inches) in front of the rack on the air inlet side at one-quarter and three-quarter frame height off the floor or where the air velocity is much higher.
Particulate contamination	Data centers must meet the cleanliness level of ISO 14644-1 class 8. For data centers without airside economizer, the ISO 14644-1 class 8 cleanliness might be met simply by the choice of the following filtration: • The room air might be continuously filtered with MERV 8 filters. • Air entering a data center might be filtered with MERV 11 or preferably MERV 13 filters. For data centers with airside economizers, the choice of filters to achieve ISO class 8 cleanliness depends on the specific conditions present at that data center. The deliquescent relative humidity of the particulate contamination should be more than 60% RH.[4] Data centers must be free of zinc whiskers.[5]

Notes:

1. ANSI/ISA-S71.04. 1985. *Environmental conditions for process measurement and control systems: Airborne contaminants*, Instrument Society of America, Research Triangle Park, NC, 1985.
2. The derivation of the equivalence between the rate of copper corrosion product thickness growth in Å/month and the rate of weight gain assumes that Cu_2S and Cu_2O grow in equal proportions.
3. The derivation of the equivalence between the rate of silver corrosion product thickness growth in Å/month and the rate of weight gain assumes that Ag_2S is the only corrosion product.
4. The deliquescent relative humidity of particulate contamination is the relative humidity at which the dust absorbs enough water to become wet and promote ionic conduction.
5. Surface debris is randomly collected from 10 areas of the data center on a 1.5 cm (0.6 inch) diameter disk of sticky electrically conductive tape on a metal stub. If examination of the sticky tape in a scanning electron microscope reveals no zinc whiskers, the data center is considered free of zinc whiskers.

Acoustical specifications

Several conditions must be in place to accommodate the acoustical specifications of the TS4500 tape library. This topic provides a general statement about the acoustical specifications.

When the TS4500 tape library is both operating and idling, the following conditions apply:

- Power is on.
- All air-moving devices are operating.
- Tape cartridges are loaded in all drives.

When the library is operating the cartridge accessor loads, unloads, or moves tape cartridges. When the library is idling the accessor does not move.

The TS4500 tape library is a Category 1 product as defined in C-S 1-1710-006.

Acoustical specifications for models L25, D25, L55, and D55

Use this table to view the acoustical specifications and noise emission values for Models L25, D25, L55, and D55 of the TS4500 tape library.

Table 36. Noise emission values for the TS4500 tape library models L25, D25, L55, and D55			
Declared Sound Power Level L_{WAd}		**Mean A-weighted Sound Pressure Level at the 1 m (Bystander) Positions $<L_{pA}>_m$**	
Operating (bels)	**Idling (bels)**	**Operating (dB)**	**Idling (dB)**
7.5 B	7.4 B	54 dB	51 dB
All measurements are in accordance with ANSI S12.10, and conform with ISO 9296.			

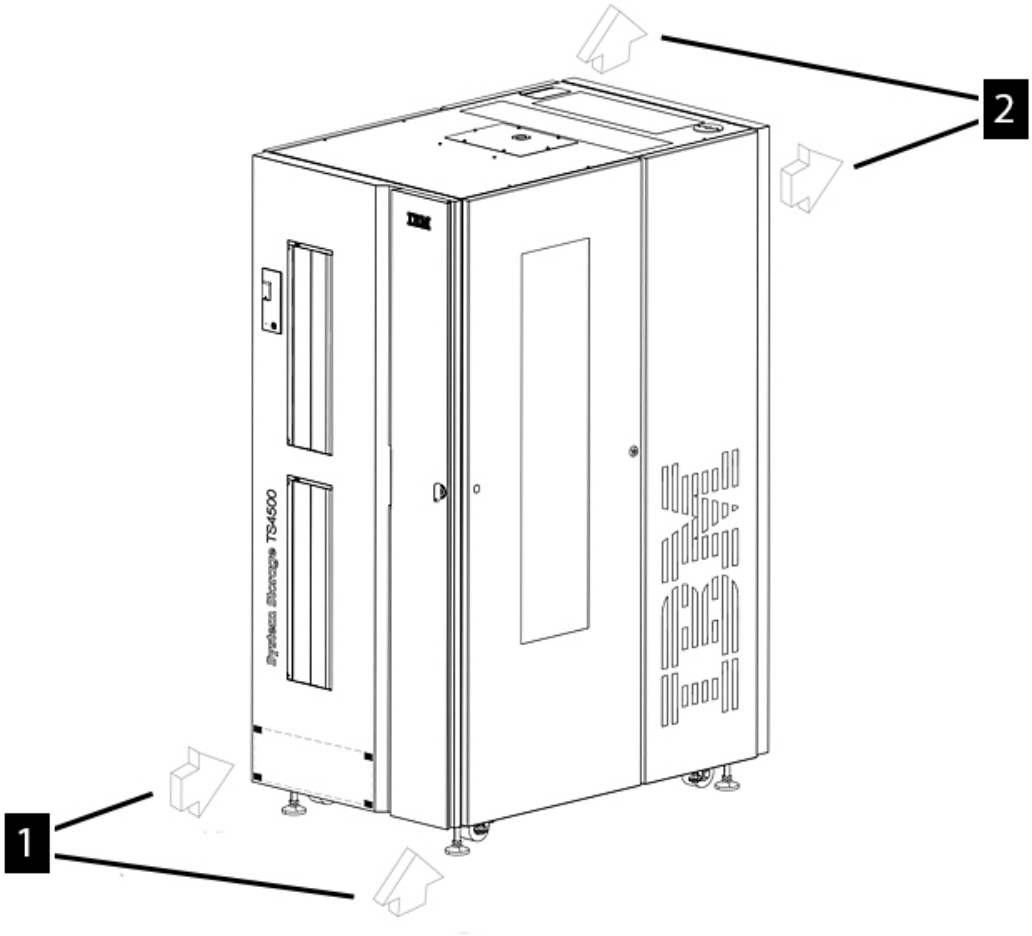
Air flow

The TS4500 Tape Library draws cool air in through the perforated holes in the front door and bottom front of the frame. Hot air vents through perforated holes in the back door and top back of the frame. The Sx5

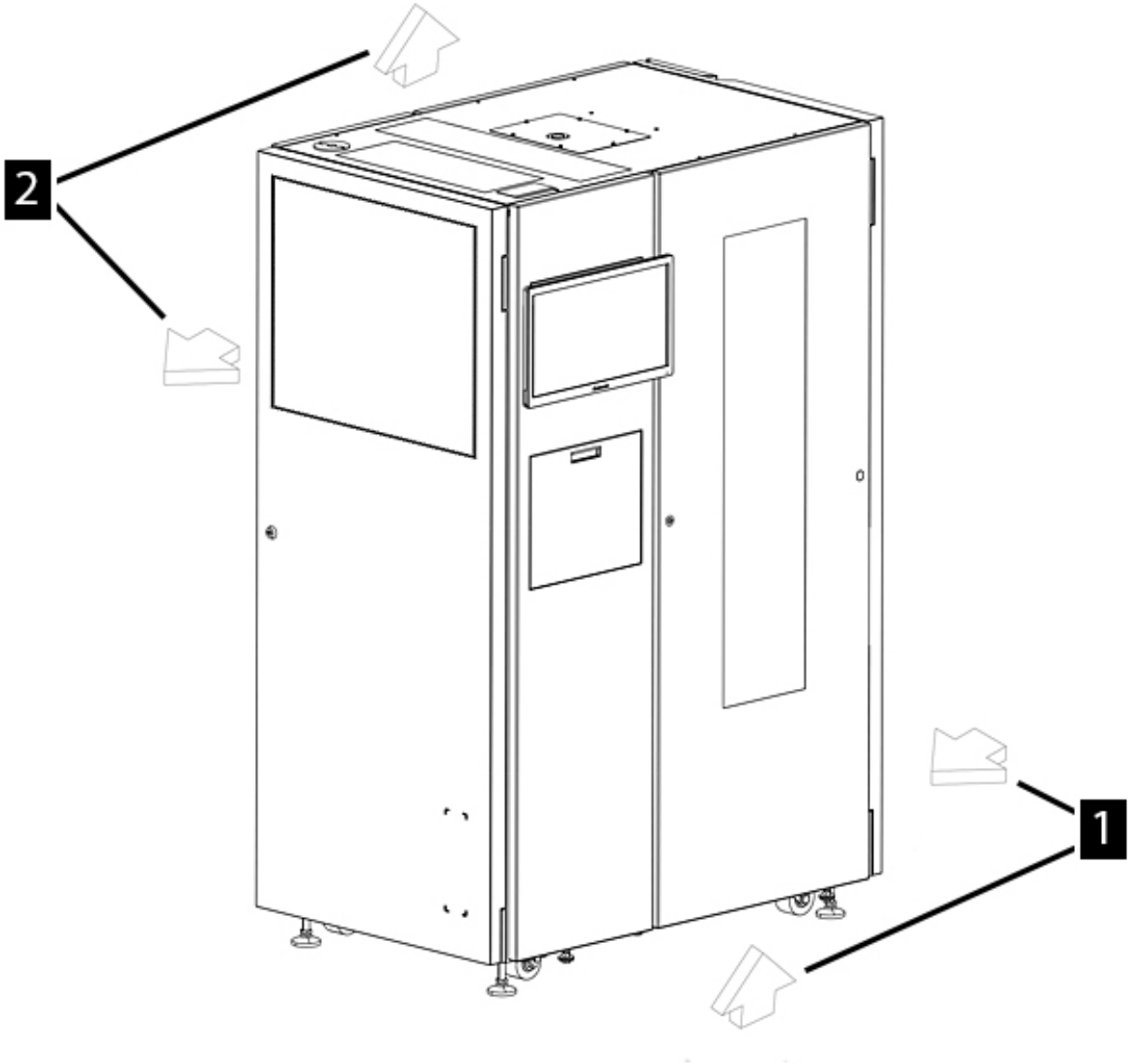
frames do not have any perforated holes in the back door. However, the cool air inlet in the front and hot air outlet in the top back of the frame are the same as the other frames.

Refer to “Air Flow - Front Isometric” on page 83 and “Air Flow - Rear Isometric view” on page 84.
Cold air 1 enters the library from the front and hot air 2 exits out the back.

Air Flow - Front Isometric



Air Flow - Rear Isometric view



The FCA and tape drives have their own cooling as part of their packages, but air must be allowed to flow freely from the top of the library. With the top rack installed, air flows from the top of the library through a 2-inch gap in the bottom of the top rack. Internal components in the top rack must be mounted so that they do not interfere with the air flow through the 2-inch gap in the bottom of the top rack. The rear door of the top rack is perforated to allow the hot air to exit.

Note: For air to flow freely from the top of the library, do not stack cartridges, books, or other materials on the top of the library.

Powering the components within the frame

The TS4500 tape library connects to AC power in multiple ways. The library is powered by two AC to DC power supplies in the Lx5 frame. You can also have power supplies that are installed in a Dx5 frame.

Powering the components within the frame

The Frame Control Assembly (FCA) includes power supplies for the tape drives that are installed in the frame. All Lx5 frames ship with an FCA. For Dx5 models, FC 1450 provides an FCA. If you have tape drives in a Dx5 frame, then FC1450 is required in that frame. The frame power supply provides power to the

drives and control cards within that frame. A single power supply is adequate to power the frame, but two power supplies are present for redundancy. Any of the AC to DC power supplies can supply power to components shared between frames, such as the frame lighting and cartridge accessors.

You can power TS4500 tape library in three basic ways (1) Standard Configuration, (2) Using Power Distribution Unit (PDU) Feature Code 1951/1952, (3) Using Feature code 1751/1752 with a Top Rack.

Standard power configuration

The standard TS4500 tape library power configuration requires the customer to supply two 20-amp power outlets per powered frame.

Figure 24 on page 85 shows a five frame library with the standard power configuration. In this example, the customer would provide six outlets.

Referring to 4, two power cords are shipped with each powered frame. The customer must specify the feature codes for the proper power cord type for their geographic location. The power cord feature codes for the standard configuration are FC99xx (Excluding FC9954 through 9959, and 9966).

The example also shows how two fiber channel switches 1 (FC 4880) are powered in this configuration. Two bifurcated power cords 2 and two bifurcated extensions (shown in blue) are shipped with the mounting kit FC 4879.

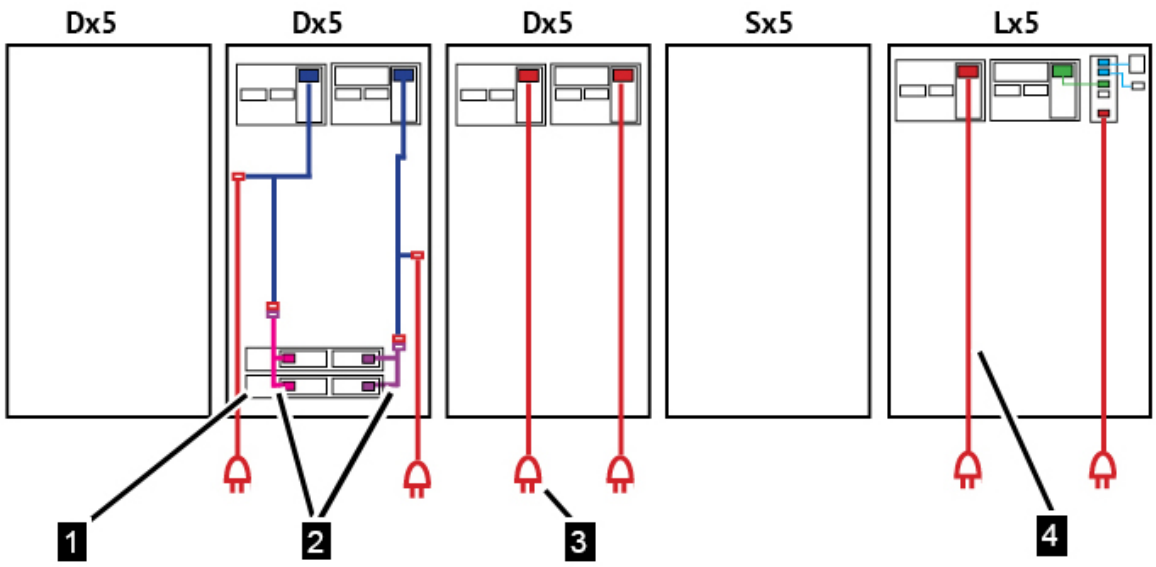


Figure 24. Standard power configuration (rear view of the library)

Using Power Distribution Unit (PDU) Feature Code 1951/1952

Feature Code 1951/1952 provides 2 PDUs to power the TS4500 tape library.

Figure 25 on page 86 shows a five frame library that is powered by using 2 PDUs (each FC 1951/1952 includes 2 PDUs, for redundancy) which are installed at the bottom of Frame 4. FC 1951/1952 can provide power for up to a total of three frames that are no more than three frames away from the PDUs. In this example, Frame 1 is three frames away from the PDUs in Frame 4.

The PDU requires two 200-240 vac power receptacles and a 30 amp circuit breaker. In this example, the customer only needs to provide two 30 amp rated outlets (one for each PDU in the FC 1951/1952) to power the entire library. The specific type of outlet that is required is determined by the specific power cord feature (FC 9954 through 9959, and 9966) that was ordered with the FC 1951 or (FC 9954 through 9958, and 9948) for FC 1952 (See 3, and 4 in Figure 25 on page 86). The FC1951/1952 includes two internal power cords that power the frame where the PDUs are installed (Frame 4). The customer

must order FC9989 (two 4.3-m power cords) for each powered frame that attaches to the PDUs. In this example, FC9989 would be ordered for Frame1, and Frame 5.

The fiber channel switches that are installed (In this example, Frame 5) plug directly into the PDU in the adjacent frame. Two of the power supply cables from the switches 1 plug into one PDU, and the other power cables 2 plug into the other PDU for redundancy. With this example of the switches plugged directly into the PDUs, the switches and PDUs must be in adjacent frames. For configurations that require the switches and PDUs to be 2 or 3 frames away from each other, the bifurcated power cords extensions must be used.

Referring to 4, the customer must specify the feature codes for the proper power cord type for their geographic location. The power cord feature codes that are used with FC1951 are FC9954 through 9959, and 9966. The power cord feature codes that are used with FC1952 are FC9954 through 9958, and 9948.

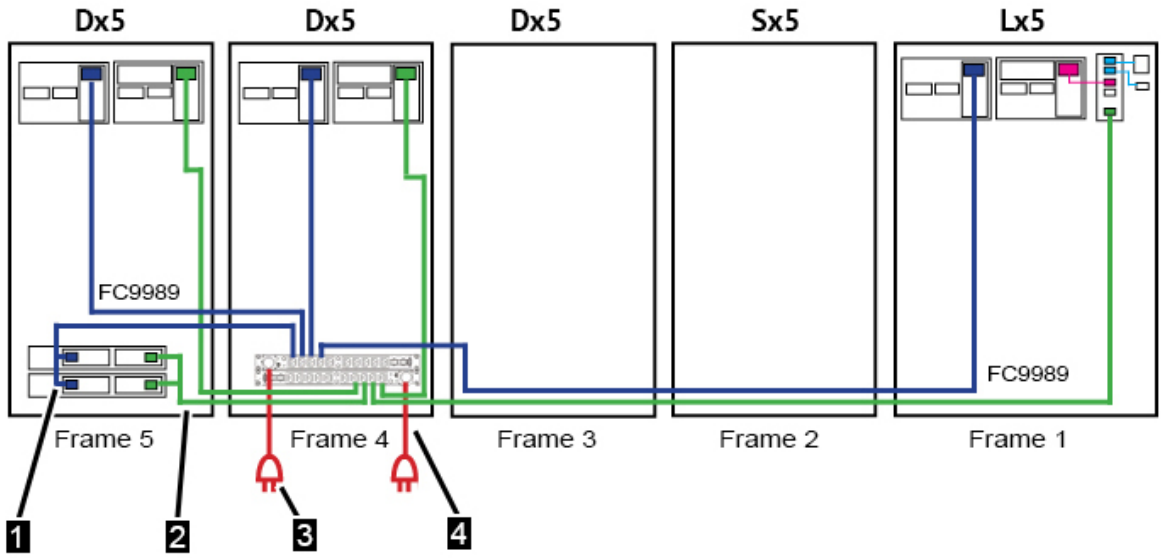


Figure 25. Power configuration with Feature Code 1951/1952 (rear view of the library)

Using Feature code 1751/1752 with a Top Rack

Feature Code 1751/1752 provides 1 PDU that is installed in a Top Rack, to power the TS4500.

Figure 26 on page 87 shows a five frame library that is powered with FC 1751. FC 1752 installs in the same way. This feature code provides one PDU. If the customer wants redundant power, then a second PDU (an extra FC1751/1752) must be ordered. In this example, two FC1751 would need to be ordered.

The customer must order FC9989 (Two 4.3-m power cords) for all the powered frames that attach to the PDU. In this example, FC9989 would be ordered for Frame 1, Frame 3, and Frame 4.

The customer must specify the feature codes for the proper power cord type 2 for their geographic location. The power cord feature codes that are used with FC1751 are FC9954 through 9959, and 9966. The power cord feature codes that are used with FC1752 are FC9954 through 9958, and 9948.

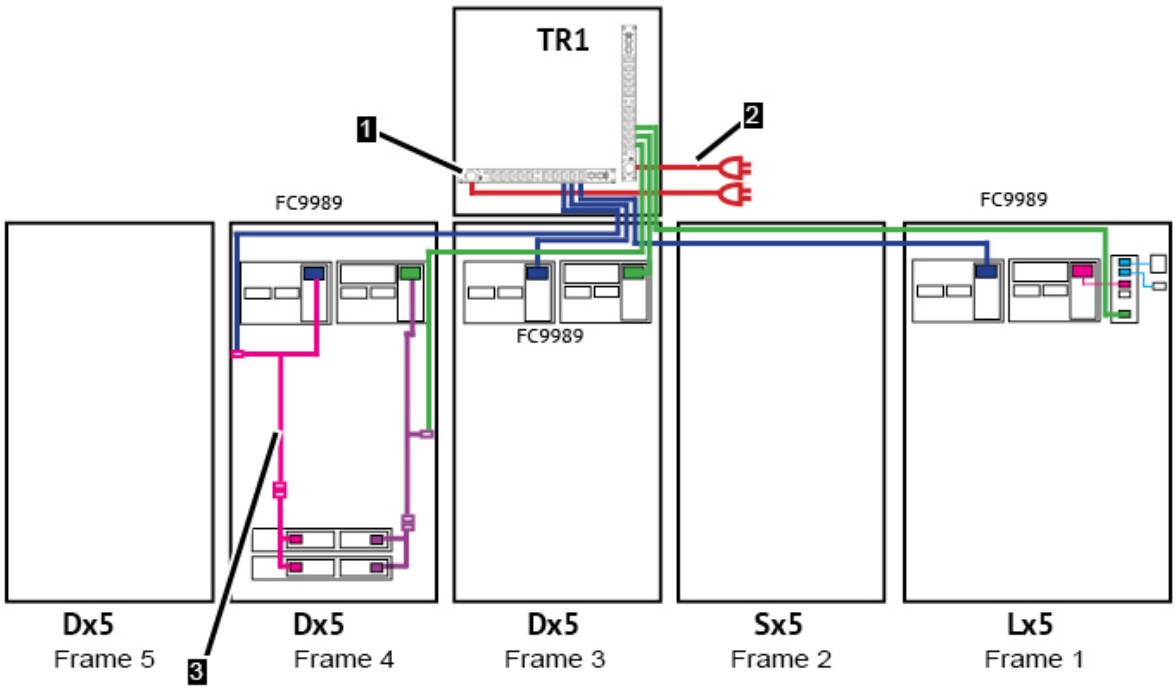


Figure 26. Power configuration with Feature Code 1751/1752 and Top Rack (rear view of the library)

Power consumption and cooling requirements

The power and cooling requirements for a frame depend on the frame model type, feature codes, and number and type of tape drives installed. Generally, the greater the number of tape drives in a frame, the more heat the frame generates. The cooling requirements increase in direct proportion to the amount of heat that is generated.

Table 37 on page 87 shows the power consumption and cooling requirements for frames, common feature codes, and tape drives. Table 38 on page 89 provides an example of how to calculate these values.

Table 37. Power consumption and cooling requirements for frame models

Description	Power consumption (watts)			Cooling requirements (Btu/hr, max. continuous) [2]
	Off [1]	Idle	Max. continuous (not peak)	
FRAME MODELS				
L25, L55 [3, 4]	11	95	130	443
D25, D55, S25, S55 [3, 5]	0	11	11	38
FEATURE CODES				
FC 1442 HA kit with second accessor	0	24	85	290
FC 1450 (TS4500 FCA) including one LCC and two AC/DC power supplies	11	38	38	130

Table 37. Power consumption and cooling requirements for frame models (continued)

Description	Power consumption (watts)			Cooling requirements (Btu/hr, max. continuous) [2]
	Off [1]	Idle	Max. continuous (not peak)	
FC 1460 (second LFI for Lx5 frame in a multiple frame library)	0	5	5	17
FC 1521, 1522, 1523, 1524 (quad drive mounting kits)	0	3	3	10
FC 1531, 1532, 1533, 1534 (quad drive mounting kits)	0	3	3	10
FC 1751 PDU (for TR1 top rack)	9	9	9	31
FC 1752 PDU	17	17	17	58
FC 1951 PDU	17	17	17	58
FC 1952 PDU	34	34	34	116
TAPE DRIVES (3592)				
TS1140 drive (3592 EH7) [6]	0	28	50	171
TS1150 drive (3592 EH8) [6]	0	23	48	164
TS1155 drive (3592 55F) [6]	0	23	48	164
TS1155 drive (3592 55E) [6]	0	50	63	215
TS1160 drive (3592 60F) [6]	0	39	63	215
TS1160 drive (3592 60E) [6]	0	38	62	211
TAPE DRIVES (LTO)				
TS1050 drive (LTO 3588 F5C) [6]	0	16	32	109
TS1060 drive (LTO 3588 F6C) [6]	0	13	36	123
TS1070 drive (LTO 3588 F7C) [6]	0	15	31	106
TS1080 drive (LTO 3588 F8S and F8C) [6]	0	18	40	136

Table 37. Power consumption and cooling requirements for frame models (continued)

Description	Power consumption (watts)			Cooling requirements (Btu/hr, max. continuous) [2]
	Off [1]	Idle	Max. continuous (not peak)	

Notes:

1. "Off" refers to power consumed when the library is connected to an AC power source and the library on/off switch is set to off.
2. To calculate the total cooling required by the library in Btu/hr, multiply the total power in watts by 3.41. To convert Btu/hr to kBtu/hr, divide your result by 1000.
3. Lx5 models and models with FC 1450 or FC1951 come equipped with dual AC power cords. The figures in the table show the total power that is consumed, including power that is consumed by redundant power supplies. Each power cord supplies approximately half of the power.
4. Lx5 frame power includes all frame loads, cartridge accessor, IMC, and display.
5. For base models that do not include FC 1450 (TS4500 FCA), the power consumption values indicate power that is provided by other frames. These values include power consumption for the lighting and two LFIs.
6. Idle power is consumed when the drive has no tape cartridge loaded. Maximum continuous power is consumed when the drive is actively reading and writing to the tape. These power consumption values includes the power that is required for the cooling fan at normal speed. In ambient environments that are hotter than the recommended range, the cooling fan might speed up and draw more power.

Table 38. Sample calculation of total library power consumption and cooling requirements

Frame model, feature codes, and drives	Quantity	Power (watts)			Cooling (kBtu/hr)[1]
		Off	Idle	Max. continuous	Max. continuous
L25	1	11	95	130	0.4
FC 1460 (multi-frame network; second LFI for Lx5 frame)	1	0	5	5	0.0
FC 1531, 1532, 1533, and 1534 (one of each FC per frame)	4	0	12	12	0.0
TS1160 drives	12	0	468	756	2.6
D25	3	0	33	33	0.1
FC 1450 (TS4500 FCA including one LCC and two ac/dc power supplies)	3	33	114	114	0.4
FC 1531, 1532, 1533, and 1534 (one of each FC per frame)	12	0	36	36	0.1
TS1160 drives	48	0	1872	3024	10.3
S25	4	0	44	44	0.2
FC 1442 (HA kit with second accessor; for Dx5 or Sx5)	1	0	24	85	0.3
Total library power consumption (watts)	--	**44**	**2703**	**4239**	14.5
Total cooling requirement (kBtu/hr)[1]	--	**0.2**	**9.2**	**14.5**	--

Table 38. Sample calculation of total library power consumption and cooling requirements (continued)					
		Power (watts)			Cooling (kBtu/hr)[1]
Frame model, feature codes, and drives	Quantity	Off	Idle	Max. continuous	Max. continuous

Notes:

1. To calculate the total cooling required by the library in Btu/hr, multiply the total power in watts by 3.41. To convert Btu/hr to kBtu/hr, divide your result by 1000.

Power cords and receptacles

Refer to tables that list the feature codes for each type of required power cord for your TS4500 tape library.

Power cords

Each frame receives single-phase (200–240 V ac) power on its own power cord from a customer-supplied outlet. Refer to Figure 27 on page 92 and match the number that is beside each receptacle to the receptacle number listed in the table.

Table 39. Specifications for power cords used with xx5 frame models		
Length and type of power cord	Part number and feature code[1]	Type of service receptacle
Dual 4.3 m (14 ft.) watertight, international 250 V ac, 16 A single phase. This power cord is for countries other than the United States and Canada (IEC-309)	45E2699 / 9970	IEC-309 2P +GND 16 A Uses receptacle #2
Dual 4.3 m (14 ft.) watertight, 250 V ac, 20 A single phase. This power cord is for the United States and Canada (IEC-309).	23R9540 / 9970	Hubbell HBL320R6W, IEC-309 2P +GND 20 A Uses receptacle #2
Dual 4.3 m (14 ft.) non-watertight, twistlock 250 V ac, 15 A. This power cord is for the United States and Canada.	39M5114 / 9972	NEMA L6-15R Uses receptacle #1
Dual 4.3 m (14 ft.) non-watertight, 250 V ac, 10 A, IRAM 2073. This power cord is for Argentina.	39M5066 / 9976	Uses receptacle #3
Dual 4.3 m (14 ft.) non-watertight, 250 V ac, 15 A, Earth Pin InMetro NBR 14136. This power cord is for Brazil.	39M5238 / 9977	Uses receptacle #4
Dual 4.3 m (14 ft.) non-watertight, 250 V ac, 10 A, AS/NZS 3112/2000. This power cord is for Australia and New Zealand.	39M5100 / 9978	Uses receptacle #3
Dual 4.3 m (14 ft.) non-watertight, 250 V ac, 15 A, JIS C8303, C8306. This power cord is for Japan.	39M5184 / 9979	Uses receptacle #5

Table 39. Specifications for power cords used with xx5 frame models (continued)		
Length and type of power cord	**Part number and feature code[1]**	**Type of service receptacle**
Dual 4.3 m (14 ft.) non-watertight, 250 V ac, 10 A, GB 2099.1, 1002. This power cord is for China.	39M5204 / 9980	Uses receptacle #3
Dual 4.3 m (14 ft.) non-watertight, 250 V ac, 15 A, with earth pin KS C8305, K60884-1. This power cord is for Korea.	39M5217 / 9981	Uses receptacle #6
Dual 4.3 m (14 ft.) non-watertight, 250 V ac, 10 A, CNS 10917-3. This power cord is for Taiwan.	39M5252 / 9982	Uses receptacle #5
Dual 4.3 m (14 ft.) non-watertight, 250 V ac, 16 A, SANS 164-1. This power cord is for South Africa.	39M5142 / 9983	Uses receptacle #7
Dual 4.3 m (14 ft.) 250 V ac, 15A, single phase power cord, non-watertight twistlock 20A receptacles. This power cord is for US and Canada.	23R9760 / 9984	NEMA L6-20R Uses receptacle #8
Dual 4.3 m (14 ft.) 250 V ac, 15A, single phase power cord, watertight 15A plugs. This power cord is for US and Canada.	23R9972 / 9985	Russellstoll 3743U2 or 9R23U2W receptacles, or Russellstoll 3913U2 or 9C23U2 connectors Uses receptacle #9
Dual 4.3 m (14 ft.) non-watertight, 250 V ac, 10 A power cord with IEC 60320 C14 connector. This power cord can be used worldwide to connect to spare outlets on FC 1950 PDUs. It can be used in an adjacent library frame or to a customer-provided PDU that is mounted external to the library frames.	46X7337 / 9989	IEC 60320 C13 Uses receptacle #13
Dual 4.3 m (14 ft.) power cords with NEMA L6–30P non-watertight 30A plug, 200–240 V ac, 30 Amps. This power cord is for US, Canada, Latin America, and Japan.	39M5416 / 9954 (Used with FC 1951 only)	NEMA L6–30R Uses receptacle #10
Dual 4.3 m (14 ft.) power cords with watertight Russellstoll 3750DP 30A plug, 200–240 V ac, 30 Amps. This power cord is used in US, Chicago, Canada, Latin America, and Japan.	39M5418 / 9955 (Used with FC 1951 only)	Russellstoll 3753 or 9R33UOW receptacle, or a Russellstoll 3933 or 9C33UO connector Uses receptacle #11
Dual 4.3 m (14 ft.) power cords with IEC-309 p+n+g 32A plug, 200–240 V ac single phase, 32 Amps. This power cord is used in Europe, the Middle East, and Africa.	39M5414 / 9956 (Used with FC 1951 only)	IEC-309 p+n+g Uses receptacle #2
Dual 4.3 m (14 ft.) power cords with PDL 56P332 32A plug, 200–240 V ac single phase, 32 Amps. This power cord is used in Australia and New Zealand.	39M5419 / 9957 (Used with FC 1951 only)	1–gang, 3–pin 32A socket, PDL 56SO332 or equivalent Uses receptacle #12

Table 39. Specifications for power cords used with xx5 frame models (continued)		
Length and type of power cord	**Part number and feature code[1]**	**Type of service receptacle**
Dual 4.3 m (14 ft.) non-watertight power cords with 30A plug type Shin Ju SJ-3302, 200–240 V ac, 30 Amps. This power cord is used in North and South Korea.	39M5420 / 9958 (Used with FC 1951 only)	200–250 V ac single phase Uses receptacle #3
Dual 4.3 m (14 ft.) power cords, unterminated (without a power plug), 200–240 V ac single phase, 30 Amps maximum, with IRAM and BSMI agency certifications. Wire size 4 mm^2. This is the recommended cord for Argentina, Taiwan, Europe, the Middle East, and Africa if an unterminated power cord is preferred.	23R7324 / 9959 (Used with FC 1951 only)	Not specified (no plug supplied)
Dual 4.3 m (14 ft.) power cords, unterminated (without a power plug), 200–240 V ac single phase, 30 Amps maximum, with CCC certification. This is the recommended power cord for China.	23R9543 / 9966 (Used with FC 1951 only)	Not specified (no plug supplied)
Note: Each feature code ships two power cords so that dual power is supported.		

Power receptacles

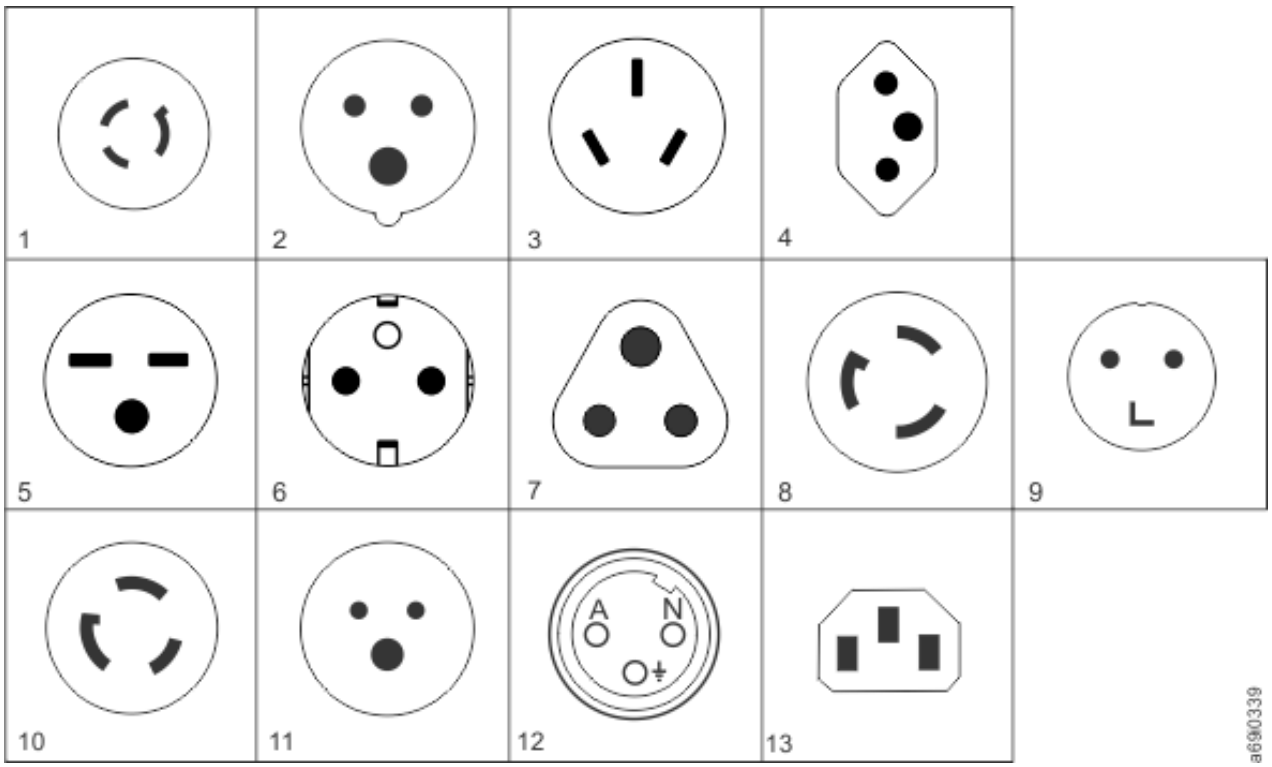


Figure 27. Types of receptacles

Note: For more information about FC 9989, refer to *Powering adjacent frames*.

Electrical characteristics

Table 40 on page 93 lists the electrical characteristics for each frame model. To calculate the total power consumption (in watts) of a particular library configuration, multiply the quantity of each power-consuming item in the configuration by the corresponding value in Table 37 on page 87.

Note: Library power consumption is dynamic and usage dependent. Short peaks might exceed the maximum continuous power values. Typical average power consumption is lower than the calculated maximum continuous value because all drives are not likely to be active simultaneously.

Table 40. Electrical characteristics for frame models

Electrical characteristic	Rating (models Lx5, Dx5)	Rating (Models xx5 with FC 1951)
Nameplate electrical limits[1]	200 - 240 V AC, 8.0 A, 50 - 60 Hz, 1.6 kVA, single phase	200 - 240 V AC, 24.0 A, 50 - 60 Hz, 4.8 kVA, single phase [2]

Notes:

1. Maximum certified electrical limits for a single frame. Do not use nameplate limits to calculate product power or cooling requirements.
2. Electrical limits increase for frames with FC 1951 because the PDUs for FC 1951 can be used to supply power for up to two adjacent frames.

Recommended customer circuit breakers

Maximum rating	Minimum rating
20 A (32 A if feature 1951 is installed)	10 A (20 A if feature 1951 is installed).

Feature codes for the TS4500

Order feature codes to install components in library frames or to enhance the capacity or capabilities of the library.

A customer-setup unit (CSU) is a feature that you, as the customer, can install when the feature is ordered as a field upgrade. If you choose not to install a CSU, IBM can install it for an extra charge. However, detailed installation instructions are included for most features when you order and receive these features. To access the instructions for installing a CSU online, go to the Support Portal for the TS4500 Tape Library and choose **Plan and install documentation**.

Table 41. FCs for the frame models of the TS4500 tape library

FC	Model	CSU	Description
0983	Lx5, Dx5, 60F	No	**TAA compliance**
1404	L25, L55	No	**TS1140 and TS1150 tape drive support** This triggers the shipment of a JK diagnostic cartridge. When model L25 is ordered or when FC 9080 (Mixed Media) is ordered for model L55, a minimum of one of FC 1404 or 1406 is required but any may be selected.

Table 41. FCs for the frame models of the TS4500 tape library (continued)

FC	Model	CSU	Description
1405	L25, L55	No	**LTO5 and LTO6 tape drive support** This triggers the shipment of an L5 diagnostic cartridge. When model L55 is ordered, a minimum of one of FC 1405 or 1407 is required but both can be selected. When FC 9080 (Mixed Media) is ordered for model L25, a minimum of one of FC 1405 or 1407 is required but both can be selected.
1406	L25, L55	Both	**TS1150, TS1155, and TS1160 tape drive support** This feature provides a JL diagnostic cartridge. When model L25 is ordered or when FC 9080 (Mixed Media) is ordered for model L55, a minimum of one of FC 1404 or 1406 is required but any may be selected.
1407	L25, L55	No	**LTO6 and LTO7 tape drive support** This triggers the shipment of an L6 CE cartridge. When model L55 is ordered, a minimum of one of FC 1405 or 1407 is required but both can be selected. When FC 9080 (Mixed Media) is ordered for model L25, a minimum of one of FC 1405 or 1407 is required but both can be selected.
1408	L25, L55	No	**LTO7 and LTO8 tape drive support** This triggers the shipment of an L7 CE cartridge. When model L55 is ordered, a minimum of one of FC 1407 or 1408 is required but both can be selected. When FC 9080 (Mixed Media) is ordered for model L25, a minimum of one of FC 1407 or 1408 is required but both can be selected.
1442	HA Kit w/ Second Accessor	No	**Dual Accessors** This triggers the shipment of • Four CE/diagnostic cartridges (two of latest generation for both LTO and 3592) • Service Bay Stop-A and Service Bay Stop-B related parts • TS4500 Accessor B including scanner, enhanced grippers, and enhanced node cards There is a maximum of one HA kit (FC 1442) per library.
1450	D25, D55	No	**TS4500 frame control assembly (FCA)** Includes 1x LCC and 2x power supplies.
1460	L25, L55	No	**Redundant Accessor Power/Network** This provides power and internal network redundancy for the L25/L55 frame. This is a prerequisite to FC 9002.

Table 41. FCs for the frame models of the TS4500 tape library (continued)

FC	Model	CSU	Description
1530	D25, D55, L25, L55, S25 S55	No	**Web camera mounting hardware** Provides mounting hardware only.
1531	D25, D55, L25, L55	No	**First quad drive mounting kit** This feature provides signal and power cabling for a column of 4 adjacent drives. Fiber cables can be ordered via one of the following: • FC 1536, MMF Quad Drive-to-Patch Panel cables • FC 1537, SMF Quad Drive-to-Patch Panel cables • FC 9713, Direct Fiber - No Patch Panel Cables **Prerequisite:** • Models L25/D25: One FC 1536 or 9713 is required • Models L55/D55: One FC 1536 or 1537 or 9713 is required. • Models D25/D55: FC 1450 is required.
1532	D25, D55, L25, L55	No	**Second quad drive mounting kit** This feature provides signal and power cabling for a column of 4 adjacent drives. Fiber cables can be ordered via one of the following: • FC 1536, MMF Quad Drive-to-Patch Panel cables • FC 1537, SMF Quad Drive-to-Patch Panel cables • FC 9713, Direct Fiber - No Patch Panel Cables This feature is not supported in the leftmost frame of a dual accessor library. **Prerequisite:** • Models L25/D25: One FC 1536 or 9713 is required. • Models L55/D55: One FC 1536 or 1537 or 9713 is required. • FC 1521 or 1531 is required.

Table 41. FCs for the frame models of the TS4500 tape library (continued)

FC	Model	CSU	Description
1533	D25, D55, L25, L55	No	**Third quad drive mounting kit** This feature provides signal and power cabling for a column of 4 adjacent drives. Fiber cables can be ordered via one of the following: • FC 1536, MMF Quad Drive-to-Patch Panel cables • FC 1537, SMF Quad Drive-to-Patch Panel cables • FC 9713, Direct Fiber - No Patch Panel Cables This feature is not supported in the leftmost or rightmost frame of a dual accessor library. **Prerequisite:** • Models L25/D25: One FC 1536 or 9713 is required. • Models L55/D55: One FC 1536 or 1537 or 9713 is required. • FC 1522 or 1532 is required.
1534	D25, D55, L25, L55	Both	**Fourth quad drive mounting kit** This feature provides signal and power cabling for a column of 4 adjacent drives. Fiber cables can be ordered via one of the following: • FC 1536, MMF Quad Drive-to-Patch Panel cables • FC 1537, SMF Quad Drive-to-Patch Panel cables • FC 9713, Direct Fiber - No Patch Panel Cables This feature is not supported in the leftmost frame of a single accessor library. This feature is not supported in the leftmost or rightmost frame of a dual accessor library. **Prerequisite:** • Models L25/D25: One FC 1536 or 9713 is required. • Models L55/D55: One FC 1536 or 1537 or 9713 is required. • FC 1523 or 1533 is required.
1536	D25, D55, L25, L55	Both	**MMF Quad Drive-to-Patch Panel Cables (all drive models)** This feature includes all fiber cables required for a column of 4 drives, 8x LC-LC Multimode Fiber (MMF) Drive-to-Patch Panel cables. **Prerequisite:** One FC 1536 or 1537 or 9713 per each FC 1531, 1532, 1533, and 1534.

Table 41. FCs for the frame models of the TS4500 tape library (continued)

FC	Model	CSU	Description
1537	D55, L55	Both	**SMF Quad Drive-to-Patch Panel Cables (LTO8)** This feature includes all fiber cables required for a column of 4 drives, 8x LC-LC Single Mode Fiber (SMF) Drive-to-Patch Panel cables. **Prerequisite:** One FC 1536 or 1537 or 9713 per each FC 1531, 1532, 1533, and 1534.
1604	L25, L55	Yes	**Transparent LTO encryption** Provides license keys to enable transparent LTO encryption.
1628	L55	Yes	**Additional LTO Cartridge Magazines** Provides magazine and cover for transport or storage of up to 18 cartridges.
1629	L25	Yes	**Additional 3592 Cartridge Magazine** Provides magazine and cover for transport or storage of up to 16 cartridges.
1643	L25, L55	Yes	**Intermediate capacity on demand** Provides license key to increase storage from entry capacity to intermediate capacity.
1644	L25, L55	Yes	**Base capacity on demand** Provides license key to increase storage from intermediate capacity to base capacity. This feature code is a prerequisite for FC 9002 or Model Lx5 HD CoD FC 164x. **Prerequisite:** FC 1643
1645	S25	Yes	**High density capacity on demand**
1646	S55	Yes	**High density capacity on demand**
1647	L25	Yes	**High density capacity on demand** **Prerequisite:** FC 1644
1648	L55	Yes	**High density capacity on demand** **Prerequisite:** FC 1644
1649	D25	Yes	**High density capacity on demand**
1650	D55	Yes	**High density capacity on demand**
1652	D25, D55	No	**Two additional I/O stations** This feature code adds either 36 (LTO) or 32 (3592) I/O slots.
1663	D25, D55 L25, L55	No	**Drive removal**

Table 41. FCs for the frame models of the TS4500 tape library (continued)			
FC	**Model**	**CSU**	**Description**
1682	L25, L55	Yes	**Path failover**
1742	Sx4	No	**TS4500 Control - Upgrade** This includes 1x top panel and 2x Ethernet cables, card cages, ASCs, BPCs, and LFIs.
1750	TR1	No	**Left-side and right-side end covers** This feature is required only for the first top rack ordered (if multiple top racks are installed on adjacent frames).
1751	TR1	No	**Power distribution unit** Provides one PDU to be mounted in the top rack. The first PDU in a top rack does not consume any of the 10U of rack space. The second PDU in a top rack consumes 1U of rack space. **Note:** • A maximum of two FC 1751s can be ordered. • FC 1751 cannot be installed in the same rack as an FC 1752 PDU. Each PDU has 10 C13 outlets divided into 2 groups of 5 outlets. Each group is protected by a 15 amp circuit breaker. In addition, there is a master 25 amp circuit breaker for the entire PDU. All of the circuit breakers are rated at 5 kAIC. Each PDU has a control input that can be used to turn all of the outlets on or off by an external switch or relay contact (not provided). The control input is defaulted to ON by a jumper plug included with the PDU. **Prerequisite:** For each FC 1751 ordered, one power cord (FC 9954 through 9959 or 9966) must also be ordered. **Limitation:** Mutually exclusive with 1752

Table 41. FCs for the frame models of the TS4500 tape library (continued)

FC	Model	CSU	Description
1752	TR1	Both	**Enhanced PDU** Provides one PDU with 3-phase (wye) or single phase input power, to be mounted in top rack (max of two may be ordered). The first PDU in a top rack does not consume any of the 10U of rack space. The second PDU in a top rack consumes 1U of rack space. Each PDU has 9 outlets divided into three groups. Within each group there are two C-13, and one C-19 outlets. Each group is protected by 20amp circuit breakers rated at 10 kAIC. **Prerequisite:** • For single phase input power, for each PDU ordered must order one power cord FC 9954 thru 9958. • For 3-phase (wye) input power, for each PDU ordered must order one power cord FC 9948. **Limitation:** Mutually exclusive with 1751
1802	L25, L55	No	**1- to 2-frame X-track cable** Non-HA 1 to 2 Frame Track Cable
1806	L25, L55	No	**3- to 6-frame X-track cable** Non-HA 3 to 6 Frame Track Cable
1814	L25, L55	No	**7- to 14-frame X- track cable** Non-HA 7 to 14 Frame Track Cable. See 3584 X Track Cable Features/Specify codes for more details. **Limitation:** Not supported with FC 2071 or FC 9071.
1818	L25, L55	No	**9- to 18-frame X- track cable** Non-HA 9 to 18 Frame Track Cable. See 3584 X Track Cable Features/Specify codes for more details. **Limitation:** Not supported with FC 2071 or FC 9071.
1909	L25, L55, D25, D55	No	**Single power source bifurcated cable** Allows attachment of a powered frame to a single outlet while also maintaining drive redundant power.

Table 41. FCs for the frame models of the TS4500 tape library (continued)

FC	Model	CSU	Description
1951	D25, D55, L25, L55, S25, S55	No	**Power distribution units** Provides two PCAs, mounting hardware including rack brackets, and internal power cables. Supports any combination of up to 3 pairs of power cords for FC 4875 on the same frame and FC 9989 on adjacent frames. Each PDU has 10 C13 outlets divided into 2 groups of 5 outlets. Each group is protected by a 15 amp circuit breaker. In addition, there is a master 25 amp circuit breaker for the entire PDU. All of the circuit breakers are rated at 5 kAIC. Each PDU has a control input that can be used to turn all of the outlets on or off by an external switch or relay contact (not provided). The control input is defaulted to ON by a jumper plug included with the PDU. **Corequisite:** One power cord feature (FC 9954 through 9959 or 9966) **Limitation:** FC 1951 cannot be installed in the same rack as an FC 1952 PDU.
1952	D25, D55, L25, L55, S25, S55	No	**Enhanced PDUs** Provides two PDUs with 3-phase (wye) or single phase input power, mounting hardware including rack brackets, and internal power cables to provide power to the local frame control assembly. These line cord features may require different customer facility outlets than frames without FC 1952. Can be used for adjacent frame AC power cord aggregation, or for unique facility AC socket requirements. Supports any combination of up to 3 pairs of power cords for FC 9989 on adjacent frames. Each PDU has 9 outlets divided into three groups. Within each group there are two C-13, and one C-19 outlets. Each group is protected by 20amp circuit breakers rated at 10 kAIC. **Prerequisite:** • For single phase input power, must order one power cord FC 9954 through 9958. • For 3-phase (wye) input power, must order one power cord FC 9948. **Limitation:** • Mutually exclusive with legacy PDU FC 1951, Fibre Channel switch mounting FC 4879, and Ethernet switch FC 2704. • Mutually exclusive with FC 4879 or 2704.
2002	L25, L55	No	**1-2 Frame Flex Track A Cable**

Table 41. FCs for the frame models of the TS4500 tape library (continued)

FC	Model	CSU	Description
2006	L25, L55	No	**3-6 Frame Flex Track A Cable**
2014	L25, L55	No	**7-14 Frame Flex Track A Cable**
2018	L25, L55	No	**9-18 Frame Flex Track A Cable**
2071	L25, L55	No	**Flex Track Guide** This includes AXY, AXY plate, ASC to Flex track cable, and new end stops.
2072	D25, D55, S25 S55, Sx4	No	**Flex Track Guide for Expansion Frame**
2309	xx5	No	**TS4500 Accessor Refresh** Provides a complete accessor assembly with HD grippers to Lxx models or models with FC 1442. **Prerequisite:** FC 2071, 2072, or 9071, 9072.
2402	L25, L55	No	**1-2 Frame Flex Track B Cable**
2406	L25, L55	No	**3-6 Frame Flex Track B Cable**
2414	L25, L55	No	**7-14 Frame Flex Track B Cable**
2418	L25, L55	No	**9-18 Frame Flex Track B Cable**
2704	L25, L55	No	**Console expansion 26-port Ethernet switch/rack mount** Provides a 26-port Ethernet switch and attachment cable for connection to an IMC as a centralized system console. Up to 24 extra connections of FC 2715 are provided by this feature. This feature is supported on Lx5 models to allow other products to share the IMC.
2715	L25, L55	No	**TSSC attachment cable** FC 2715 is a cable to attach a unit to the Ethernet switch provided by the TSSC. **Note:** A maximum of 43 of FC 2715 can be included in a single TSSC facility. **Note:** FC 2704 is supported on Lx5 models if you are connecting the frame to an existing TSSC.
2735	L25, L55	No	**USB Optical Drive** Required for all new plant orders. Provides a USB optical drive for use with the Integrated Management Console (IMC). The optical drive is required for IMC code and updates to the service Knowledge Center.

Table 41. FCs for the frame models of the TS4500 tape library (continued)

FC	Model	CSU	Description
2737	S25, S55	No	**IMC Separate Power Source** This feature allows longer distances between the IMC end panel and an FCA by supplying 2 Ethernet cables that are longer than normal. For both plant and field, instructions are also provided for moving the IMC PDU from another frame into this frame. **Prerequisite:** One of the FC 9970-9985, 9989 power cords.
4879	L25, D25, TR1	No	**TS7700 BE Switch Mounting Hardware** Provides 2x Fibre channel switch mounting hardware, including rack brackets and power cords. **Prerequisite:** FC 4880
4880	L25, D25, TR1	No	**TS7700 BE 16 Gb Switch** Provides 1x Fibre channel switch (16 Gb). **Limitation:** There is a maximum of 2x FC 4880 per model x25.
6013	D25, D55, L25, L55	Yes	**LC to LC Fibre Channel cable - 13m (43 ft)**
6025	D25, D55, L25, L55	Yes	**LC to LC Fibre Channel Cable - 25m (82 ft)**
6061	D25, D55, L25, L55	Yes	**LC to LC Fibre Channel Cable - 61m (200 ft)**
8750	D55, L55	No	**LTO cleaning cartridge** Universal cleaning cartridge.
8802	D25, L25	No	**3592 cleaning cartridge**
9001	D25, D55, L25, L55	No	**Driveless frame**
9002	L25, L55	No	**First expansion frame attachment** Used as a part of the process to add any Dxx or Sxx frame. **Prerequisites:** • FC 1460 and 1644. • FC 9001 for Lxx models.
9003	L25, L55	No	**Additional expansion frame attachment** Used as a part of the process to add any Dxx or Sxx frame.

Table 41. FCs for the frame models of the TS4500 tape library (continued)

FC	Model	CSU	Description
9040	High Availability Library	Lx5	**Prerequisites:** One Flex-track A and B cable of the same length. Flex-Track A cable: FC 2002, 2006, 2014, or 2018. Flex-Track B Cable: FC 2402, 2406, 2414, or 2418.
9071	L25, L55	No	**Flex Track Guide Base** Includes AXY, AXY plate, ASC to Flex track cable, and new end stops.
9072	D25, D55, S25 S55, Sx4	No	**Flex Track Guide for Expansion Frame**
9080	L25, L55	No	**Mixed Media Library** **Prerequisite:** Library must contain a mix of LTO and 3592 frames. • For model L25, FC 1628 (LTO Magazine) and a minimum of one of FC 1405 or 1407 (LTO CE cartridge). • For model L55, FC 1629 (3592 Magazine) and FC 1404 (3592 CE cartridge). **Limitation:** Mixed media not supported for Lx2/Lx3.
9210	L25, L55	No	**Attached to HP-UX system**
9211	L25, L55	No	**Attached to Solaris system**
9212	L25, L55	No	**Attached to Windows system**
9213	L25, L55	No	**Attached to other non-IBM system**
9215	L25, L55	No	**Attached to Linux system**
9217	L25, L55	No	**Attached to LM/TS7700**
9218	L25, L55	No	**Attached to HPSS**
9400	L25, L55	No	**Attached to i5/OS or OS/400 system**
9600	L25, L55	No	**Attached to AIX system**

Table 41. FCs for the frame models of the TS4500 tape library (continued)

FC	Model	CSU	Description
9607	D55, L55	No	**3588 F7A/F7C tape drive - plant install** This feature informs the plant to install one TS1070 Tape Drive Model F7A/ F7C (3588 Model F7A or F7C) into a Tape Library Model D55, or L55 coming from the plant. **Prerequisites:** • L55/D55 Models – FC 1521 or 1531 when tape drive FCs 9690, 9695, 9697, 9607, 9609, 9611 are greater than zero. • L55/D55 Models – FC 1522 or 1532 when tape drive FCs 9690, 9695, 9697, 9607, 9609, 9611 are greater than four. • L55/D55 Models – FC 1523 or 1533 when tape drive FCs 9690, 9695, 9697, 9607, 9609, 9611 are greater than eight. • L55/D55 Models – FC 1524 or 1534 when tape drive FCs 9690, 9695, 9697, 9607, 9609, 9611 are greater than twelve.
9609	D55, L55	No	**3588 F8A/F8C tape drive - plant install** This feature informs the plant to install one TS1080 Tape Drive Model F8A/F8C (3588 Model F8A or F8C) into a Tape Library Model D55, or L55 coming from the plant. Installation of a 3588 Tape Drive canister requires that a Quad Drive Mounting Kit feature (FC 1521, 1522, 1523, 1524 or 1531, 1532, 1533, 1534) be installed in the TS4500 frame to contain the canister. **Prerequisite:** • L55/D55 Models – FC 1521 or 1531 when tape drive FCs 9690, 9695, 9697, 9607, 9609, 9611 are greater than zero. • L55/D55 Models – FC 1522 or 1532 when tape drive FCs 9690, 9695, 9697, 9607, 9609, 9611 are greater than four. • L55/D55 Models – FC 1523 or 1533 when tape drive FCs 9690, 9695, 9697, 9607, 9609, 9611 are greater than eight. • L55/D55 Models – FC 1524 or 1534 when tape drive FCs 9690, 9695, 9697, 9607, 9609, 9611 are greater than twelve. **Note:** One feature 1408 is required per Tape Library if this is the first TS1080 (3588 Model F8A, F8C, or F8S) tape drive ordered.

Table 41. FCs for the frame models of the TS4500 tape library (continued)

FC	Model	CSU	Description
9611	D55, L55	No	**3588 F8S tape drive - plant install** This feature informs the plant to install one TS1080 Tape Drive Model F8S (3588 Model F8S) into a Tape Library Model D55 or L55 coming from the plant. **Prerequisite:** • L55/D55 Models – FC 1521 or 1531 when tape drive FCs 9690, 9695, 9697, 9607, 9609, 9611 are greater than zero. • L55/D55 Models – FC 1522 or 1532 when tape drive FCs 9690, 9695, 9697, 9607, 9609, 9611 are greater than four. • L55/D55 Models – FC 1523 or 1533 when tape drive FCs 9690, 9695, 9697, 9607, 9609, 9611 are greater than eight. • L55/D55 Models – FC 1524 or 1534 when tape drive FCs 9690, 9695, 9697, 9607, 9609, 9611 are greater than twelve. **Note:** One feature 1408 is required per Tape Library if this is the first TS1080 (3588 Model F8A, F8C, or F8S) tape drive ordered.
9677	D25, L25	No	**Plant Install 3592 in a 3584 Frame** This specify code notifies the plant to factory install a new 3592 Tape Drive into a new 3584 Tape Library Frame coming from the plant. This code must appear on the tape drive order and also the Plant Install 3592 E05 in a 3584 feature (#9680) or Plant Install 3592 E06 in a 3584 feature (#9683) or Plant Install 3592 E07/EH7 in a 3584 feature (#9692) or Plant Install 3592 E08/EH8 in a 3584 feature (#9699) or Plant Install 3592 55E in a 3584 feature (#9704) or Plant Install 3592 55F/55G in a 3584 feature (#9705) or Plant Install 3592 60F in a 3584 feature (#9706) or Plant Install 3592 60E in a 3584 feature (#9707) must appear on the 3584 Frame order.
9689	D25, L25	Yes	**Plant Install 3592 in a 3584 Frame** This feature notifies the plant to ship one 3592 Tape Drive, which will be field installed in a 3584 Tape Library Frame. This code must appear on the tape drive order and also the Field Merge 3592 Tape Drive (#1674) or (#1675) or (#1676) for an 3592 E07/E08/55G/60G, (#9690) for an 3592 EH7/EH8/55E/55F or (#9726) for an 3592 60E/60F must appear on the 3584 Tape Library Frame order.

Table 41. FCs for the frame models of the TS4500 tape library (continued)

FC	Model	CSU	Description
9690	D25, D55, L25, L55	Both	**LTO, TS1140, TS115x - field install drive in 3584** This feature field installs one 3592 Model EH7 or EH8 or 55E or 55F, or one 3588 Model F5C or F6C or F7C or F8C or F8S Tape Drive into an installed 3584 Model D25 or L25, or D55 or L55. This feature is also required to field merge a 3592 Model EH7, EH8, 55E, 55F, or 3588 Model F5C, F6C, F7C, F8C, F8S Tape Drive into a 3584 frame coming from the plant. The Tape Drive requires a Quad Drive mounting kit to contain the drive. **Prerequisite:** • FC 1521 or 1531 when tape drive FCs 9690, 9692, 9699, 9695, 9697, 9607, 9704, 9705, 9706, 9707, 9726, 9611, 9609 are greater than zero. • FC 1522 or 1532 when tape drive FCs 9690, 9692, 9699, 9695, 9697, 9607, 9704, 9705, 9706, 9707, 9726, 9611, 9609 are greater than four. • FC 1523 or 1533 when tape drive FCs 9690, 9692, 9699, 9695, 9697, 9607, 9704, 9705, 9706, 9707, 9726, 9611, 9609 are greater than eight. • FC 1524 or 1534 when tape drive FCs 9690, 9692, 9699, 9695, 9697, 9607, 9704, 9705, 9706, 9707, 9726, 9611, 9609 are greater than twelve.
9692	L25, L55	No	**3592 E07/EH7 tape drive - plant install in 3584** FC 9692 is a manufacturing routing code. **Prerequisite:** FC 152x (drive mounting kit). Each FC 152x supports up to 4 of FC 969x.
9695	L25, L55	No	**3588 F5A/F5C tape drive - plant install in 3584** FC 9695 is a manufacturing routing code. **Prerequisite:** FC 152x/153x (drive mounting kit). Each FC 152x/153x supports up to 4 of FC 969x.
9697	D55, L55	No	**3588 F6A/F6C tape drive - plant install** FC 9697 is a manufacturing routing code. **Prerequisite:** FC 152x/153x (drive mounting kit). Each FC 152x/153x supports up to 4 of FC 969x.
9699	D25, L25	No	**3592 E08/EH8 tape drive - plant install in 3584** FC 9699 is a manufacturing routing code. **Prerequisite:** FC 152x (drive mounting kit). Each FC 152x supports up to 4 of FC 969x.
9700	D25, D55, L25, L55	No	**No host attach cables - from plant**
9704	D25, L25	No	**3592 55E tape drive - Plant Install in 3584**

Table 41. FCs for the frame models of the TS4500 tape library (continued)

FC	Model	CSU	Description
9705	D25, L25	No	**3592 55F tape drive - Plant Install in 3584**
9706	D25, L25	No	**3592 60F tape drive - Plant Install in 3584** This feature tells the plant to install one 3592 Tape Drive Model 60F into a 3584 Model D25 or Model L25 coming from the plant. **Prerequisite:** Installation of the 3592 Model 60F Tape Drive requires a Quad Drive mounting kit to contain the drive. Mounting Kit feature (#1515) or (#1535).
9707	D25, L25	No	**3592 60E tape drive - Plant Install in 3584** This feature tells the plant to install one 3592 Tape Drive Model 60E into a 3584 Model D25 or Model L25 coming from the plant. **Prerequisite:** • Installation of the 3592 Model 60E Tape Drive requires a Quad Drive mounting kit to contain the drive: Feature #1531 or #1532 or #1533 or #1534 • One feature #1406 is required per Tape Library if this is the first TS1160 60E Tape drive ordered.
9713	D25, D55, L25, L55	Both	**Direct Fiber - No Patch Panel Cables** This feature should be specified if you do not want the factory to ship any Fiber Channel cable FC 1536 “MMF Quad Drive-to-Patch Panel cables” or FC 1537 “SMF Quad Drive-to-Patch Panel cables”.
9726	L25, D25	Both	**TS1160 tape drive - Field Install Drive in 3584** This feature field installs one 3592 Model 60E or 60F Tape Drive into an installed 3584 Model D25 or L25. This feature is also required to field merge a 3592 Model 60E or 60F Tape Drive into a 3584 frame coming from the plant. **Prerequisite:** • Installation of the 3592 Model 60E/60F Tape Drive requires a Quad Drive mounting kit to contain the drive: Feature #1531 or #1532 or #1533 or #1534 • One feature #1406 is required per Tape Library if this is the first TS1160 60E/60F Tape drive ordered.
9735	L25, L55	No	**IMC broadband Call Home** This feature originally indicated that the customer would allow broadband Call Home, however the feature code is no longer utilized.

Table 41. FCs for the frame models of the TS4500 tape library (continued)			
FC	**Model**	**CSU**	**Description**
9948	D25, D55, L25, L55, S25, S55, TR1	Both	**3 Phase Power Cord** This feature provides a 4.3 meter (14 foot) long power cord with an IEC 309 3P+N+G 32A plug, rated for 230 Vac, 24 Amps. This power cord supports 3 phase (wye) power. To be used with Enhanced PDU FC 1752 or FC 1952.
9949	D25, D55, L25, L55, S25, S55, TR1	Both	**C20-C13 Power Cord for spare outlets in the Enhanced PDU** This feature provides a 2.8 meter long C20-C13 Power Cord to be used between computer equipment and the Enhanced PDU Feature 1752 or 1952 or customer-supplied PDU with C19 outlets. C13 connects to the male C14 inlet or power cord plug and the C20 mates with the C19 receptacle on the Enhanced PDU. This power cord is intended to be used on PDUs with C19 outlets.
9954	D25, D55, L25, L55, S25, S55	No	**NEMA L6-30 Power Cord** FC 9954 is used with PDU FCs 1751 and 1752 (in model TR1) or 1951 and 1952 (in model xx5). FC 9954 provides 1x power cord when ordered on a model TR1 and 2x power cords when ordered on a model xx5.
9955	D25, D55, L25, L55, S25, S55	No	**RS 3750DP power cord** FC 9955 is used with PDU FCs 1751 (in model TR1) or 1951 (in model xx5). FC 9955 provides 1x power cord when ordered on a model TR1 and 2x power cords when ordered on a model xx5.
9956	D25, D55, L25, L55, S25, S55	No	**IEC 309 power cord** FC 9956 is used with PDU FCs 1751 (in model TR1) or 1951 (in model xx5). FC 9956 provides 1x power cord when ordered on a model TR1 and 2x power cords when ordered on a model xx5.
9957	D25, D55, L25, L55, S25, S55	No	**PDL 4.3m power cord (Australia/NZ)** FC 9957 is used with PDU FCs 1751 (in model TR1) or 1951 (in model xx5). FC 9957 provides 1x power cord when ordered on a model TR1 and 2x power cords when ordered on a model xx5.
9958	D25, D55, L25, L55, S25, S55	No	**4.3m power cord (Korea)** FC 9958 is used with PDU FCs 1751 (in model TR1) or 1951 (in model xx5). FC 9958 provides 1x power cord when ordered on a model TR1 and 2x power cords when ordered on a model xx5.

Table 41. FCs for the frame models of the TS4500 tape library (continued)

FC	Model	CSU	Description
9959	D25, D55, L25, L55, S25, S55	No	**Unterminated power cord** FC 9959 is used with PDU FCs 1751 (in model TR1) or 1951 (in model xx5). FC 9959 provides 1x power cord when ordered on a model TR1 and 2x power cords when ordered on a model xx5. **Limitation:** Not supported with FC 1752 or 1952.
9966	D25, D55, L25, L55, S25, S55	No	**Unterminated power cords (China CCC cert)** FC 9966 is used with PDU FCs 1751 (in model TR1) or 1951 (in model xx5). FC 9966 provides 1x power cord when ordered on a model TR1 and 2x power cords when ordered on a model xx5. **Limitation:** Not supported with FC 1752 or FC 1952.
9970	D25, D55, L25, L55, S25, S55	No	**Dual 4.3m power cord (international, 250 VAC 16A single phase, watertight connector, IEC-309)** FC 9970 includes model-dependent contents. For countries other than the United States and Canada, the connector is rated at 16A (plug type Hubbell HBL316P6W or equivalent) for connection to Hubbell type HBL316R6W or equivalent receptacles. In the United States and Canada, the connector is rated at 20A (plug type Hubbell HBL320P6W) for connection to Hubbell type HBL320R6W or equivalent receptacles. This is the default power cord for all countries other than those specified for FC 9972 and FCs 9976 through 9983. **This power cord can be used for all countries except:** • Japan • Korea • Philippines • Taiwan • Argentina • Brazil • Australia • New Zealand • China • South Africa **Note:** Only 1 power cord is shipped for an S25 and S55 to be used in conjunction with FC 2737.

Table 41. FCs for the frame models of the TS4500 tape library (continued)			
FC	**Model**	**CSU**	**Description**
9972	D25, D55, L25, L55, S25, S55	No	**Dual 4.3m power cords, 250 VAC 15, non-watertight twist lock connector, Nema L6-15P mates with L6-15R** FC 9972 includes model-dependent contents. It is the default power cord for US, Canada, Japan, Korea, Philippines, and Taiwan. **Note:** Only 1 power cord is shipped for an S25 and S55 to be used in conjunction with FC 2737.
9976	D25, D55, L25, L55, S25, S55	No	**Dual 4.3m power cords with 10 Amp/250 Vac, non watertight IRAM 2073 plug (Argentina)** **Note:** Only 1 power cord is shipped for an S25 and S55 to be used in conjunction with FC 2737.
9977	D25, D55, L25, L55, S25, S55	No	**Dual 4.3m power cords with 15 Amp/250 Vac with earth pin InMetro NBR 14136 plug (Brazil)** **Note:** Only 1 power cord is shipped for an S25 and S55 to be used in conjunction with FC 2737.
9978	D25, D55, L25, L55, S25, S55	No	**Dual 4.3m power cords with 10 Amp/250 Vac Aust/ NZS 3112/2000 plug (Australia and New Zealand)** **Note:** Only 1 power cord is shipped for an S25 and S55 to be used in conjunction with FC 2737.
9979	D25, D55, L25, L55, S25, S55	No	**Dual 4.3m power cords with 15 Amp/250 Vac JIS C8303, C8306 plug (Japan)** **Note:** Only 1 power cord is shipped for an S25 and S55 to be used in conjunction with FC 2737.
9980	D25, D55, L25, L55, S25, S55	No	**Dual 4.3m power cords with 10 Amp/250 Vac, GB 2099.1, 1002 plug (China)** **Note:** Only 1 power cord is shipped for an S25 and S55 to be used in conjunction with FC 2737.
9981	D25, D55, L25, L55, S25, S55	No	**Dual 4.3m power cords with 15 Amp/250 Vac with earth pin KS C8305, K60884-1 plug (Korea)** **Note:** Only 1 power cord is shipped for an S25 and S55 to be used in conjunction with FC 2737.
9982	D25, D55, L25, L55, S25, S55	No	**Dual 4.3m power cords with 10 Amp/250 Vac CNS 10917-3 plug (Taiwan)** **Note:** Only 1 power cord is shipped for an S25 and S55 to be used in conjunction with FC 2737.
9983	D25, D55, L25, L55, S25, S55	No	**Dual 4.3m power cords with 10 Amp/250 Vac SANS 164-1 plug (South Africa)** **Note:** Only 1 power cord is shipped for an S25 and S55 to be used in conjunction with FC 2737.

Table 41. FCs for the frame models of the TS4500 tape library (continued)

FC	Model	CSU	Description
9984	D25, D55, L25, L55, S25, S55	No	**Dual 4.3m power cords with 15 Amp/250V single phase power cord assemblies, NEMA L6-20P non-watertight twistlock 20A plug** FC 9984 is 2x power cords which are UL / CSA certified for use in US and Canada. These power cords mate with customer-supplied NEMA L6-20R receptacles. **Note:** Only 1 power cord is shipped for an S25 and S55 to be used in conjunction with FC 2737.
9985	D25, D55, L25, L55, S25, S55	No	**Dual 4.3m power cords with 15 Amp/250V single phase power cord assemblies with watertight 15A Russellstoll plug** FC 9985 is 2x power cords which are UL/CSA certified for use in US and Canada. These power cords mate with customer-supplied Russellstoll 3743U2 or 9R23U2W receptacles. **Note:** Only 1 power cord is shipped for an S25 and S55 to be used in conjunction with FC 2737.
9989	D25, D55, L25, L55, S25, S55	No	**Dual 4.3m power cords with 10Amp/250V with IEC 309 C14 plug** FC 9989 is for use with adjacent frame PDUs (FC 1951) or external (customer-supplied) PDUs. **Note:** Only 1 power cord is shipped for an S25 and S55 to be used in conjunction with FC 2737.
AGK1	D25, D55, L25, L55	Yes	**10 Meter OM3 Fiber Cable (LC)** Provides a 10m fiber cable to connect a drive to a switch that is external to the tape library. This cable can also be used to connect to a TS7700 back-end fiber switch that is 2 to 3 frames away. Order the number of this feature code for each drive to be connected.
AGK2	D25, D55, L25, L55	Yes	**25 Meter OM3 Fiber Cable (LC)** Provides a 25m fiber cable to connect drives to a fiber switch that is external to the tape library. Order the number of this feature code for each drive to be connected.
AGK3	D25, D55, L25, L55	Yes	**80 Meter OM3 Fiber Cable (LC)** Provides an 80m fiber cable to connect drives to a fiber switch that is external to the tape library. Order the number of this feature code for each drive to be connected.

Table 41. FCs for the frame models of the TS4500 tape library (continued)			
FC	**Model**	**CSU**	**Description**
AGKQ	D25, D55, L25, L55	Yes	**3 Meter OM3 Fiber Quad Cables (LC)** Provides 2 space-efficient 3m bundles (of four cables each) to connect four drives to a fiber switch in the same or one frame away, or in a TR1 top rack. To attach tape drives in the same frame or 1 frame away from a model x25 frame containing TS7700 BE switches, order one of this feature code for each quad-drive mounting kit to be connected. For xx5 models, each FC AGKQ has a prerequisite of an associated FC 152x or 153x.

Frame capacity

The cartridge capacity of the frames of the TS4500 tape library varies depending on whether the frame has I/O stations, tape drives, or any of the available capacity on demand features that increase the amount of licensed capacity of the frame.

Capacity of L25, D25, and S25 frames

The total available capacity of the L25, D25, and S25 frames is affected by the position and configuration of the frame and the installation of capacity on demand (CoD) features.

Table 42 on page 112 shows available storage capacity based on frame position and configuration. Table 43 on page 113 lists the quantity of accessible slots in each frame model based on frame position and quantity of I/O slots.

Table 42. Available storage capacity in L25, D25, and S25 frames					
Frame model	**Licensed feature(s)**	**Frame position**	**Quantity of drives**	**Quantity of I/O slots**	**Available storage capacity**
L25	Entry	1	1 to 12	32	100
	Intermediate CoD	1	1 to 12	32	200
	Base CoD	1	0 to 12	32	400
	Base CoD	2+	0 to 16	32	400
	HD CoD	1	0 to 12	32	550
	HD CoD	2+	0 to 16	32	660
D25	Base	1	0 to 12	0 or 32	500
	Base	2+	0 to 16	0 or 32	500
	HD CoD	1	0 to 12	32	550
	HD CoD	1	0 to 12	0	590
	HD CoD	2+	0 to 16	32	660
	HD CoD	2+	0 to 16	0	740
S25	Base	Any	0	0	600

Table 42. Available storage capacity in L25, D25, and S25 frames (continued)					
Frame model	**Licensed feature(s)**	**Frame position**	**Quantity of drives**	**Quantity of I/O slots**	**Available storage capacity**
	HD CoD	1	0	0	798
	HD CoD	2+	0	0	1000

Table 43. Quantity of accessible slots in L25, D25, and S25 frames				
Frame model	**Frame position**	**Quantity of I/O slots**	**Quantity of accessible slots per tier (tier 0)**	**Quantity of accessible slots per tier (tiers 1 - 4)**
L25	1	32	120	108
	2+	32	120	135
D25	1	32	120	108
	1	0	160	108
	2+	32	120	135
	2+	0	200	135
S25	1	0	160	160
	2+	0	200	200

Capacity of L55, D55, and S55 frames

The total available capacity of the L55, D55, and S55 frames is affected by the position and configuration of the frame and the installation of capacity on demand (CoD) features.

Table 44 on page 113 shows available storage capacity based on frame position and configuration. Table 45 on page 114 lists the quantity of accessible slots in each frame model based on frame position and quantity of I/O slots.

Table 44. Available storage capacity in L55, D55, and S55 frames					
Frame model	**Licensed feature(s)**	**Frame position**	**Quantity of drives**	**Quantity of I/O slots**	**Available storage capacity**
L55	Entry	1	1 to 12	36	100
	Intermediate	1	1 to 12	36	200
	Base	1	0 to 12	36	400
	Base	2+	0 to 16	36	400
	HD CoD	1	0 to 12	36	730
	HD CoD	2+	0 to 16	36	882
D55	Base	1	0 to 12	0 or 36	500
	Base	2+	0 to 16	0 or 36	500
	HD CoD	1	0 to 12	36	730
	HD CoD	1	0 to 12	0	774

Table 44. Available storage capacity in L55, D55, and S55 frames (continued)					
Frame model	**Licensed feature(s)**	**Frame position**	**Quantity of drives**	**Quantity of I/O slots**	**Available storage capacity**
	HD CoD	2+	0 to 16	36	882
	HD CoD	2+	0 to 16	0	970
S55	Base	Any	0	0	660
	HD CoD	1	0	0	1054
	HD CoD	2+	0	0	1320

Table 45. Quantity of accessible slots in L55, D55, and S55 frames				
Frame model	**Frame position**	**Quantity of I/O slots**	**Quantity of accessible slots per tier (tier 0)**	**Quantity of accessible slots per tier (tiers 1 - 5)**
L55	1	32	132	120
	2+	32	132	150
D55	1	32	132	120
	1	0	176	120
	2+	32	132	150
	2+	0	220	150
S55	1	0	176	176
	2+	0	220	220

Tape encryption overview

The tape drives that are supported by the TS4500 tape library can encrypt data as it is written to a tape cartridge.

Encryption is performed at full line speed in the tape drive after compression. (Data is compressed more efficiently before it is encrypted.) This capability adds a strong measure of security to stored data without any processing usage and performance degradation.

The following three major elements comprise the tape drive encryption solution:

The encryption-enabled tape drive

All of the tape drives that are supported by the TS4500 tape library are encryption capable. Encryption capability means that they are functionally capable of performing hardware encryption, but this capability is not yet activated. To perform hardware encryption, the tape drives must be encryption-*enabled*. Encryption can be enabled through the TS4500 management GUI .

Note: FC 1604, Transparent LTO Encryption, is required for library-managed encryption on LTO tape drives. It is not required for application-managed encryption.

Encryption key management

Encryption involves the use of several kinds of keys in successive layers. How these keys are generated, maintained, controlled, and transmitted depends upon the operating environment where the encrypting tape drive is installed. Some data management applications, such as Tivoli Storage Manager, can perform key management. For environments without such applications, or environments

where application-independent encryption is necessary, IBM provides a key manager to perform all necessary key management tasks. Provided key managers include:

- The IBM Encryption Key Manager component for the Java™ platform
- The IBM Security Key Lifecycle Manager (formerly the Tivoli Key Lifecycle Manager)

The “Managing encryption” on page 115 topic provides more information.

Encryption policy

This is the method that is used to implement encryption. It includes the rules that govern which volumes are encrypted and the mechanism for key selection. How and where these rules are set up depends on the operating environment. See “Managing encryption” on page 115 for more information about each of the available methods.

Encryption policy is managed at the logical library level. The **Logical Libraries** GUI page is used to enable encryption for a logical library and modify the encryption method that is being used. The **Security** GUI page is used to manage key servers and key labels.

Note: In the tape storage environment, the encryption function on tape drives (desktop, stand-alone, and within libraries) is configured and managed by the customer. It is not configured and managed by the IBM System Services Representative (SSR). In some instances, SSRs are required to enable encryption at a hardware level when service access or service password controlled access is required. Customer setup support is by field technical sales specialist (FTSS), customer documentation, and software support for encryption software problems. Customer "how to" support is also provided with the support line contract.

Related information

Choosing or modifying an encryption method

Encryption Key Servers

Encryption Internal Label (3592 or LTO)

Managing encryption

A key manager is a software program that assists IBM encryption-enabled tape drives in generating, protecting, storing, and maintaining encryption keys. The encryption keys encrypt information that is being written to tape media (tape and cartridge formats), and decrypt information that is being read from tape media.

IBM currently supports the IBM Security Key Lifecycle Manager (formerly Tivoli Key Lifecycle Manager) with the TS4500 tape library.

The key manager operates on z/OS®, i5/OS, AIX, Linux, HP-UX, Sun Solaris, and Windows. It is a shared resource that is deployed in several locations within an Enterprise. It can serve numerous IBM encrypting tape drives, regardless of where those drives are installed (for example, in tape library subsystems, connected to mainframe systems through various types of channel connections, or installed in other computing systems).

The key manager uses a key store to hold the certificates and keys (or pointers to the certificates and keys) required for all encryption tasks. Refer to the appropriate documentation for detailed information about the key manager and the key stores it supports.

The following encryption methods are supported:

- Application-managed encryption (AME)
- System-managed encryption (SME)
- Library-managed encryption (LME)

These methods differ in three ways:

- Where the encryption policy engine resides
- Where key management occurs for your encryption solution
- How the key manager is connected to the drive

Your operating environment determines which method is the best for you.

Key management and the encryption policy engine can be in any of the environment layers shown in Figure 28 on page 116

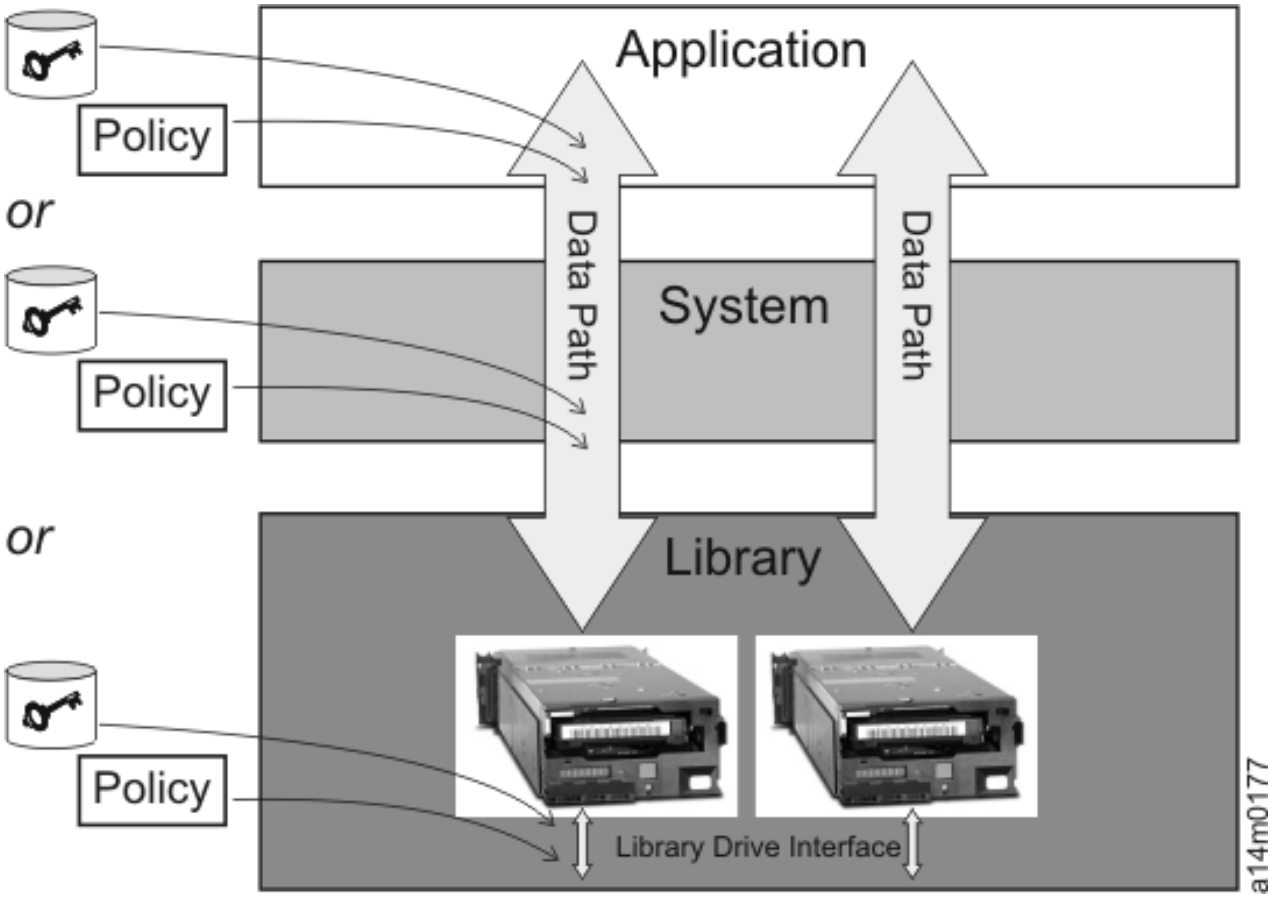


Figure 28. Possible locations for encryption policy engine and key management

Application layer
Initiates data transfer for tape storage; for example, Tivoli Storage Manager.

System layer
Everything between the application and the tape drives; for example, z/OS DFSMS and FICON®/ESCON controllers.

Library layer
The TS4500 tape library, which contains an internal interface to each tape drive installed in the library.

Planning for application-managed encryption
Application-managed encryption (AME) is useful in operating environments that run an application that is already capable of generating and managing encryption policies and keys, such as Tivoli Storage Manager.

With AME, policies that specify when encryption is to be used are defined through the application interface. The policies and keys pass through the data path between the application layer and the encrypting tape drives. Encryption is the result of interaction between the application and the encryption-enabled tape drive, and does not require any changes to the system and library layers. Because the application manages the encryption keys, data volumes that are written and encrypted using the application-managed encryption method can be read only by the same software application that wrote them. A key manager is not required by, or used with, application-managed tape encryption.

Note: The capability to use AME is not pre-set. The logical library must be set to use AME.

Application-managed tape encryption on TS1120, LTO 4 and later tape drives can use either of two encryption command sets:

- The IBM encryption command set developed for the key manager
- The T10 command set defined by the InterNational Committee for Information Technology Standards (INCITS)

For more information about setting up application-managed encryption for Tivoli Storage Manager, visit the IBM Tivoli Storage Manager page in the IBM Knowledge Center.

Planning for system-managed encryption
System-managed encryption (SME) is useful in System z® operating environments.

Note: The capability to use SME is not pre-set. The logical library must be set to use SME. SME is not available for LTO drives. It is available only on 3592 drives.

Encryption policies that specify when to use encryption are set up in z/OS DFSMS (Data Facility Storage Management Subsystem). Additional software products such as IBM Integrated Cryptographic Service Facility (ICSF) and IBM Resource Access Control Facility (RACF®) can also be used. Key generation and management are performed by the key manager that is running on the host or externally on another host. Policy controls and keys pass through the data path between the system layer and the encrypting tape drives. Encryption is transparent to the applications.

Planning for library-managed encryption
Library-managed encryption (LME) is useful for encryption-enabled tape drives in an open-attached TS4500 tape library.

Note: The capability to use LME is not pre-set. The logical library must be set to use LME.

Bar code encryption policies, which are set up through the TS4500 management GUI, can be used to specify when to use encryption. In such cases, policies are based on cartridge volume serial numbers. Library-managed encryption also allows other options, such as encryption of all volumes in a library, independent of bar codes. Key generation and management are performed by the key manager. Policy control and keys pass through the library-to-drive interface, therefore encryption is not apparent to the applications.

Library-managed encryption, when used with certain applications such as Symantec Netbackup or the EMC Legato NetWorker, includes support for an internal label option. When the internal label option is configured, the encryption-enabled tape drive automatically derives the encryption policy and key information from the metadata that is written on the tape volume by the application.

Notes:

- If you use LME and IBM device drivers that run on Open Systems platforms (AIX, HP-UX, Linux, Solaris, Windows), information for bulk rekey is available in the *IBM Tape Device Drivers Installation and User's Guide*.
- When you use LME, an extra Ethernet cable must be attached, preferably to a different network switch. The extra cable is for redundancy and better backup job reliability.
- When you use LME with LTO 5 or later LTO tape drives, the IBM Security Key Lifecycle Manager (formerly the Tivoli Key Lifecycle Manager) is required as the key manager.

System-managed encryption and library-managed encryption interoperate with one another. In other words, a tape encrypted using system-managed encryption can be decrypted when using library-managed encryption, and vice versa, provided they both have access to the same keys and certificates. Otherwise, this action might not be feasible.

The following components are required to use encryption:

- Encryption-enabled tape drive
- Keystore
- Key manager

Prerequisites for using encryption

Certain hardware and software prerequisites must be met before using encryption with the TS4500 tape library.

With the TS4500 tape library, encryption is managed at the logical library level. All encryption-enabled drives that are assigned to a logical library use the same method of encryption.

The rules for setting up encryption differ based on whether the library is installed with 3592 or LTO tape drives, and whether you use Library-Managed Encryption (LME), System-Managed Encryption (SME), or Application-Managed Encryption (AME).

If the library contains 3592 tape drives, the following prerequisites apply:

- IBM Security Key Lifecycle Manager (SKLM), formerly the Tivoli Key Lifecycle Manager, must be attached to the TS4500 and configured for LME or SME.
- Tape drives must be enabled for encryption from the **Logical Libraries** page of the TS4500 management GUI.

If the library contains LTO tape drives, the following prerequisites apply:

- Tape drives must be enabled for encryption from the **Logical Libraries** page of the TS4500 management GUI.
- Feature code 1604, Transparent LTO Encryption, is required for LTO tape drives if using LME.
- SKLM is required as the key manager when using LME with LTO.

Using LTO tape drive media

The section provides information about using LTO tape drive media.

The TS4500 tape library automates the storage and movement of IBM LTO tape cartridges.

Overview of LTO tape drive media

Subject to certain restrictions, the supported LTO tape drives use the following cartridge types.

- 12 TB LTO 8 Data Cartridge (LTO 8 cartridge)
- 12 TB LTO 8 WORM Data Cartridge (LTO 8 cartridge)
- 9 TB LTO M8 Data Cartridge (LTO M8 cartridge)
- 6 TB LTO 7 Data Cartridge (LTO 7 cartridge)
- 6 TB LTO 7 WORM Data Cartridge (LTO 7 cartridge)
- 2.5 TB LTO 6 Data Cartridge (LTO 6 cartridge)
- 2.5 TB LTO 6 WORM Data Cartridge (LTO 6 cartridge)
- 1.5 TB LTO 5 Data Cartridge (LTO 5 cartridge)
- 1.5 TB LTO 5 WORM Data Cartridge (LTO 5 cartridge)
- 800 GB LTO 4 Data Cartridge (LTO 4 cartridge)
- 800 GB LTO 4 WORM Data Cartridge (LTO 4 cartridge)
- 400 GB LTO 3 Data Cartridge (LTO 3 cartridge)
- 400 GB LTO 3 WORM Data Cartridge (LTO 3 cartridge)
- 200 GB LTO 2 Data Cartridge (LTO 2 cartridge)
- 100 GB LTO 1 Data Cartridge (LTO 1 cartridge)
- Universal LTO Cleaning Cartridge
- LTO Cleaning Cartridge
- Diagnostic cartridge

Figure 29 on page 119 shows IBM LTO data and WORM cartridges.

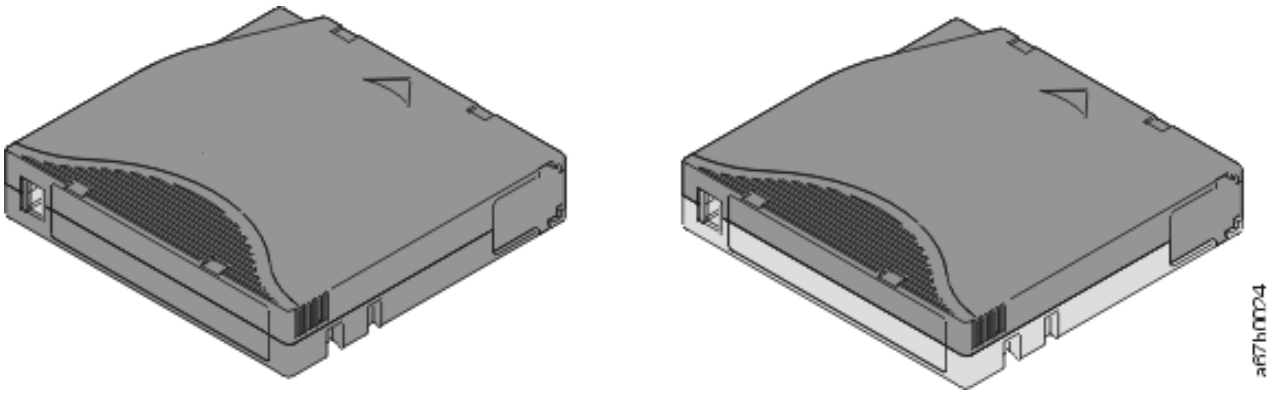


Figure 29. IBM LTO data and WORM tape cartridges

WORM functionality for LTO tape drives and media

Write-once-read-many (WORM) cartridges are designed for applications such as archiving and data retention, and to prevent the alteration or deletion of user data. They are also suitable for applications that require an audit trail.

The supported LTO tape drives include the WORM feature, which is supported by the LTO WORM data cartridges.

The following WORM media traits reduce tampering with data:

- The bottom of the WORM cartridge is molded in a color (gray) that is different from rewritable cartridges.
- A unique format is factory-written on each WORM cartridge.
- The WORM cartridge's memory, along with its unique format, protects the WORM character of the media.

Based on LTO technology, the format for the LTO WORM data cartridge provides the same capacities as the equivalent LTO data cartridges.

Compatibility among LTO tape drives and cartridges

This section defines compatibility among generations of LTO tape drives and cartridges.

“Mixed media in drives” on page 34 shows the compatibility among the LTO drives and cartridges.

Note: Only LTO 5 and later tape drives are supported with the TS4500 tape library.

LTO Type M cartridge (M8)

The LTO program introduced a new capability with LTO 8 tape drives: the ability to write 9 TB (native) on a brand new LTO Ultrium 7 cartridge instead of 6 TB (native) as specified by the LTO 7 format. Such a cartridge is called an LTO Ultrium 7 cartridge initialized as Type M media (M8). These cartridges are identifiable by using an automation barcode label ending with the characters M8.

Table 46. LTO 7 and LTO 8 cartridge types

Cartridge/density type	Barcode label	Cartridge packaging/ silkscreen labeling	Native capacity	Tape drive compatibility
L8	xxxxxxL8	LTO Ultrium 8	12 TB	LTO 8
M8	xxxxxxM8	LTO Ultrium 7	9 TB	LTO 8

Table 46. LTO 7 and LTO 8 cartridge types (continued)				
Cartridge/density type	**Barcode label**	**Cartridge packaging/ silkscreen labeling**	**Native capacity**	**Tape drive compatibility**
L7	xxxxxxL7	LTO Ultrium 7	6 TB	LTO 7, LTO 8

Hereafter, these cartridges will be referred to as L8, M8, and L7, respectively.

Only new, unused LTO Ultrium 7 cartridges can be initialized as M8 cartridges. Once a cartridge is initialized as M8, it cannot be changed back to L7. Initialized M8 cartridges can only be written and read in an LTO 8 tape drive; LTO 7 tape drives cannot read initialized M8 cartridges.

M8 cartridges can be purchased as either pre-initialized (also referred to as “labeled and initialized”) M8 data cartridges or un-initialized M8 data cartridges (M8 WORM cartridges are not supported). For either option, the barcode label is included; however, the un-initialized M8 data cartridge must first be initialized in tape libraries that support the automatic initialization of un-initialized M8 cartridges while under the control of ISV applications that recognize the M8 barcode label.

A tape cartridge is initialized when it is first loaded into a compatible tape drive and data is written by the ISV application at the beginning of tape (sometimes referred to as "labeling a tape" or "writing from BOT"). The tape drive establishes the density of the media at that time.

If an un-initialized M8 cartridge is not initialized in a tape library that supports un-initialized M8 cartridges, then the cartridge may inadvertently and silently be initialized at the L7 density (i.e., at a 6 TB native capacity) even if the barcode label states M8. This could occur with the usage of non-TS4500 tape libraries, stand-alone LTO 7 tape drives, stand-alone LTO 8 tape drives, down-level LTO 8 tape drive firmware, down-level TS4500 tape library firmware, or down-level ISV software that does not recognize that M8 cartridges should only be mounted in LTO 8 tape drives. M8 cartridges that are inadvertently initialized at the L7 density can continue to be read and written in LTO 7 and LTO 8 tape drives; however, they will remain limited to the 6 TB native capacity.

TS4500 tape library firmware version 1.4.1.2 added support for un-initialized M8 cartridges in addition to support for pre-initialized M8 cartridges. The TS3500 tape library only supports pre-initialized M8 cartridges. In any tape product with M8 cartridges, the minimum LTO 8 tape drive firmware version is HB82.

LTO data cartridge

This section describes the construction, operation, and components of the IBM LTO data cartridge.

The IBM LTO 8 cartridge is burgundy with a silk screen label on top that specifies "Ultrium 8 - 12 TB." The IBM LTO 7 cartridge is purple with a silk screen label on top that specifies "Ultrium 7 - 6 TB." The IBM LTO 6 cartridge is black with a silk screen label on top that specifies "Ultrium 6 - 2.5 TB." The IBM LTO 5 cartridge is burgundy with a silk screen label on the top that specifies "Ultrium 5 - 1.5 TB." The IBM LTO 4 cartridge is green with a silk screen label on the top that specifies "Ultrium 4 - 800 GB." The IBM LTO 3 cartridge is blue-gray. The IBM LTO 2 cartridge is purple, and the LTO 1 cartridge is black. WORM data cartridges are two tones in order to distinguish them from other data cartridges. Each WORM cartridge is the color as the same generation of data cartridge on the top, but it is gray on the bottom.

When processing tape in the cartridges, the LTO tape drives use a linear, serpentine recording format. LTO 8 drives read and write data on 6656 tracks, LTO 7 drives read and write data on 3584 tracks, LTO 6 drives read and write data on 2176 tracks, and LTO 5 drives read and write data on 1280 tracks. LTO 8 and 7 drives read and write 32 tracks at a time. LTO 6 and LTO 5 drives read and write 16 tracks at a time. The first set of tracks is written from near the beginning of the tape to near the end of the tape. The head then repositions to the next set of tracks for the return pass. This process continues until all tracks are written and the tape is full, or until all data is written. For additional information about LTO tape drive and cartridge compatibility, refer to the topic about LTO tape drives.

Figure 30 on page 121 shows the IBM LTO data cartridge and its components.

#	Component	#	Component
1	LTO cartridge memory	4	Write-protect switch
2	Cartridge door	5	Label area
3	Leader pin	6	Insertion guide

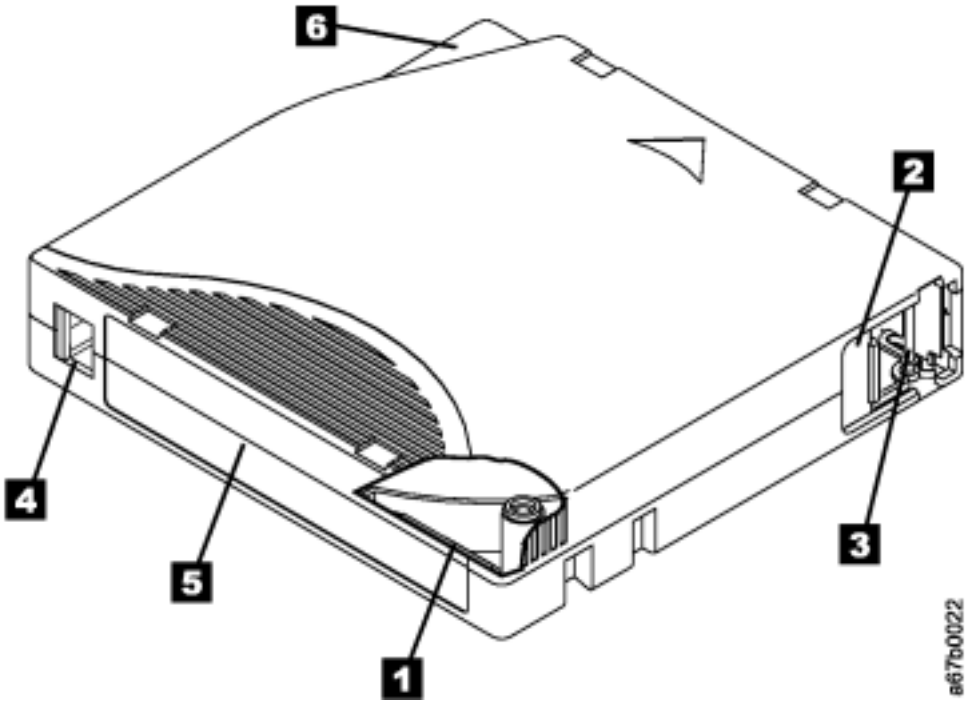


Figure 30. The IBM LTO data cartridge

All generations of the IBM LTO data cartridge include a Linear Tape-Open Cartridge Memory (LTO-CM) chip (1 in Figure 30 on page 121) that contains information about the cartridge and the tape (such as the name of the manufacturer that created the tape), as well as statistical information about the cartridge's use. The LTO-CM enhances the efficiency of the cartridge. For example, the LTO-CM stores the end-of-data location, which when you next insert a cartridge and issue the Write command, enables the drive to quickly locate the recording area and begin recording. The LTO-CM also aids in determining the reliability of the cartridge by storing data about its age, how many times it has been loaded, and how many errors it has accumulated. Whenever you unload a tape cartridge, the tape drive writes any pertinent information to the cartridge memory. The storage capacity of the LTO-CM is 4096 bytes.

The cartridge door 2 protects the tape from contamination when the cartridge is out of the drive. Behind the door, the tape is attached to a leader pin 3. When you insert the cartridge into the drive, a threading mechanism pulls the pin (and tape) out of the cartridge, across the drive head, and onto a non-removable takeup reel. The head can then read or write data from or to the tape.

The write-protect switch 4 prevents data from being written to the tape cartridge. The label area 5 provides a location for you to place a label. Affix only a bar code label. When affixing a label, place it only in the recessed label area. A label that extends outside of the recessed area can cause loading problems in the internal drive or in the TS4500 tape library. The insertion guide 6 is a large, notched area that prevents you from inserting the cartridge incorrectly. You can order tape cartridges with the bar code labels included, or you can order custom labels.

Generation 3 and later generations of the LTO data cartridge have a nominal cartridge life of 20,000 load and unload cycles.

LTO cleaning cartridge

The IBM LTO cleaning cartridge is used to clean LTO tape drives.

To maintain the operating efficiency of the drive, IBM supplies a cleaning cartridge with the first frame of each media type. Thus if the tape library contains frames with both LTO and 3592 tape drives, IBM supplies one LTO cleaning cartridge and one 3592 cleaning cartridge regardless of how many frames of each type are in the library. Each drive determines when it needs to be cleaned and alerts the library. The TS4500 tape library automatically cleans drives as needed; however, you can also use the TS4500 management GUI to initiate a manual cleaning if necessary.

Note: The volume serial (VOLSER) number on the cleaning cartridge's bar code label must begin with **CLN** or the library treats the cleaning cartridge as a data cartridge during an inventory.

The LTO Cleaning Cartridge is compatible with all LTO tape drives.

Before a drive can be cleaned, ensure that a cleaning cartridge is loaded in the library. You can load multiple cleaning cartridges and store them in any cartridge storage slots.

The tape library monitors the use of all cleaning cartridges. The IBM cleaning cartridges are valid for 50 uses. When a cleaning cartridge is almost expired, a warning icon displays on the TS4500 management GUI. When a cleaning cartridge has expired, an error icon displays. You can also enable automatic eject of expired cleaning cartridges through the TS4500 management GUI by selecting **Settings** > **Library** > **Cartridges**.

Note: It is the operator's responsibility to monitor the use of all cleaning cartridges and to remove and replace expired cartridges as necessary.

Related information

"Methods of cleaning drives" on page 32
Automatic cleaning of tape drives is enabled by default. However, it is also possible to initiate manual or host cleaning.

TS4500 management GUI Cartridges page help

LTO diagnostic cartridge

An IBM service representative uses the LTO diagnostic cartridge to ensure that the LTO tape drives run correctly and to specification.

The LTO diagnostic cartridge is a cartridge with known good media that is reserved for diagnostic purposes only. The diagnostic cartridge can be stored in any frame door slot. Depending on the mixture of LTO drives that are installed in the library, more than one LTO diagnostic cartridge might be required.

The volume serial (VOLSER) number for a diagnostic cartridge is represented as `DG IxxLy`, where `xx` equals alphanumeric characters and `y` equals the generation of the cartridge type. The characters of the VOLSER are white on a black background.

Note: Only LTO 5 and later LTO tape drives are supported in the TS4500 tape library.

Table 47. Compatibility of diagnostic cartridges with LTO tape drives

Cartridge generation (y)	LTO tape drives			
	LTO 8	**LTO 7**	**LTO 6**	**LTO 5**
8	Yes	No	No	No
7	Yes	Yes	No	No
6	No	Yes	Yes	No
5	No	Yes	Yes	Yes
4	No	No	Yes	Yes
3	No	No	No	Yes

Table 47. Compatibility of diagnostic cartridges with LTO tape drives (continued)				
Cartridge generation (y)	**LTO tape drives**			
	LTO 8	**LTO 7**	**LTO 6**	**LTO 5**
2	No	No	No	No
1	No	No	No	No

If your library is installed with a second accessor, service bay A (the HA1 frame) contains only gripper test slots for diagnostic cartridges. Service bay B contains gripper test slots for diagnostic cartridges, and also contains unusable storage slots. The storage slots in service bay B are not usable if the frame is configured as a service bay. Never insert any type of cartridge into service bays. Each service bay contains gripper test slots for three LTO diagnostic cartridges and three 3592 diagnostic cartridges.

Internal diagnostics for the LTO tape drive prevent it from writing to a WORM cartridge. All diagnostic tests that are selected from the operator panel and completed in maintenance mode causes the drive to eject a WORM cartridge. Error code 7 displays on the panel. To run diagnostics, use a non-WORM cartridge.

LTO bar code labels

Each LTO data, cleaning, and diagnostic cartridge that is processed by the tape library must bear a bar code label.

The bar code label contains:

- A volume serial (VOLSER) number that you can read
- A bar code that the library can read

When read by the library's bar code reader, the bar code identifies the cartridge's VOLSER to the tape library. The bar code also tells the library whether the cartridge is a data, cleaning, or diagnostic cartridge. In addition, the bar code includes the two-character media-type identifier Lx (where x equals 1, 2, 3, 4, 5, 6, 7, 8, T, U, V, W, X, or Y) or M8.

- L or M identifies the cartridge as an LTO cartridge.
- 1 indicates that the cartridge is the first generation of its type. 2, 3, 4, 5, 6, 7, or 8 indicates that the cartridge is the second, third, fourth, fifth, sixth, seventh, or eighth generation of its type.
- T indicates that the cartridge is a generation 3 WORM cartridge, U indicates that the cartridge is a generation 4 WORM cartridge, V indicates that the cartridge is a generation 5 WORM cartridge, W indicates that the cartridge is a generation 6 WORM cartridge, X indicates that the cartridge is a generation 7 WORM cartridge, and Y indicates that the cartridge is a generation 8 WORM cartridge.

Note: Only LTO 5 and later LTO tape drives and their supported media are supported by the TS4500 tape library.

You can use the modifyVolserReporting CLI command to configure the library so that it reports to the server all eight characters of the VOLSER on the bar code label or only the first six characters.

Note: If you suspect that the library is having problems reading bar code labels, an IBM service representative can slow scanner speed as part of problem determination.

Related information

modifyVolserReporting CLI command

“Ordering bar code labels for tape cartridges” on page 138
Each tape cartridge must have a bar code label with a unique volume serial (VOLSER) number. You can order these labels separately from IBM data cartridges and cleaning cartridges.

Guidelines for using LTO bar code labels

The guidelines listed in this topic must be followed when using LTO bar code labels.

Apply the following guidelines whenever you use LTO bar code labels:

- Use only IBM-approved bar code labels.

- Do not reuse a label or reapply a used label over an existing label.
- Before you apply a new label, remove the old label by slowly pulling it at a right angle to the cartridge case.
- Use peel-clean labels that do not leave a residue after they are removed. If there is glue residue on the cartridge, remove it by gently rubbing it with your finger. Do not use a sharp object, water, or a chemical to clean the label area.
- Examine the label before you apply it to the cartridge. Do not use the label if it has voids or smears in the printed characters or bar code (an application's inventory operation will take much longer if the bar code label is not readable).
- Remove the label from the label sheet carefully. Do not stretch the label or cause the edges to curl.
- Place the label only in the recessed bar code label area. A label that extends outside of the recessed area can cause loading problems in the drive or the library.
- With light finger pressure, smooth the label so that no wrinkles or bubbles exist on its surface.
- Verify that the label is smooth and parallel, and has no roll-up or roll-over. The label must be flat to within 0.5 mm (0.02 in.) over the length of the label and have no folds, missing pieces, or smudges.
- Do not place other machine-readable labels on other surfaces of the cartridge. They might interfere with the ability of the bar code reader to read the bar code.
- Do not place any type of mark on the white space at either end of the bar code. A mark in this area may prevent the tape library from reading the label.

Bar code label specifications

You can order tape cartridges with the labels included, or you can order custom labels. The bar code labels must meet predefined specifications. They include (but are not limited to):

- Eight uppercase alphanumeric characters, where the last 2 characters must be L1, L2, L3, L4, L5, L6, L7, L8, LT, LU, LV, LW, LX, LY, or M8.
- Label and printing to be non-glossy
- Nominal narrow line or space width of 0.423 mm (0.017 in.)
- Wide to narrow ratio of 2.75:1
- Minimum bar length of 11.1 mm (0.44 in.)

To determine the complete specifications of the bar code and the bar code label, go to the IBM LTO Ultrium Cartridge Label Specification web page and download the PDF file of the specification, *IBM LTO Ultrium Cartridge Label Specification*. You can also contact your IBM Sales Representative for this specification.

Setting the write-protect switch on an LTO tape cartridge

Use the write-protect switch to prevent data from being written to an LTO tape cartridge.

The position of the write-protect switch on an LTO tape cartridge (see **1** in Figure 31 on page 125) determines whether you can write to the tape:

- If the switch is set to  (solid red), data cannot be written to the tape.
- If the switch is set to unlocked (black void), data can be written to the tape.

If possible, use your server's application software to write-protect your cartridges (rather than manually setting the write-protect switch). This allows the server's software to identify a cartridge that no longer contains current data and is eligible to become a scratch cartridge. Do not write-protect scratch (blank) cartridges; the tape drive will not be able to write new data to them.

If you must manually set the write-protect switch, slide it left or right to the desired position.

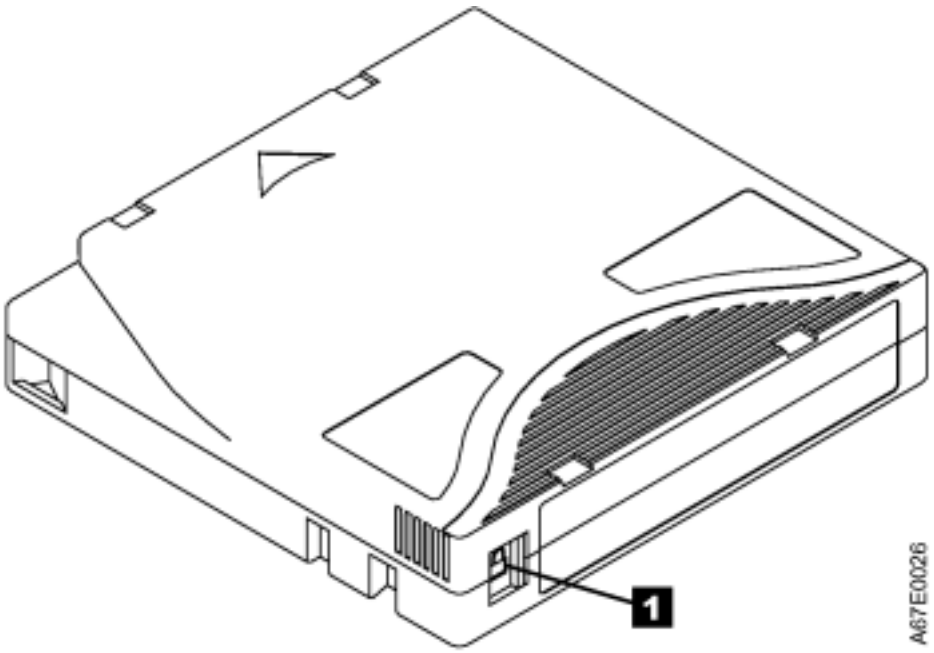


Figure 31. Setting the write-protect switch on an LTO tape cartridge

Handling LTO tape cartridges

Incorrect handling or an incorrect environment can damage IBM LTO tape cartridges or their magnetic tape. To avoid damage to your tape cartridges and ensure the continued high reliability of your IBM LTO tape drives, handle them properly as described in the following topics.

Attention: Do not insert a damaged tape cartridge into your tape library. A damaged cartridge can interfere with the reliability of a drive and may void the warranties of the drive and the cartridge. Before inserting a tape cartridge, inspect the cartridge case, cartridge door, and write-protect switch for breaks. If you need to recover data from a damaged cartridge, contact your IBM Service Representative.

Provide training for using LTO tape cartridges

Provide proper training for people using LTO tape cartridges.

- Post procedures that describe proper media handling in places where people gather.
- Ensure that anyone who handles tape has been properly trained in handling and shipping procedures. This includes operators, users, programmers, archival services, and shipping personnel.
- Ensure that any service or contract personnel who perform archiving are properly trained in media-handling procedures.
- Include media-handling procedures as part of any services contract.
- Define and make personnel aware of data recovery procedures.

Ensure proper packaging of LTO tape cartridges

LTO tape cartridges must be packed and shipped according to specific guidelines in order to ensure they are not damaged during transport.

Adhere to the following guidelines when packaging or shipping LTO tape cartridges:

- When you ship a cartridge, ship it in its original or better packaging.
- Always ship or store a cartridge in a jewel case.

- Use only a recommended shipping container that securely holds the cartridge in its jewel case during transportation. LTO Turtle Cases (by Perm-A-Store) have been tested and found to be satisfactory (see Figure 32 on page 126). They are available at http://www.turtlecase.com.

Figure 32. Tape cartridges in a Turtle Case

- Never ship a cartridge in a commercial shipping envelope. Always place it in a box or package.
- If you ship the cartridge in a cardboard box or a box of a sturdy material, ensure that the following precautions are taken:
  - Place the cartridge in polyethylene plastic wrap or bags to protect it from dust, moisture, and other contaminants.
  - Pack the cartridge snugly to ensure that it does not move around.
  - Double-box the cartridge (place it inside a box, then place that box inside the shipping box) and add padding between the two boxes (see Figure 33 on page 126).

Figure 33. Double-boxing tape cartridges for shipping

Provide proper acclimation and environmental conditions for LTO tape cartridges
Certain conditions are required to ensure the safety and quality of LTO tape cartridges.

- Before you use a cartridge, let it acclimate to the normal operating environment for a minimum of 24 hours. If you see condensation on the cartridge, wait an additional hour.
- Ensure that all surfaces of a cartridge are dry before inserting it.
- Do not expose the cartridge to moisture or direct sunlight.
- Do not expose recorded or blank cartridges to stray magnetic fields greater than 50 oersteds (4000 ampere/meter), such as terminals, motors, video equipment, X-ray equipment, or fields that exist near high-current cables or power supplies. Such exposure can cause the loss of recorded data or make the blank cartridge unusable.
- Maintain the proper conditions for storing and shipping the cartridges.

Perform a thorough inspection of LTO tape cartridges
Inspect LTO tape cartridges to ensure they are not damaged before using them with your LTO tape drives and tape library.

After purchasing a cartridge and before using it, perform the following steps:

1. Inspect the packaging to determine if the cartridge was handled roughly.

   Note: When inspecting a cartridge, open only the cartridge door. Do not open any other part of the cartridge case. The upper and lower parts of the case are held together with screws; separating them destroys the usefulness of the cartridge.
2. Inspect the cartridge for damage before using or storing it.
3. Inspect the rear of the cartridge (the part that you load first into the tape load compartment) and ensure that there are no gaps in the seam of the cartridge case. (Refer to 1 in Figure 34 on page 127. If there are gaps in the seam, the leader pin may be dislodged and may need to be repositioned.)

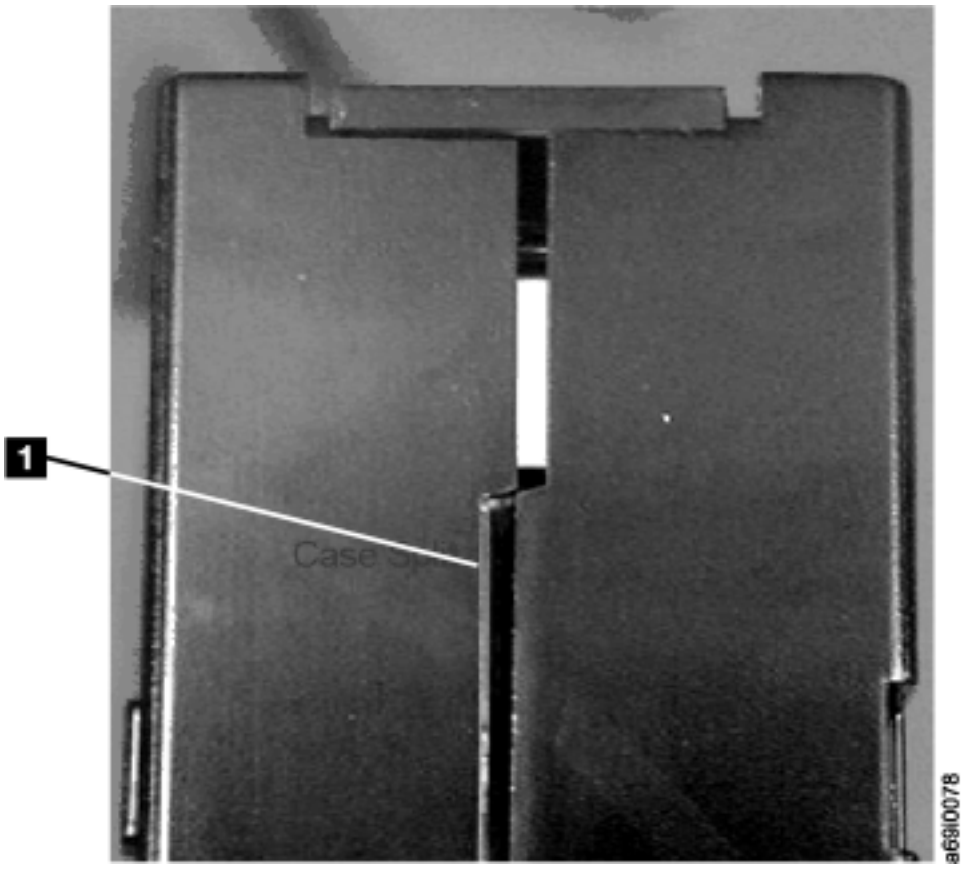


Figure 34. Gap in cartridge seam

Handle the LTO tape cartridge carefully

Handle the LTO tape cartridges carefully to ensure they do not get damaged.

- Do not drop the LTO tape cartridge. If the cartridge drops, slide the cartridge door back and ensure that the leader pin is properly positioned in the pin-retaining spring clips. If the leader pin has become dislodged, perform the procedure to reposition it.
- Do not handle tape that is outside the cartridge. Handling the tape can damage the tape's surface or edges, which may interfere with read or write reliability. Pulling on tape that is outside the cartridge can damage the tape and the brake mechanism in the cartridge.
- Do not stack more than six cartridges.
- Do not degauss a cartridge that you intend to reuse. Degaussing makes the tape unusable.

Examples of cartridge problems

If you encounter a problem with an LTO tape cartridge, try to resolve the problem and avoid any data loss.

Example: Split cartridge case

The cartridge case is damaged. There is a high possibility of media damage and potential loss. Perform the following steps to determine the cause and recover data:

1. Look for cartridge mishandling.
2. Use the IBM Leader Pin Reattachment Kit (part number 08L9129) to correctly position the pin. Then, immediately use data recovery procedures to minimize chances of data loss.
3. Review media-handling procedures.

Example: Improper placement of leader pin

The leader pin is misaligned. Perform the following steps to determine the cause and recover data:

1. Look for cartridge damage.
2. Use the IBM Leader Pin Reattachment Kit (part number 08L9129) to correctly position the pin. Then, immediately use data recovery procedures to minimize chances of data loss.

Repositioning or reattaching a leader pin in an LTO tape cartridge

Use the following procedures to move a leader pin into its proper position in an LTO tape cartridge, or to reattach the pin if it has separated from the tape.

If the leader pin in your LTO tape cartridge becomes dislodged from its pin-retaining spring clips or detaches from the tape, you must use the IBM Leader Pin Reattachment Kit (part number 08L9129) to reposition or reattach it. Do not reattach the pin if you must remove more than 7 meters (23 feet) of leader tape.

Attention: Use a repaired tape cartridge only to recover data and move it to another cartridge. Continued use of a repaired cartridge might void the warranties of the drive and the cartridge.

Repositioning a leader pin in an LTO tape cartridge

Reposition a leader pin in an LTO tape cartridge if it is improperly positioned.

Before you begin

To place the leader pin in its proper position, you will need the following tools:

- Plastic or blunt-end tweezers
- Cartridge manual rewind tool (from Leader Pin Reattachment Kit, part number 08L9129)

About this task

A leader pin that is improperly positioned inside an LTO tape cartridge can interfere with the operation of the drive. Figure 35 on page 129 shows a leader pin in the incorrect 1 and correct 2 positions.

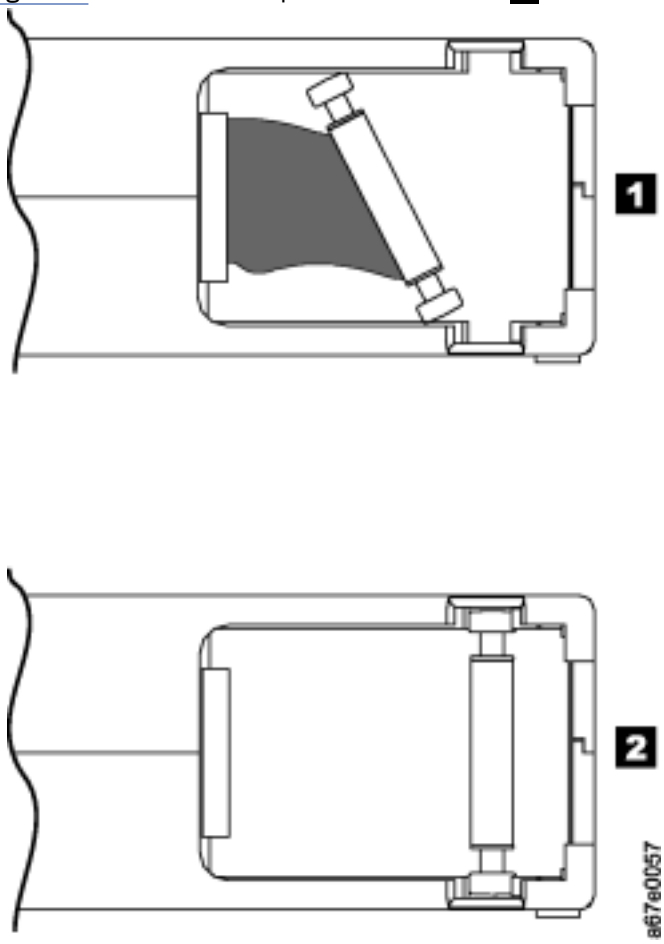


Figure 35. Leader pin in the incorrect and correct positions in an LTO tape cartridge

Procedure

Complete the following steps to reposition a leader pin:

1. Slide open the cartridge door (1 in Figure 36 on page 130) and locate the leader pin 2. You may need to shake the cartridge gently to roll the pin toward the door.
2. With plastic or blunt-end tweezers, grasp the leader pin and position it in the pin-retaining spring clips 3.
3. Press the leader pin gently into the clips until it snaps into place and is firmly seated. Ensure that there are no gaps in the seam of the cartridge 4.

   Note: If gaps exist, do not continue with this procedure and do not use the cartridge. Instead, contact your IBM service representative.

4. Close the cartridge door.

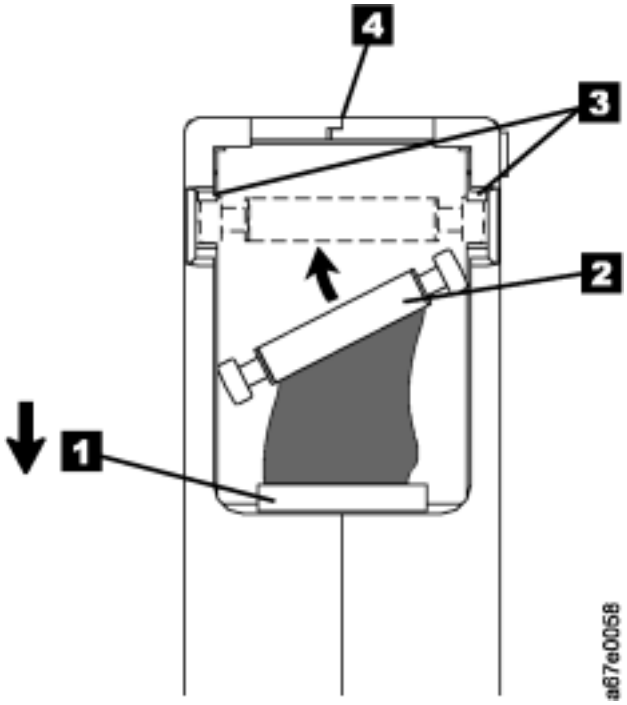


Figure 36. Placing the dislodged leader pin into the correct position

5. To rewind the tape, insert the cartridge manual rewind tool (1 in Figure 37 on page 130) into the cartridge's hub 2 and turn it clockwise until the tape becomes taut.

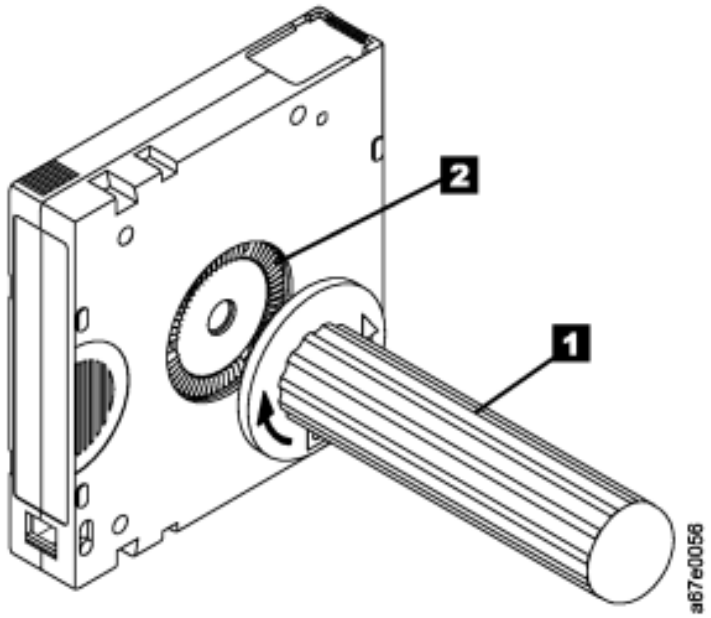


Figure 37. Rewinding the tape into the cartridge

6. Remove the rewind tool.

Reattaching a leader pin in an LTO tape cartridge

Reattach a leader pin if it has become detached from the magnetic tape and you must copy the cartridge's data onto another cartridge.

Before you begin

The first meter of tape in an LTO tape cartridge is leader tape. Once the leader tape has been removed there is a possibility of tape breakage. After reattaching the leader pin, transfer data from the defective tape cartridge. **Do not reuse the defective tape cartridge**.

The Leader Pin Reattachment Kit contains three parts:

- **Leader pin attach tool** (see 1 in Figure 38 on page 131). A plastic brace that holds the cartridge door open.
- **Cartridge manual rewind tool** (see 2 in Figure 38 on page 131). A device that fits into the cartridge's hub and lets you wind the tape into and out of the cartridge.
- **Pin supplies** (see 3 in Figure 38 on page 131). Leader pins and C-clips.

Attention:

- Use only the IBM Leader Pin Reattachment Kit to reattach the leader pin to the tape. Other methods of reattaching the pin will damage the tape, the drive, or both.
- Use this procedure on your tape cartridge only when the leader pin detaches from the magnetic tape and you must copy the cartridge's data onto another cartridge. Destroy the damaged cartridge after you copy the data. This procedure may affect the performance of the leader pin during threading and unloading operations.
- Touch only the end of the tape. Touching the tape in an area other than the end can damage the tape's surface or edges, which may interfere with read or write reliability.

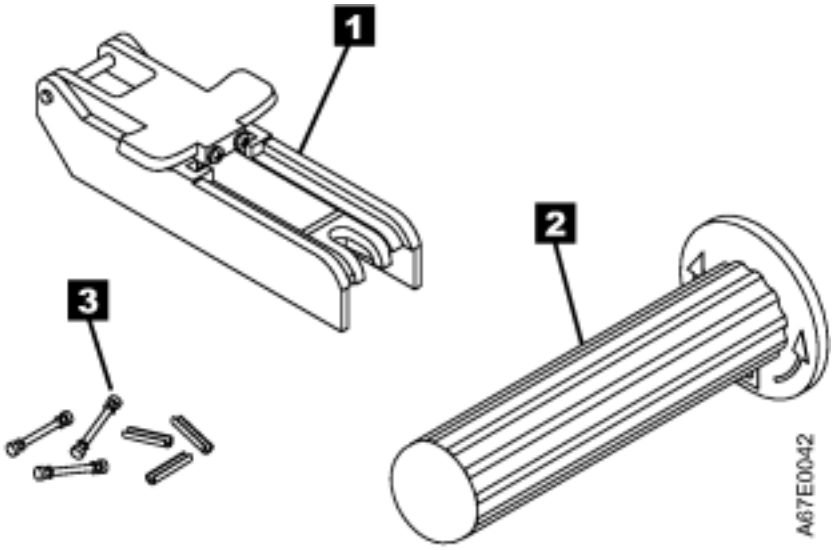


Figure 38. Leader Pin Reattachment Kit

Procedure

To reattach a leader pin by using the IBM Leader Pin Reattachment Kit, perform the following steps:

1. Attach the leader pin attach tool (1 in Figure 39 on page 132) to the cartridge 2 so that the tool's hook 3 latches into the cartridge's door 4. Pull the tool back to hold the door open, then slide the tool onto the cartridge. Open the tool's pivot arm 5.

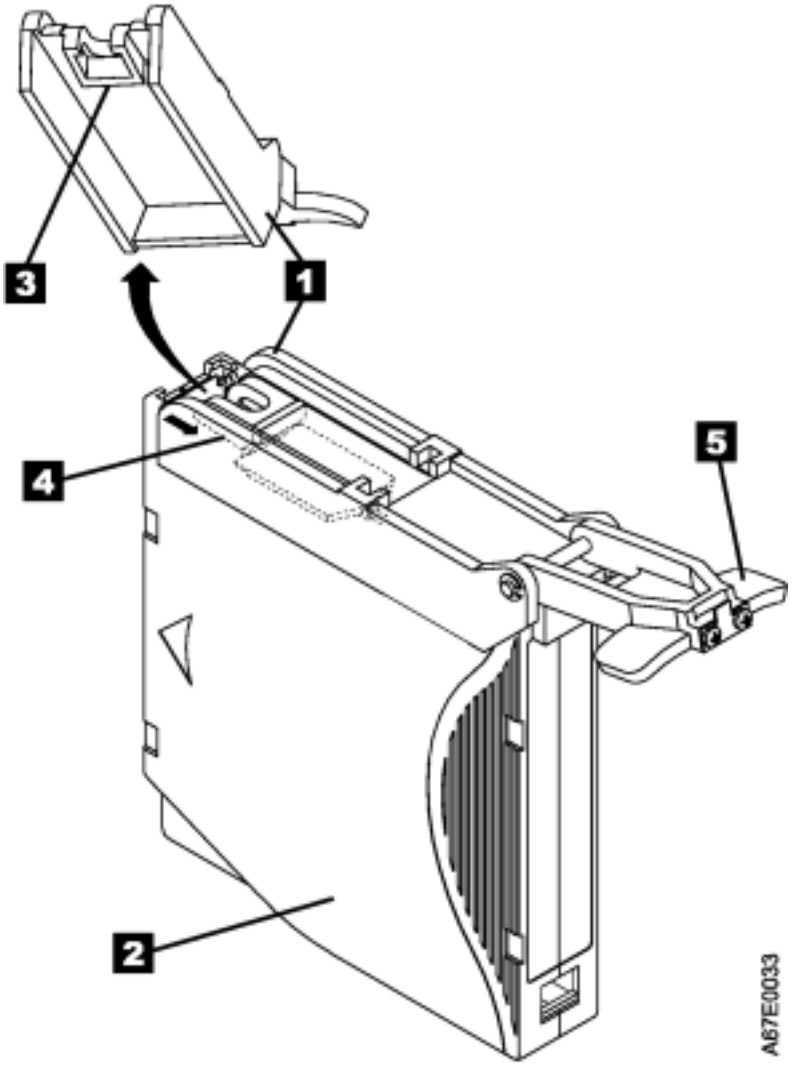


Figure 39. Attaching the leader pin attach tool to an LTO tape cartridge

2. To find the end of the tape inside the cartridge, attach the cartridge manual rewind tool (1 in Figure 40 on page 133) to the cartridge's hub 2 by fitting the tool's teeth between the teeth of the hub. Turn the tool clockwise until you see the end of the tape inside the cartridge. Then, slowly turn the rewind tool counterclockwise to bring the tape edge toward the cartridge door 3.
3. Continue to turn the rewind tool counterclockwise until approximately 13 cm (5 in.) of tape hangs from the cartridge door. If necessary, grasp the tape and pull gently to unwind it from the cartridge.

4. Remove the rewind tool by pulling it away from the cartridge. Set the tool and the cartridge aside.

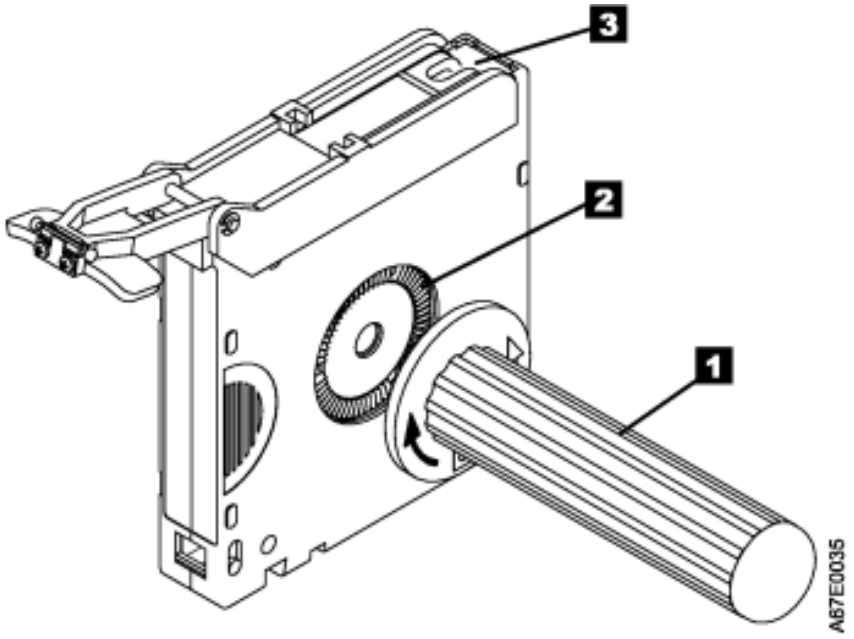


Figure 40. Winding the tape out of the LTO tape cartridge

5. On the leader pin (1 in Figure 41 on page 133), locate the open side of the C-clip 2. The C-clip is a small black part that secures the tape 3 to the pin.
6. Remove the C-clip from the leader pin by using your fingers to push the clip away from the pin. Set the pin aside and discard the clip.

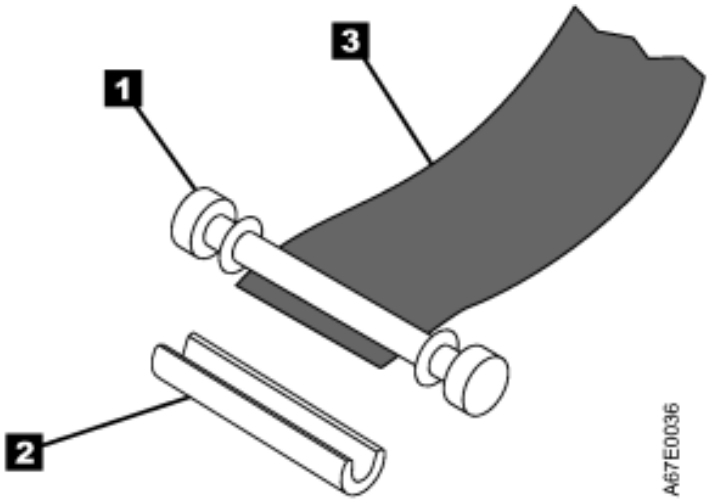


Figure 41. Removing the C-clip from the leader pin

7. Position the tape in the alignment groove of the leader pin attach tool (see 1 in Figure 42 on page 134).
8. Place a new C-clip into the retention groove 2 on the leader pin attachment tool and make sure that the clip's open side faces up.
9. Place the leader pin (from step "6" on page 133) into the cavity 3 of the leader pin attach tool.

10. **Attention:** To prevent the leader pin from rolling into the cartridge, in this step, use care when folding the tape over the pin.

    Fold the tape over the leader pin and hold it with your fingers (see Figure 42 on page 134).

    Note: Use care to ensure that the tape is centered over the leader pin. Failure to properly center the tape on the pin will cause the repaired cartridge to fail. When the tape is properly centered, a 0.25-mm (0.01-in.) gap exists on both sides of the pin.

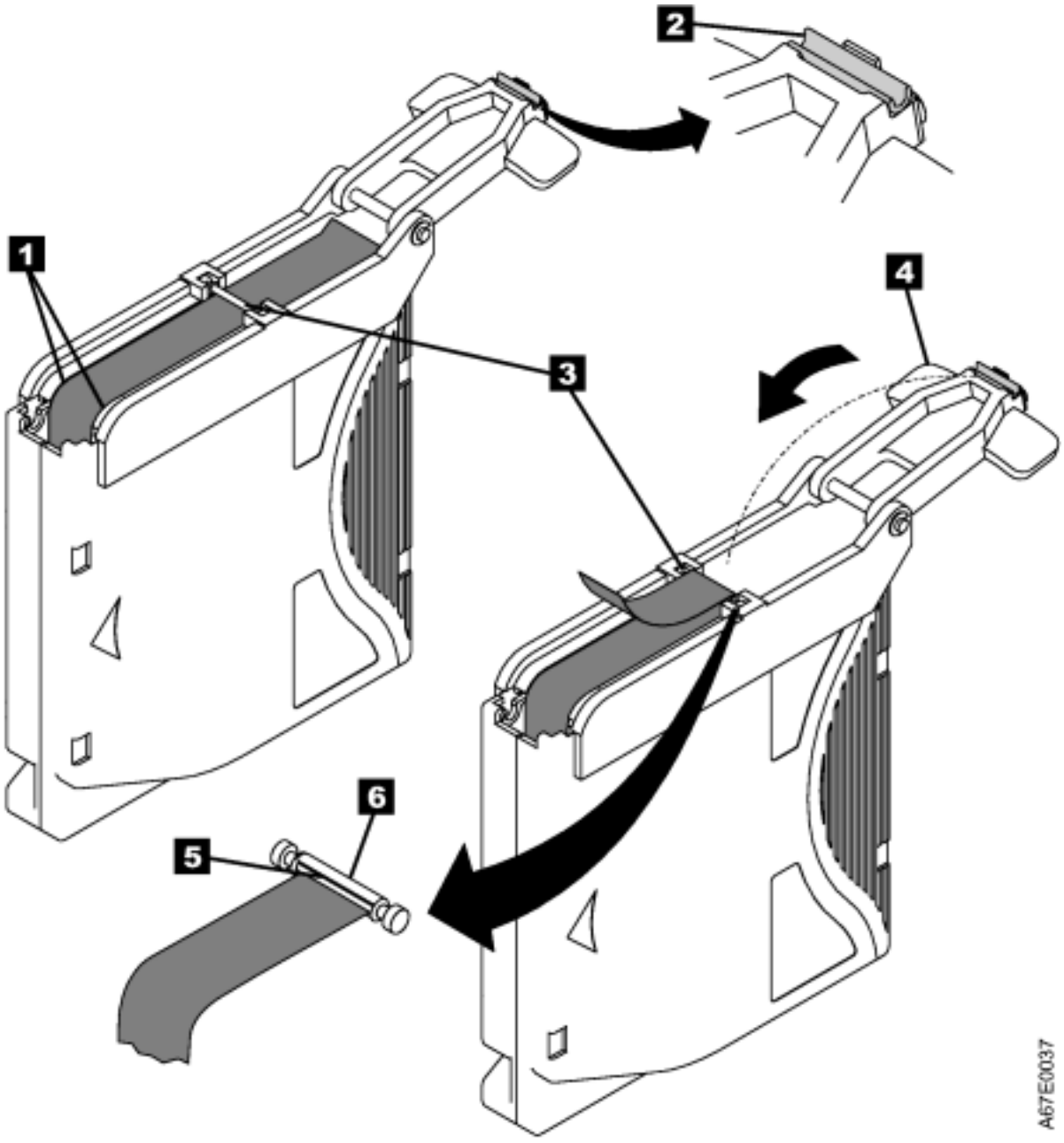


Figure 42. Attaching the leader pin to the tape

11. Close the pivot arm 4 of the leader pin attach tool by swinging it over the leader pin so that the C-clip snaps onto the pin and the tape.
12. Swing the pivot arm open and trim the excess tape 5 so that it is flush with the reattached leader pin 6.
13. Use your fingers to remove the leader pin from the cavity 3 in the leader pin attach tool.

14. Use the cartridge manual rewind tool to wind the tape back into the cartridge (wind the tape clockwise). Ensure that the leader pin is latched by the pin-retaining spring clips on each end of the leader pin.
15. Remove the rewind tool.
16. Remove the leader pin attach tool by lifting its end up and away from the cartridge.

Environmental and shipping specifications for LTO tape cartridges

Specific storage and shipping environmental conditions apply to LTO tape cartridges.

Before you use an LTO tape cartridge, acclimate it to the operating environment for 24 hours or the amount of time necessary to prevent condensation in the drive. The time varies depending on the environmental extremes to which the cartridge was exposed.

The best storage container for the cartridges (until they are opened) is the original shipping container. The plastic wrapping prevents dirt from accumulating on the cartridges and partially protects them from humidity changes.

Attention: Depending on how many drives you have installed in a frame, the temperature inside the frame might be as high as 5°C (9°F) above the temperature outside the frame. To ensure continued reliability of your media, be sure to take this temperature difference into account when you set up the environment around your library.

When you ship a cartridge, place it in its jewel case or in a sealed, moisture-proof bag to protect it from moisture, contaminants, and physical damage. Ship the cartridge in a shipping container that has enough packing material to cushion the cartridge and prevent it from moving within the container.

Table 48 on page 135 gives the environment for storing and shipping LTO tape cartridges.

Table 48. Environment for storage and shipping the LTO tape cartridges

Environmental Specifications			
Environmental Factor	**Allowable Storage**	**Recommended Storage**	**Shipping**
Temperature	16 to 32°C (61 to 90°F)	16 to 25°C (61 to 77°F)	-23 to 49°C (-9 to 120°F)
Relative humidity (noncondensing)	20 to 80%	20 to 50%	5 to 80%
Maximum wet bulb temperature	26°C (79°F)	26°C (79°F)	26°C (79°F)
Magnetic field	Stray magnetic field at any point on tape not to exceed 50 oersteds (4000 ampere/meter).		

Disposing of LTO tape cartridges

Dispose of LTO tape cartridges according to federal and other regulations.

Under the current rules of the U.S. Environmental Protection Agency (EPA), regulation 40CFR261, the LTO tape cartridge is classified as non-hazardous waste. As such, it may be disposed of in the same way as normal office trash. These regulations are amended from time to time, and you should review them at the time of disposal.

If your local, state, country (non-U.S.A.), or regional regulations are more restrictive than EPA 40CFR261, you must review them before you dispose of a cartridge. Contact your account representative for information about the materials that are in the cartridge.

If a tape cartridge must be disposed of in a secure manner, you can erase the data on the cartridge by using a high-energy ac degausser (use a minimum of 2800 oersteds over the entire space that the cartridge occupies). Degaussing makes the cartridge unusable.

If you burn the cartridge and tape, ensure that the incineration complies with all applicable regulations.

Ordering LTO cartridges and media supplies

Order LTO tape cartridges and other media supplies as described in this topic.

You can order the cartridges and media supplies listed in Table 49 on page 136 from:

- An IBM Media Authorized Distributor (find the closest distributor at IBM Storage Media).
- Your IBM Sales Representative or any authorized IBM Business Partner.

Notes:

- For cartridges with preapplied bar code labels, specify the volume serial (VOLSER) characters that you want. To order cartridges with radio frequency identification (RFID) labels, also specify the feature code from the table below.
- Only LTO 5 and later LTO tape drives and their supported media are supported.

Table 49. Ordering LTO cartridges and media supplies

Supply Item	Method of Ordering	Part numbers available from media distributors
12 TB Ultrium 8 Data Cartridge 20Pk Bar code labels are preapplied to cartridges.	Specify Machine Type 3589 Model 552 and FC 5502 and the VOLSER characters that you want.	01PL041L
12 TB Ultrium 8 Data Cartridge 20Pk Order VOLSER labels separately.	Specify Machine Type 3589 Model 652 and FC 6502.	01PL041
12 TB Ultrium 8 Data Cartridge 5Pk Order VOLSER labels separately.	Specify Machine Type 3589 Model 652 and FC 6506.	01PL041
12 TB Ultrium 8 WORM Data Cartridges Bar code labels are preapplied to cartridges.	Available from media distributors.	01PL042L
12 TB Ultrium 8 WORM Data Cartridges	Available from media distributors.	01PL042
12 TB Ultrium 8 RFID Cartridges	Available from media distributors.	01PL041RF
9 TB Ultrium 7 Uninitialized Tape Cartridge 20Pk M8 Labeled Bar code labels are preapplied to cartridges.	Available from media distributors.	38L7302L-M8
9 TB Ultrium 7 Initialized Tape Cartridge 20Pk M8 Labeled Bar code labels are preapplied to cartridges.	Available from media distributors.	38L7302LI-M8
6 TB Ultrium 7 Data Cartridge 20Pk Bar code labels are preapplied to cartridges.	Specify Machine Type 3589 Model 551 and FC 5501 and the VOLSER characters that you want.	38L7302L

Table 49. Ordering LTO cartridges and media supplies (continued)

Supply Item	Method of Ordering	Part numbers available from media distributors
6 TB Ultrium 7 Data Cartridge 20Pk Order VOLSER labels separately.	Specify Machine Type 3589 Model 651 and FC 6501.	38L7302
6 TB Ultrium 7 WORM Data Cartridge 20Pk Bar code labels are preapplied to cartridges.	Available from media distributors.	38L7303L
6 TB Ultrium 7 WORM Data Cartridge 20Pk	Available from media distributors.	38L7303
6 TB Ultrium 7 RFID Cartridges	Available from media distributors.	38L7302RF
6 TB Ultrium 7 Data Cartridge 5Pk No labeling	Specify Machine Type 3589 Model 651 and FC 6505	38L7302
2.5 TB Ultrium 6 Data Cartridge Bar code labels are preapplied to cartridges.	Specify Machine Type 3589 Model 550 and FC 5500 and the VOLSER characters that you want.	00V7590L
2.5 TB Ultrium 6 Data Cartridge Order VOLSER labels separately.	Specify Machine Type 3589 Model 650 and FC 6500.	00V7590
2.5 TB Ultrium 6 WORM Data Cartridge Bar code labels are preapplied to cartridges.	Available from media distributors.	00V7591L
2.5 TB Ultrium 6 WORM Data Cartridge Order VOLSER labels separately.	Available from media distributors.	00V7591
2.5 TB Ultrium 6 RFID Cartridges	Available from media distributors.	29201
1.5 TB Ultrium 5 Data Cartridge Bar code labels are preapplied to cartridges.	Specify Machine Type 3589 Model 014 and FC 1420 and the VOLSER characters that you want.	46X6666
1.5 TB Ultrium 5 Data Cartridge Order VOLSER labels separately.	Specify Machine Type 3589 Model 015 and FC 1520.	46X1290
1.5 TB Ultrium 5 WORM Data Cartridge Bar code labels are preapplied to cartridges.	Available from media distributors.	46X4444
1.5 TB Ultrium 5 WORM Data Cartridge Order VOLSER labels separately.	Available from media distributors.	46X1292
1.5 TB Ultrium 5 RFID Cartridges	Available from media distributors.	27879

Table 49. Ordering LTO cartridges and media supplies (continued)		
Supply Item	**Method of Ordering**	**Part numbers available from media distributors**
Ultrium Cleaning Cartridge 5-pack (universal cleaning cartridge for use with all Ultrium tape drives) VOLSER labels are included.	Specify Machine Type 3589 Model 004 and FC 4005 and the VOLSER characters that you want.	35L2087
Ultrium Cleaning Cartridge (universal cleaning cartridge for use with all Ultrium tape drives) Order VOLSER labels separately.	Available from media distributors.	35L2086
Leader Pin Reattachment Kit	Order as part number 08L9129.	08L9129

Ordering bar code labels for tape cartridges
Each tape cartridge must have a bar code label with a unique volume serial (VOLSER) number. You can order these labels separately from IBM data cartridges and cleaning cartridges.

Bar code labels must meet the following specifications:

- IBM LTO Ultrium Cartridge Label Specification
- Label Specification for IBM 3592 Cartridges when used in IBM Libraries

Table 50. Authorized suppliers of custom bar code labels[1]	
In the Americas	**In Europe and Asia**
EDP/Tri-Optic 6800 West 117th Avenue Broomfield, CO 80020 U.S.A. Telephone: 888-438-8362 or 303-464-3547 Fax: 888-438-8363 or 303-666-2166 http://www.tri-optic.com	
Netc, L.L.C.[2] 100 Corporate Drive Trumbull, CT 06611 U.S.A. Telephone: 203-372-6382 Fax: 203-372-0676 http://www.netclabels.com	Netc Europe Telephone.: +49-2151-970-900 Fax: +49-2151-970-908 Email: Vertrieb@netclabels.de http://www.netclabels.de Netc Asia Pacific Pty. Ltd. 7 Cordwood Drive Cooroy QLD 4563 Australia Telephone: +61 (0)7 5442 6263 Fax: +61 (0)7 5442 6522 http://www.netclabels.com.au

Table 50. Authorized suppliers of custom bar code labels[1] (continued)	
In the Americas	**In Europe and Asia**

Notes:

1. These label providers have demonstrated the ability to produce finished bar code labels that meet the foregoing specifications and requirements. This information is provided for the convenience of users only and is not an endorsement or recommendation of such providers. IBM is not responsible for the quality of bar code labels that are procured from sources other than IBM. This information is applicable to bar code labels that are printed by the listed companies. IBM does not review the quality of any labels that are produced by software or services that are offered by such companies that allow users to print labels on their own printing equipment.
2. Netc is the only authorized supplier of radio frequency identification (RFID) labels. Orders for RFID labels must be placed through the U.S. office. Orders are shipped worldwide.

Using 3592 tape drive media

The tape library automates the storage and movement of IBM 3592 tape cartridges.

Overview of 3592 tape drive media

The 3592 tape drive uses ten different data cartridge types, plus a cleaning cartridge and a diagnostic (CE) cartridge.

Figure 43 on page 139 shows an IBM 3592 Tape Cartridge.

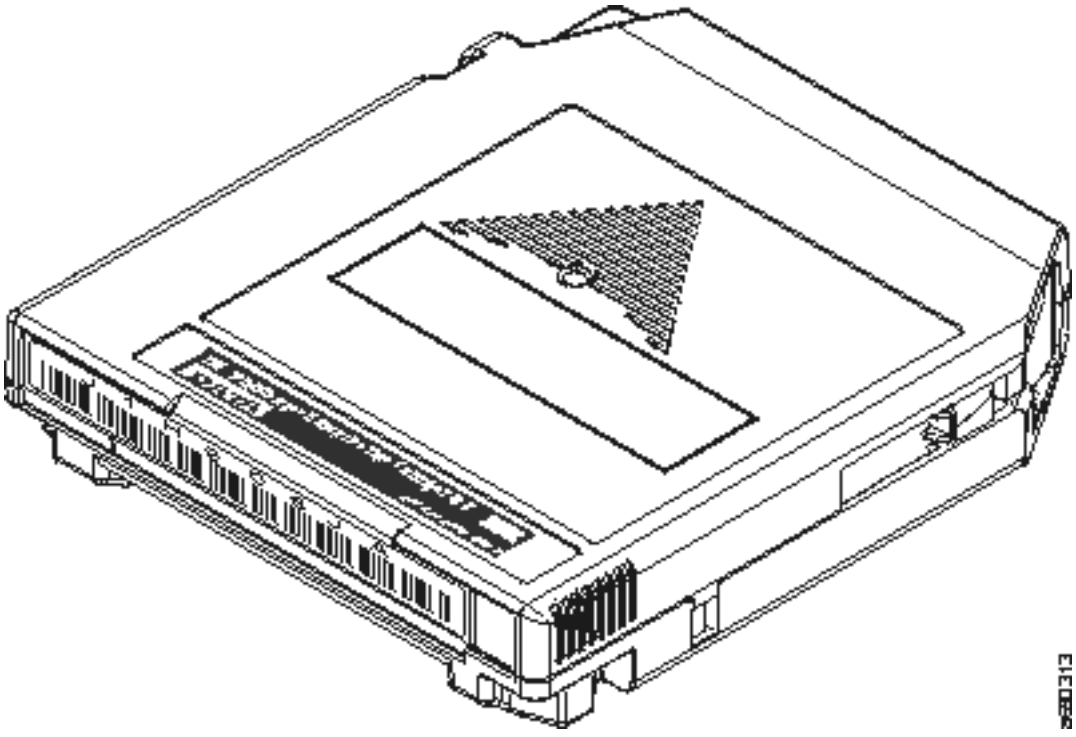


Figure 43. IBM 3592 Tape Cartridge

Note: Each 3592 tape drive model has a unique firmware version that will not work for any other 3592 tape drive model. You can update the firmware of a 3592 tape drive without scheduling downtime. This enhancement is called a *nondisruptive drive firmware update*. It is available through the TS4500 management GUI.

Cartridges can be identified by the text on the product label and by the color of the cartridge label, door, and write-protect switch. Table 51 on page 140 describes the appearance of each cartridge type.

Table 51. Visual differences between 3592 tape cartridges

Text on product label	Cartridge type[1]	Case color	Label, door, and write-protect switch color	Part number
Data	JA	Black	Dark blue	18P7534
Extended data	JB	Black	Dark green	23R9830
Advanced Type C data	JC	Black	Dark purple	46X7452
Advanced Type D read/write	JD	Black	Burnt orange	2727263
Advanced Type E read/write	JE	Black	Brick red	02CE960
Advanced Type C economy	JK	Black	Light purple	46X7453
Advanced Type D economy	JL	Black	Apricot	2727264
Advanced Type E economy	JM	Black	Red	02CE961
Extended WORM	JX	Platinum (silvery gray)	Dark green	23R9831
Advanced Type C WORM	JY	Platinum (silvery gray)	Dark purple	46X7454
Advanced Type D WORM	JZ	Platinum (silvery gray)	Burnt orange	2727265
Advanced Type E WORM	JV	Platinum (silvery gray)	Brick red	02FJ980

Notes:

1. This designation appears as the last two characters on standard bar code labels.

The 3592 tape drive also supports cleaning and diagnostic cartridges:

- Cleaning cartridges have a black case with a white label. Instead of a write-protect switch, there is a non-moveable light gray block. The cartridge door is also light gray. The label for this cartridge says `CLEANING`. If you order cleaning cartridges with pre-attached labels, the first three characters on the label are `CLN` followed by three digits and then the characters `JA` (for example, `CLN 123JA`).
- Diagnostic cartridges – also called CE (Customer Engineer) cartridges – are used by IBM service representatives. The label for this cartridge is `CE xxxJy`, where `xxx` is three digits and `Jy` is the cartridge type (such as `JJ` or `JK`).

Related information

“Tape cartridges” on page 37
Libraries that are installed with LTO tape drives use LTO tape cartridges. Libraries that are installed with 3592 tape drives use 3592 tape cartridges.

Updating drive firmware

WORM functionality for 3592 tape drive and media

Write-once-read-many (WORM) cartridges are designed for applications such as archiving and data retention, and to prevent the alteration or deletion of user data. They are also suitable for applications that require an audit trail.

A 3592 tape drive with the appropriate microcode version installed is capable of reading and writing WORM cartridges. The TS1120 and later 3592 tape drive support WORM behaviors and format attributes. These tape drives support the following WORM media types:

JR (short length)
Supported by the J1A, TS1120, and TS1130 tape drives.

TS1130 in read-only mode.

JV (advanced)
Supported by the TS1160 tape drive.

JW (full length)
Supported by the J1A, TS1120, and TS1130 tape drives.

TS1130 in read-only mode.

JX (extended)
Supported by the TS1120, TS1130, and TS1140 tape drives.

JY (advanced)
Supported by the TS1140, TS1150, TS1155, and TS1160 tape drives.

JZ (advanced)
Supported by the TS1150, TS1155, and TS1160 tape drives.

WORM cartridges are formatted at the factory and cannot be converted to data cartridges. The WORM tape media are formatted differently than the standard read/write media. One field in the manufacturer's servo track tape identifier on the tape designates that the medium is WORM. In addition, the cartridge memory (CM) has a WORM indicator byte in the cartridge type field. Both of these conditions must be true for the drive to work with a WORM cartridge. If one condition is true and the other is false, an `ATTN DRV - Invalid Cartridge` message displays. When the drive senses that a cartridge is a WORM cartridge, the microcode prohibits the changing or altering of user data that is already written on the tape. The microcode tracks the last appendable point on the tape by an overwrite-protection pointer that is stored in the CM. Statistical Analysis and Reporting System (SARS) data can be written and updated on WORM tapes because the SARS data is not in the user area of the tape.

Each WORM cartridge is identified by using a unique cartridge identifier (UCID) that is permanent and locked; this provides another level of security for data that must be maintained. This permanent locked information is stored in both the cartridge CM and on the tape itself, and can also be associated with the unique bar code volume serial (VOLSER) number.

Some records retention and data security applications require the WORM function of tape data storage. This WORM function is accomplished on the 3592 tape drive by a combination of microcode controls in the drive and a WORM tape cartridge. Special tamper-proofing techniques and checking prevent WORM cartridges from being transported to or from a data cartridge shell or cartridge memory and being inadvertently processed as a read/write cartridge. The drive microcode provides an interface and control mechanisms that allow an application or system to manage as needed. The related control and status mechanisms can be found primarily in mode pages X'23' and X'24'. For more information, see the *IBM 3592 Tape Drive SCSI Reference* (GA32-0466).

The 3592 tape drive allows append operations to data already on WORM cartridges, and allows overwrite of file marks and other non-data attributes to provide application transparency. However, they do not allow data-overwrite under any circumstances. Once full of data, WORM cartridges cannot be reused or erased by the drive and must be physically destroyed or bulk degaussed to delete data. For full tape application usage, certain trailer and label record overwrites are allowed.

Related information

“Tape cartridges” on page 37

Libraries that are installed with LTO tape drives use LTO tape cartridges. Libraries that are installed with 3592 tape drives use 3592 tape cartridges.

Capacity scaling and segmentation

The 3592 tape drive use capacity scaling and segmentation to place data in a designated section of tape to speed access and manage efficient capacity.

The 3592 tape drive supports capacity scaling for tape cartridges of media types JA, JB, JC, JD, and JE over a broad range of capacities. The effect of capacity scaling is to contain data in a specified fraction of the tape, which yields faster locate and read times. Alternatively, you can purchase economy tapes (the JJ, JK, JL, or JM media type) to achieve this faster performance.

The 3592 J1A tape drive divides tape into longitudinal segments. Using this capability, it is possible, for example, to segment 300 GB (279.39 GiB) data tapes into two segments: one segment with 64.42 GB (60 GiB) fast access, and another 200 GB (186.26 GiB) segment for more capacity. You can purchase 300 GB (279.39 GiB) data tapes that are pre-formatted with these segments, or you can segment and capacity scale them later. Segmentation is only available within a specified range of settings for capacity scaling. Capacity scaling is not supported for economy or write-once-read-many (WORM) tapes. For information about implementing segmentation and capacity scaling, refer to the README files that pertain to your device driver at Fix Central.

For more technical information about WORM, capacity scaling, and segmentation, see also the *IBM 3592 Tape Drive SCSI Reference*.

All TS1120 and later tape drives also support multiple format options, such as scaling and segmentation modes that trade capacity for improved access times. While 256 settings of the Capacity Scaling byte (and resulting fractional capacities) are supported on these drives, the following three primary settings are recommended for use:

- Full capacity default mode
- 20% scaled fast access mode (20% capacity that is scaled, front of tape used). The Capacity Scaling byte is x'35'.
- Performance scaling for 87% capacity and a segmented format with recursive accumulating backhitchless flush (RABF) capability (a non-volatile caching technique) for the full cartridge. For WORM firmware for the 3592 tape drive, the Capacity Scaling byte is x'E0'.

These settings are fully certified and are available as labeled and initialized part-numbered cartridges. For the exact Mode Select commands and settings that are necessary to invoke scaling, see the *IBM 3592 Tape Drive SCSI Reference*.

Scaling support in drive

Capacity scaling in the TS1120 and later tape drives is controlled by the host program that performs a Scaling operation. The Scaling operation uses the Capacity Scaling byte and the Capacity Scaling Valid control bit in Mode page X'23'. These tape drives do not change their current cartridge scaling, except for a special condition. The drives change scaling when a SCSI Mode Select command that specifies Mode Page X'23' (with appropriate non-default parameter settings) is received while the cartridge is positioned at the beginning of the tape. The drive can sense and report the scaling state of the current medium by using a Mode Sense command that specifies Mode Page X'23'. The default unscaled capacity is 300 GB (279.39 GiB) for a JA cartridge in J1A density, 500 GB (465.66 GiB) for a JA cartridge in E05 density, 700 GB (651.93 GiB) for a JB cartridge in E05 density, and 1 000 GB (931.32 GiB) for a JB cartridge in E06 density. The default unscaled capacity for a JY cartridge in E07 density is 4 TB (3.64 TiB).The default unscaled capacity for a JZ cartridge in E08 density is 10 TB (9.1 TiB).

- The cartridge can be rescaled from any current Capacity Scaling byte value to any supported new value. The tape is logically erased by this (End of Data mark that is written at beginning of tape), but not physically erased as with the long erase command. Scaling or rescaling one cartridge does not cause rescaling of the next cartridge; an explicit command must be issued for each cartridge to be rescaled.
- The drive provides the option of setting the scaling values of N/256ths of full capacity, where N ranges from X'16' (22 -- equals about 8% capacity) to X'EC' (236 -- equals about 92%).

- For scaling factors N, between X'4B' and X'EB', the drive scales to the specified amount and creates a fast-access 20% capacity segment in the beginning of the scaled region. (Not applicable for JE cartridge types or 60F format cartridges.)
- At all scaling factors, the drive supports early warning at the end of the scaled region (with the appropriate unit attention to inform the software that it flushes buffers and close volume) and reports a physical end-of-tape check condition at the end of the scaled region, just as it would if unscaled tape reached the real physical end of the tape.

Capacity scaling is not offered on any of the short length (economy) cartridge types (JJ, JK, JL, or JM), or on the WORM cartridges (JR, JV, JW, JX, JY, and JZ). Capacity scaling is only offered on the JA, JB, JC, and JD cartridge types (not JE).

Three important attributes are controlled by the setting of the Capacity Scaling byte value:

- The total Medium Capacity
- The ability to perform the RABF function on an entire cartridge, including last wraps
- Information about whether the format is segmented (not supported on JE cartridges or 60F format). If the format is segmented, a fast-access segment is created on the front part of the tape followed by a larger remainder segment that occupies the remainder of the tape. The fast access segment is always filled (written) first, followed by the filling of the remainder segment. For some applications that want improved access attributes for partially filled cartridges but still want to use full capacity (if required) without rescaling, this option is available.

It is important to note that the scaled state and attributes (segmentation, RABF) of the cartridge format is retained when a cartridge is reformatted between the J1A and E05 logical formats, although the exact resulting used capacity as a percentage of full capacity is not identical for all mapped settings.

Related information

"Tape cartridges" on page 37
Libraries that are installed with LTO tape drives use LTO tape cartridges. Libraries that are installed with 3592 tape drives use 3592 tape cartridges.

3592 data cartridge

This section describes the capacity, construction, operation, and components of the IBM 3592 Enterprise Tape Cartridge.

The 3592 tape drive has a bidirectional read/write head with an Enterprise Tape 3592 format. The TS1140, TS1150, TS1155, and TS1160 tape drives write or read 32 tracks at a time. The capacity of 3592 data cartridges varies by drive model and recording format. See the 3592 tape cartridges in "Tape cartridges" on page 37 for these details.

Encryption-enabled tape drives encrypt the data after compression.

Figure 44 on page 144 shows an IBM 3592 tape cartridge and its components.

#	Component	#	Component
1	Cartridge case	5	IBM product label
2	Cartridge bar code label	6	Cartridge door
3	Volume serial (VOLSER) number	7	Write-protect switch
4	Label area	8	Stacking indent

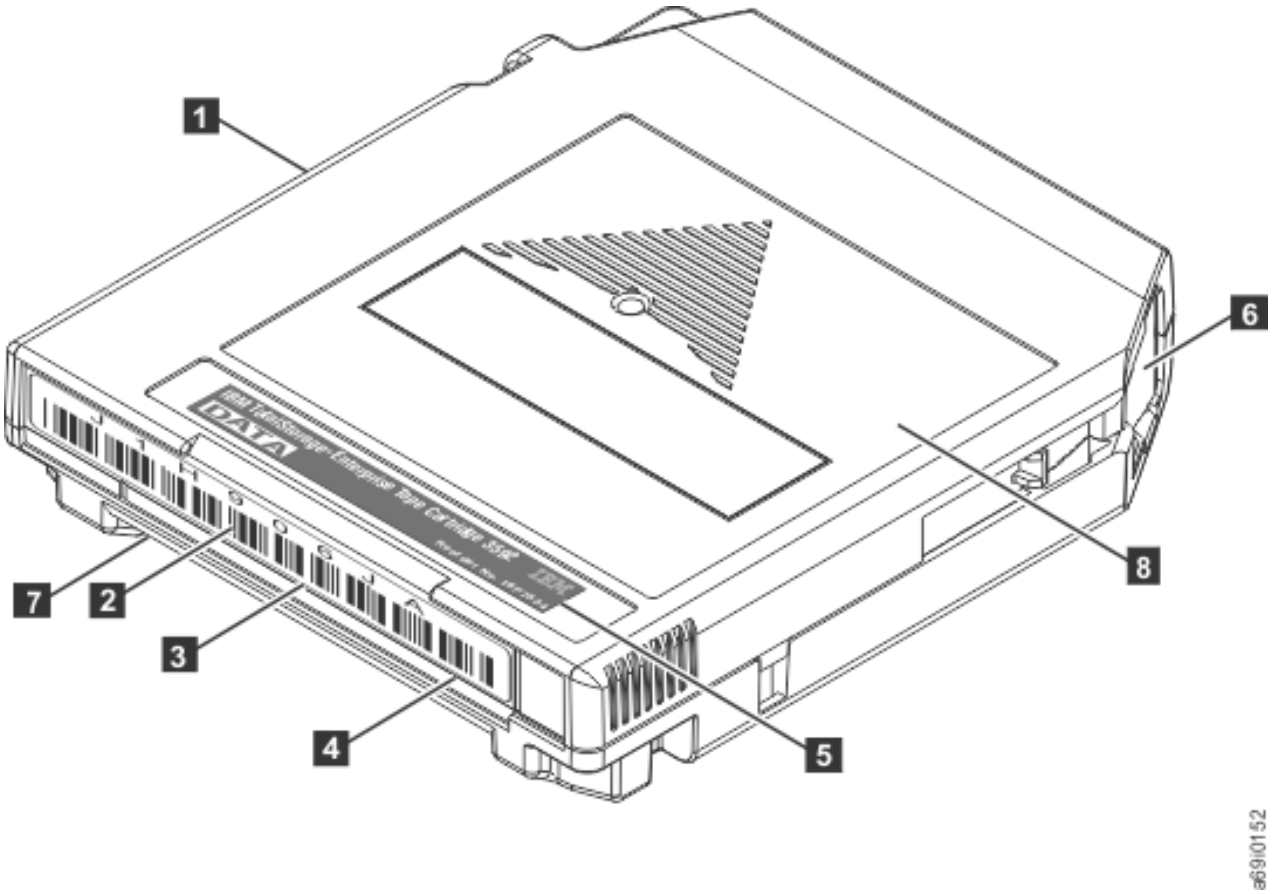


Figure 44. Components of the IBM 3592 tape cartridge

Through its vision system, the TS4500 tape library identifies the types of cartridges it contains during an inventory operation. The bar code reader reads the VOLSER (see 3 in Figure 44 on page 144) of the cartridge bar code label 2 that is in the label area 4 of the cartridge. If your cartridge does not have a pre-attached bar code label and you attach one to it, place it entirely within the recessed label area. (See 3 and 4 as an example of proper placement.) The label must be flat to within 0.5 mm (0.02 inches) over the length of the label and have no folds, missing pieces, tears, or any extraneous markings. Failure to follow these placement requirements results in degraded readability.

The IBM product label 5 specifies the type of cartridge: data, economy, WORM, or cleaning. The indent on the top of the tape cartridge 8 is for stacking cartridges on top of each other. No labels are to be affixed in this area.

The cartridge door 6 protects the tape from contamination when the cartridge is out of the drive. When you insert the cartridge into the drive, a threading mechanism pulls the tape out of the cartridge, across the drive head, and onto a non-removable takeup reel. The head can then read or write data from or to the tape.

Each data cartridge includes a write-protect switch 7 that you can set to prevent data from being overwritten or erased from the tape by the drive.

You can order tape cartridges with the bar code labels included, or you can order custom labels.

The 3592 data cartridge has a nominal cartridge life of 20,000 load and unload cycles. The quantity of load and unload cycles to reach this number depends on the environment in which the tape is used.

Cartridge memory in 3592 tape cartridges

Each 3592 data cartridge contains a passive, contactless, silicon storage device called cartridge memory (CM).

The CM module holds information about that specific cartridge, the media in the cartridge, and the data on the media. The cartridge and media information is stored in a protected, read-only area of the CM. When the cartridge is loaded into the drive, a CM reader in the drive uses a contactless, radio-frequency interface to read the information. The media's performance statistics are stored in an unprotected, read/write area of the CM module. Prior to when the cartridge is unloaded, these statistics are updated by the CM reader. They are maintained by a portion of the drive's microcode known as the Statistical Analysis and Reporting System (SARS). Each cleaning cartridge also contains a CM module, which tracks the number of cleaning uses and the location of the used cleaning media.

3592 cleaning cartridge

To help prevent errors caused by debris, it is important to clean the tape path of the 3592 tape drives and to manually clean the outside of its data cartridges, when needed.

IBM supplies a specially labeled IBM 3592 cleaning cartridge with the first 3592 tape drive in the tape library. This cleaning cartridge may be used in every 3592 tape drive.

Attention: Insert only clean and undamaged cleaning cartridges into a tape system. Before you insert a cartridge into a drive or storage slot, inspect the cartridge for damage or debris. **Damaged or dirty cartridges can reduce system reliability and cause the loss of recorded data.** If debris appears on the cartridge, wipe the outside surfaces with a lint-free cloth lightly moistened with water. Do not allow any liquid to contact the tape. Ensure that all cartridge surfaces are dry and that the leader pin is in place (see 1 in Figure 45 on page 146) before you load the cartridge.

The cleaning of the tape path in the drive is an automatic procedure initiated by the drive when changes in drive performance generate a request for cleaning. This occurs when more than 5000 mounts have occurred, when more than 20 full file passes of data have been processed, or when the drive detects a degraded head or channel condition. If you load an expired cleaning cartridge, the drive will eject the cartridge and post a status message to indicate that cleaning was not performed. Failure to clean a drive can result in buildup of debris on the read/write head and drive malfunction. If no cleaning cartridges are installed in the library, or if the available cleaning cartridges have reached the maximum number of 50 uses, cleaning cannot be completed.

Note: It is the operator's responsibility to monitor the use of all cleaning cartridges and to remove and replace expired cartridges as necessary. Use the TS4500 management GUI to monitor cleaning cartridge usage, remove an expired cartridge, or enable automatic eject of expired cleaning cartridges.

Before you insert a cartridge into a drive or storage cell, inspect the cartridge for damage or debris. **Damaged or dirty cartridges can reduce system reliability and cause the loss of recorded data.** If debris appears on the cartridge, wipe the outside surfaces with a lint-free cloth lightly moistened with water. No visible water residue or droplets should be observable on the cartridge during or after the wiping effort.

Attention: Do not allow any liquid to contact the tape itself. Special care should be made to never allow liquid water to enter the cartridge which can potentially wick into the layers of the tape and cause them to adhere to each other. This creates the risk that the coatings may pull out during unwind.

Ensure that all cartridge surfaces are dry and that the leader pin is in place (see 1 in Figure 45 on page 146) before you load the cartridge.

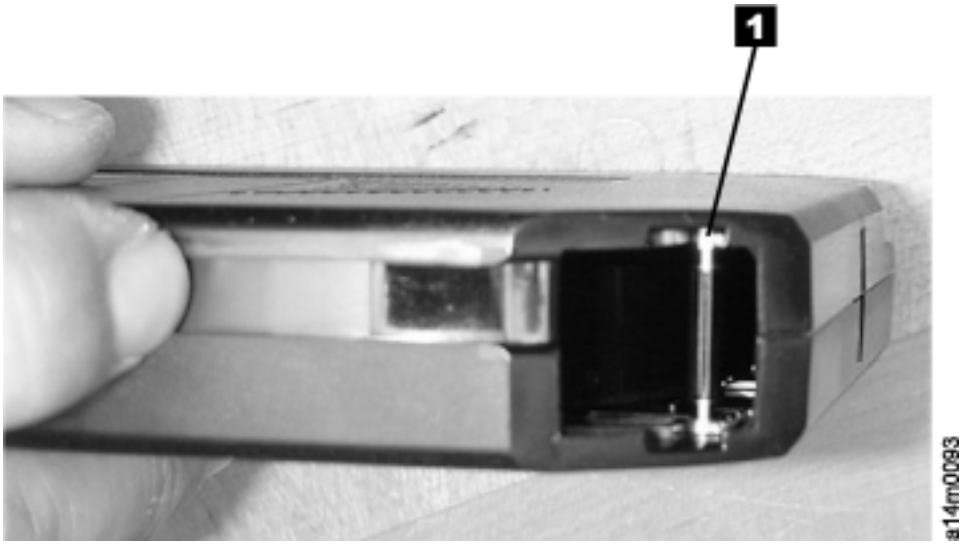


Figure 45. Leader pin in proper position in the 3592 cleaning cartridge (the cartridge door is manually retracted)

While the cleaning is in process, the 8-character message display on the drive shows the message, CLEAN*.

The IBM 3592 cleaning cartridge contains a cartridge memory (CM) device that automatically keeps track of the number of times it has been used. Cleaning cartridges need to be replaced after 50 uses. Automatic cleaning is only available if the appropriate cleaning cartridges are installed in the library and have remaining use.

The physical characteristics of the 3592 cleaning cartridge distinguish it from the 3592 data cartridge. The product label on the top of the cartridge is white, with the word CLEANING printed on it. In place of the write-protect switch, there is a non-moveable light gray block (see 1 in Figure 46 on page 146). If you order cleaning cartridges with pre-attached labels, the first three characters of the volume serial (VOLSER) number 2 are CLN. The cartridge door (see 1 in Figure 47 on page 147) is also light gray.

#	Component
1	Non-moveable light gray block
2	Sample label for cleaning cartridge

Figure 46. Characteristics that identify the 3592 cleaning cartridge

Figure 47. Door of the 3592 cleaning cartridge

Before a drive can be cleaned, you must ensure that an IBM 3592 cleaning cartridge is loaded in the library. You can load multiple cleaning cartridges and store them in any cartridge storage slot. To determine whether one or more cleaning cartridges are loaded, go to the **Cartridges** page of the TS4500 management GUI.

Related information

TS4500 management GUI Cartridges page help

3592 diagnostic cartridge

This section gives information about the appearance and usage of the 3592 diagnostic cartridge.

The 3592 diagnostic cartridge is a cartridge with verified media that is reserved for diagnostic purposes. The diagnostic cartridge is stored in a tier 0 cartridge storage slot. During a service call, your IBM service representative uses the cartridge to ensure that the tape drives run correctly and to specification. The volume serial (VOLSER) number for the diagnostic cartridge is CE xxxJy, where xxx is three digits and Jy is the cartridge type (such as JJ or JK).

A new diagnostic cartridge comes with the L25 frame.

3592 bar code label

Each 3592 data, cleaning, and diagnostic cartridge that is processed by the TS4500 tape library must bear a bar code label.

The label contains:

- A volume serial (VOLSER) number that you can read
- A bar code that the library can read

When read by the library's bar code reader, the bar code identifies the cartridge's VOLSER to the tape library. The bar code also tells the cartridge type: data (JA), extended data (JB), advanced type C data (JC), advanced type D data (JD), advanced type E data (JE), economy (JJ), advanced type C economy (JK), advanced type D economy (JL), advanced type E economy (JM), economy WORM (JR), WORM (JW), extended WORM (JX), advanced type C WORM (JY), advanced type D WORM (JZ), advanced type E WORM (JV), cleaning, or diagnostic cartridge. Figure 48 on page 148 shows a sample bar code label for the IBM 3592 Enterprise Tape Cartridge.

You can order tape cartridges with the labels included, or you can order custom labels. The labels have a peel-and-stick backing. The bar code must meet predefined specifications. The recommended specifications include (but are not limited to):

- Eight uppercase alphanumeric characters, where the last two characters must be JA, JB, JC, JD, JE, JJ, JK, JL, JM, JR, JV, JW, JX, JY, or JZ.
- Label and printing to be non-glossy
- Nominal narrow line or space width of 0.500 mm (0.019 in.)
- Wide to narrow ratio of 2.75:1
- Minimum bar length of 7.0 mm (0.27 in.)

To determine the complete specifications of the bar code and the bar code label, go to Barcode Label Specification for use with 3592 Tape Media and download the PDF file of the specification, *Label Specification for IBM 3592 Cartridges when used in IBM Libraries*. You can also contact your IBM sales representative for this specification.

When attaching a bar code label to a tape cartridge, place the label only in the recessed bar code label area (see Figure 48 on page 148). A label that extends outside of the recessed area can cause loading problems in the drive or the library.

Attention: Do not place any type of mark on the white space at either end of the bar code. A mark in this area may prevent the tape library from reading the label.

You can configure the library so that it reports to the server all eight characters of the VOLSER on the bar code label or only the first six characters using the modifyVolserReporting CLI command.

Note: If you suspect that the library is having problems reading the bar code labels, an IBM service representative can use the TS4500 management GUI to slow the scanner speed as part of problem determination.

To order bar code labels, see "Ordering bar code labels for tape cartridges" on page 138.

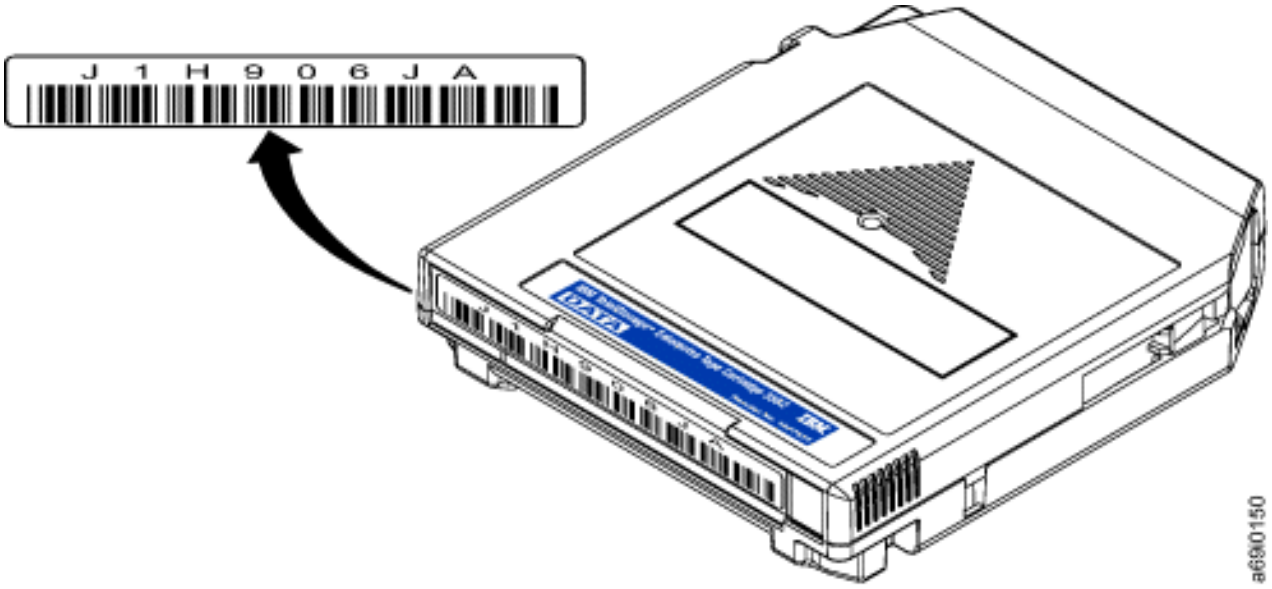


Figure 48. Sample bar code label on an IBM 3592 tape cartridge

Guidelines for using 3592 bar code labels
This topic provides guidelines for using 3592 bar code labels.

Apply the following guidelines whenever you use bar code labels:

- Use only IBM-approved bar code labels.
- Do not reuse a label or reapply a used label over an existing label.
- Examine the label before you apply it to the cartridge. Do not use the label if it has voids or smears in the printed characters or bar code (an application's inventory operation will take much longer if the bar code label is not readable).
- Position the label within the recessed bar code label area.
- Verify that the label is smooth and parallel, and has no roll-up or roll-over. The label must be flat to within 0.5 mm (0.02 in.) over the length of the label and have no folds, missing pieces, or smudges.
- Do not place other labels on any other cartridge surfaces. They might interfere with the ability of the bar code reader to read the bar code or cause the cartridge to get jammed.
- Use peel-clean labels that do not leave a residue after they are removed. If there is glue residue on the cartridge, remove it by gently rubbing it with your finger; do not use a sharp object, water, or a chemical to clean the label area.

- Before you apply a new label, remove the old label by slowly pulling it at a right angle to the cartridge case.
- Remove the label from the label sheet carefully. Do not stretch the label or cause the edges to curl.
- With light finger pressure, smooth the label so that no wrinkles or bubbles exist on its surface.

Setting the write-protect switch on a 3592 cartridge

Use the write-protect switch to prevent data from being written to a 3592 tape cartridge.

The position of the write-protect switch on the 3592 tape cartridge (see Figure 49 on page 149) determines whether or not you can write to the tape.

- To write data to or erase data from the cartridge, set the switch to **1**. This exposes a square hole.
- To prevent data from being overwritten or erased from the cartridge, set the switch to **2**. This covers the hole.

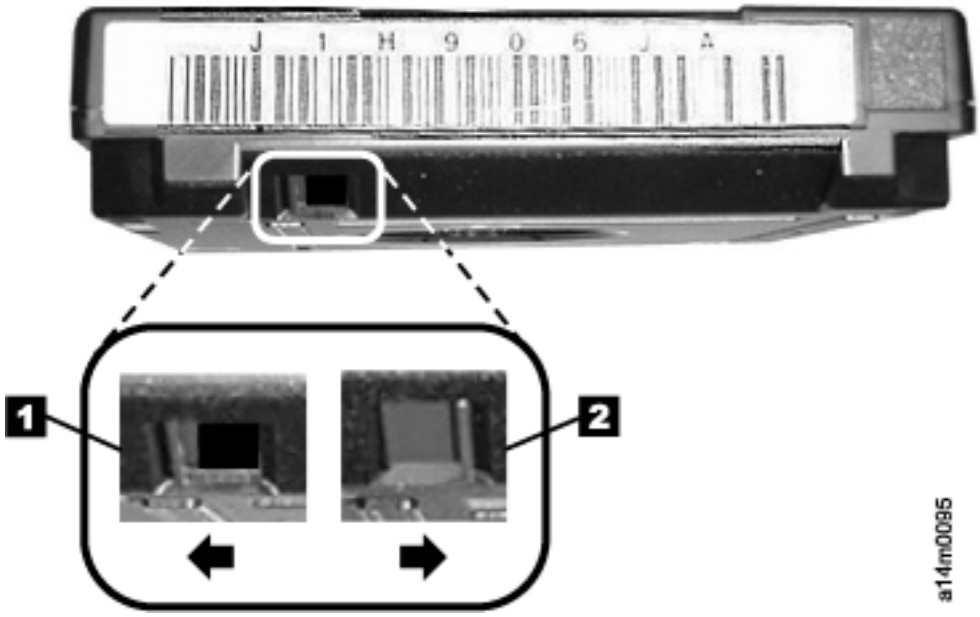


Figure 49. Setting the write-protect switch on the 3592 tape cartridge

Handling 3592 tape cartridges

Incorrect handling or an inhospitable environment can damage IBM 3592 tape cartridges or their magnetic tape. To avoid damage to your tape cartridges and ensure the continued high reliability of your IBM 3592 tape drives, handle them properly as described in the following topics.

Attention: Do not insert a damaged tape cartridge into your tape drive. A damaged cartridge can interfere with the reliability of a drive and may void the warranties of the drive and the cartridge. Before inserting a tape cartridge, inspect the cartridge case, cartridge door, and write-protect switch for breaks.

Provide training for using 3592 tape cartridges

Provide proper training for anyone that is handling 3592 tape cartridges.

It is recommended that you take the following precautions to ensure the 3592 tape cartridges are handled properly.

- Post procedures that describe proper media handling in places where people gather.
- Ensure that anyone who handles tape has been properly trained in handling and shipping procedures. This includes operators, users, programmers, archival services, and shipping personnel.

- Ensure that any service or contract personnel who perform archiving are properly trained in media-handling procedures.
- Include media-handling procedures as part of any services contract.
- Define and make personnel aware of data recovery procedures.

Ensure proper packaging of 3592 tape cartridges
3592 tape cartridges must be packed and shipped according to specific guidelines in order to ensure they are not damaged during transport.

It is recommended that you adhere to the following packaging and shipping guidelines to avoid damage to 3592 tape cartridges:

- When you ship a cartridge, ship it in its original or better packaging.
- Use only shipping containers that securely hold the cartridge in place during transportation. Such containers can be procured from Perm-A-Store on the web at www.turtlecase.com. The 3592 tape cartridges support racks and storage containers designed for 3590 tape cartridges.
- Never ship a cartridge in a commercial shipping envelope. Always place it in a box or package.
- If you ship the cartridge in a cardboard box or a box of a sturdy material, ensure that the following precautions are taken:
  - Place the cartridge in polyethylene plastic wrap or bags to protect it from dust, moisture, and other contaminants.
  - Pack the cartridge snugly; do not allow it to move around.
  - Double-box the cartridge (place it inside a box, then place that box inside the shipping box) and add padding between the two boxes.

Provide proper acclimation and environmental conditions for 3592 tape cartridges
Certain conditions ensure the safety and quality of 3592 tape cartridges.

- Before you use a cartridge, allow it acclimate to the normal operating environment for a minimum of 24 hours. If you see condensation on the cartridge, wait an extra hour.
- Ensure that all surfaces of a cartridge are dry before you insert it.
- Do not expose the cartridge to moisture or direct sunlight.
- Do not expose recorded or blank cartridges to magnetic fields of greater than 50 Oersteds (4000 ampere/meter). Devices that can produce strong magnetic fields are terminals, motors, video equipment, X-ray equipment, fields that exist near high-current cables or power supplies. Such exposure can cause the loss of recorded data or make the blank cartridge unusable.
- Maintain the proper conditions for storing and transporting the cartridges.

Perform a thorough inspection of 3592 tape cartridges
This topic offers guidelines for inspecting tape cartridges.

After purchasing a 3592 tape cartridge and before using it, perform the following steps:

- Inspect the cartridge's packaging to determine potential rough handling.
- Ensure that no moisture or condensation exists on or in the cartridge shell or media.
- When inspecting a cartridge, open only the cartridge door. Do not open any other part of the cartridge case. The upper and lower parts of the case are welded and held together with screws; separating them destroys the usefulness of the cartridge.
- Inspect the cartridge for damage before using or storing it.
- Check that the leader pin is properly positioned.
- Ensure that labels are affixed in a manner that does not adversely affect drive operation. Labels must only be affixed in the recessed bar code label area provided on the cartridge. No labels should be placed in the indent on the top of the cartridge.

- If you suspect that the cartridge has been mishandled but it appears usable, copy any data onto a good cartridge immediately for possible data recovery. Discard the mishandled cartridge.

Handle the 3592 tape cartridge carefully
Handle 3592 tape cartridges carefully to ensure they do not get damaged.

- Do not drop the 3592 tape cartridge. If the cartridge drops, slide the cartridge door back and ensure that the leader pin is properly positioned.
- Avoid mechanical loads that would distort the cartridge's shape.
- Do not handle tape that is outside the cartridge. Handling the tape can damage the tape's surface or edges, which may interfere with read or write reliability. Pulling on tape that is outside the cartridge can damage the tape and the brake mechanism in the cartridge.
- Do not stack more than six cartridges.
- Do not degauss a cartridge that you intend to reuse. Degaussing the tape erases the servo tracks and makes the tape unusable. An attached host can be used to run a Data Security Erase if the data on the tape needs to be physically erased. This physically overwrites the data on the tape without damaging the servo tracks.

Repositioning a leader pin in a 3592 cartridge

Move a leader pin into its proper position in a 3592 tape cartridge in the event that the pin is improperly positioned.

Before you begin

Attention: Use a repaired tape cartridge only to recover data and move it to another cartridge. Continued use of a repaired cartridge might void the warranties of the drive and the cartridge.

If the leader pin in your 3592 tape cartridge becomes dislodged from its pin-retaining spring clips, you must use the IBM Leader Pin Reattachment Kit (part number 18P8887) to reposition it.

A leader pin that is improperly seated inside a cartridge can interfere with the operation of the drive. Figure 50 on page 151 shows a leader pin in the incorrect 1 and correct 2 positions.

To place the leader pin in its proper position, you will need the following tools:

- Plastic or blunt-end tweezers
- Cartridge manual rewind tool (from the Leader Pin Reattachment Kit, part number 18P8887)

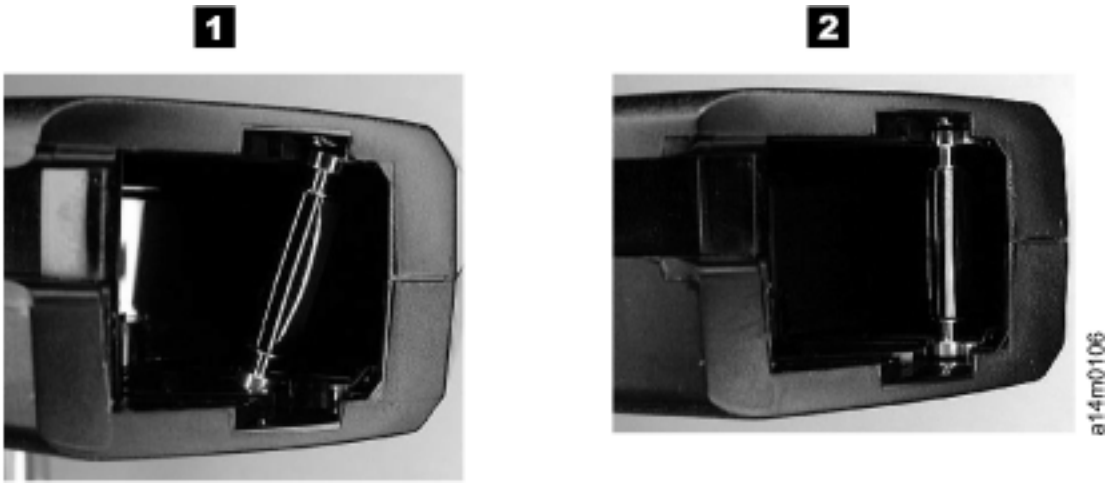


Figure 50. Leader pin in the incorrect and correct positions in a 3592 tape cartridge

To reposition the leader pin, perform the following steps.

Procedure

1. Slide open the cartridge door (see 1 in Figure 51 on page 152) and locate the leader pin 2 (you may need to shake the cartridge gently to roll the pin toward the door).
2. With plastic or blunt-end tweezers, grasp the leader pin and position it in the pin-retaining spring clips 3.
3. Press the leader pin gently into the clips until it snaps into place and is firmly seated.
4. Close the cartridge door.

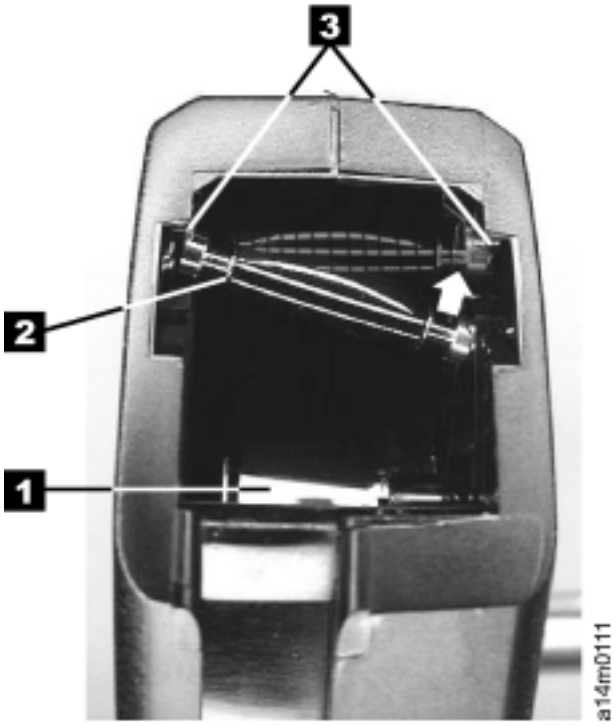


Figure 51. Placing the dislodged leader pin into the correct position

5. To rewind the tape, insert the cartridge manual rewind tool (see 1 in Figure 52 on page 153) into the cartridge's hub 2 and turn it clockwise until the tape becomes taut.

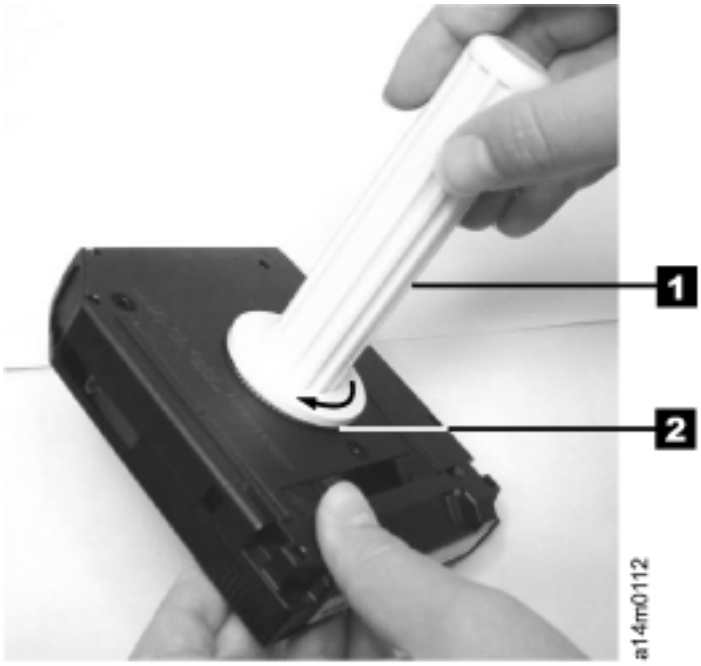


Figure 52. Rewinding the tape into the cartridge

6. Remove the rewind tool by pulling it away from the cartridge.

Environmental and shipping specifications for IBM 3592 tape cartridges

Specific storage and shipping environmental conditions apply to IBM 3592 tape cartridges.

Before you use a tape cartridge, acclimate it to the operating environment for 24 hours or the time necessary to prevent condensation in the drive (the time will vary, depending on the environmental extremes to which the cartridge was exposed).

The best storage container for the cartridges (until they are opened) is the original shipping container. The plastic wrapping prevents dirt from accumulating on the cartridges and partially protects them from humidity changes.

Attention: Depending on how many drives you have installed in the frame, the temperature inside the frame may be as much as 5°C (9°F) above the temperature outside the frame. To ensure continued reliability of your media, be sure to take this temperature difference into account when you set up the environment around your library.

When you ship a cartridge, place it in a sealed, moisture-proof bag to protect it from moisture, contaminants, and physical damage. Ship the cartridge in a shipping container that has enough packing material to cushion the cartridge and prevent it from moving within the container.

Table 52 on page 153 lists the environmental conditions for storing and shipping IBM 3592 tape cartridges.

Table 52. Environment for storage and shipping the IBM 3592 tape cartridge

Environmental specifications			
Environmental factor	**Allowable storage**	**Recommended storage**	**Shipping**
Temperature	16 to 32°C (61 to 90°F)	16 to 25°C (61 to 77°F)	-23 to 49°C (-9 to 120°F)

Table 52. Environment for storage and shipping the IBM 3592 tape cartridge (continued)			
Environmental specifications			
Environmental factor	**Allowable storage**	**Recommended storage**	**Shipping**
Relative humidity (noncondensing)	20 to 80%	20 to 50%	5 to 80%
Maximum wet bulb temperature (does not apply to 3592 JE tape cartridges)	26°C (79°F)	26°C (79°F)	26°C (79°F)
Maximum dew point temperature (applies only to 3592 JE tape cartridges)	22°C (72°F)	22°C (72°F)	22°C (72°F)
Magnetic field	Stray magnetic field at any point on tape not to exceed 50 oersteds (4000 ampere/meter).		

Disposing of 3592 cartridges

Dispose of 3592 tape cartridges according to federal and other regulations.

Under the current rules of the U.S. Environmental Protection Agency (EPA), regulation 40CFR261, the IBM 3592 tape cartridge is classified as non-hazardous waste. As such, it may be disposed of in the same way as normal office trash. These regulations are amended from time to time, and you should review them at the time of disposal.

If your local, state, country (non-U.S.A.), or regional regulations are more restrictive than EPA 40CFR261, you must review them before you dispose of a cartridge. Contact your account representative for information about the materials that are in the cartridge.

If a tape cartridge must be disposed of in a secure manner, IBM recommends that you use a qualified service provider to degauss and destroy the media.

If you burn the cartridge and tape, ensure that the incineration complies with all applicable regulations.

Cartridge quality and library maintenance

Monitor the cartridges and library regularly to identify cartridges that need to be replaced to ensure proper operation of the tape drives and library.

The 3592 tape cartridge provides high performance and reliability with IBM magnetic tape cartridge drives when the cartridge is properly handled and stored. As stated previously, repeated handling or inadvertent mishandling can damage the physical parts of the cartridge and make it unusable.

The magnetic tape inside the cartridge is made of highly durable materials. However, the tape wears after repeated cycles in the tape system. Eventually, such wear can cause an increase in tape errors.

Track the error data available by monitoring both the cartridge and cartridge library performance. By monitoring error data, you can identify and replace cartridges that are no longer acceptable for continued use.

Proper maintenance of the tape library helps to keep IBM magnetic tape cartridge systems operating in a reliable and efficient manner.

Ordering 3592 cartridges and media supplies

You can order 3592 tape cartridges and related media supplies by part number or, for larger quantities, using the 3599 model number with feature codes to specify the cartridge type.

Ordering 3592 cartridges and media supplies by part number

Supported 3592 data cartridges and media supplies can be ordered by part number.

The tape cartridges and media supplies listed in Table 53 on page 155 can be ordered from:

- An IBM Media Authorized Distributor (find the closest distributor at IBM Storage Media).
- Your IBM Sales Representative or any authorized IBM Business Partner.

Table 53. Part numbers for 3592 tape cartridges and media supplies

Brand name	Tape cartridge[1]	Type	Capacity[2]	Part number
IBM Enterprise	3592 Standard read/write	JA	E06 format: 640 GB (596.04 GiB) E05 format: 500 GB (465.66 GiB) J1A format: 300 GB (279.39 GiB)	18P7534
IBM Enterprise	3592 Extended read/write	JB	E07 format: 1600 GB (1490.12 GiB) E06 format: 1000 GB (931.32 GiB) E05 format: 700 GB (651.93 GiB)	23R9830
IBM Enterprise	3592 Advanced Type C data	JC	60F format: 7 TB (6.37 TiB) 55F format: 7 TB (6.37 TiB) E08 format: 7 TB (6.37 TiB) E07 format: 4 TB (3.64 TiB)	46X7452
IBM Enterprise	3592 Advanced Type D data	JD	60F format: 15 TB (13.64 TiB) 55F format: 15 TB (13.64 TiB) E08 format: 10 TB (9.1 TiB)	2727263
IBM Enterprise	3592 Advanced Type E data	JE	60F format: 20 TB (18.19 TiB)	02CE960
IBM Enterprise	3592 Economy read/write	JJ	E06 format: 128 GB (119.21 GiB) E05 format: 100 GB (93.13 GiB) J1A format: 60 GB (58.88 GiB)	24R0316
IBM Enterprise	3592 Advanced Type C economy	JK	60F format: 900 GB (838.19 GiB) 55F format: 900 GB (838.19 GiB) E08 format: 900 GB (838.19 GiB) E07 format: 500 GB (465.66 GiB)	46X7453
IBM Enterprise	3592 Advanced Type D economy	JL	60F format: 3 TB (2.73 TiB) 55F format: 3 TB (2.73 TiB) E08 format: 2 TB (1.82 TiB)	2727264
IBM Enterprise	3592 Advanced Type E economy	JM	60F format: 5 TB (4.55 TiB)	02CE961
IBM Enterprise	3592 Economy WORM	JR	E06 format: 128 GB (119.21 GiB) E05 format: 100 GB (93.13 GiB) J1A format: 60 GB (55.88 GiB)	24R0317
IBM Enterprise	3592 Standard WORM	JW	E06 format: 640 GB (596.04 GiB) E05 format: 500 GB (465.66 GiB) J1A format: 300 GB (279.39 GiB)	18P7538
IBM Enterprise	3592 Extended WORM	JX	E07 format: 1600 GB (1490.12 GiB) E06 format: 1000 GB (931.32 GiB) E05 format: 700 GB (651.93 GiB)	23R9831

Table 53. Part numbers for 3592 tape cartridges and media supplies (continued)

Brand name	Tape cartridge[1]	Type	Capacity[2]	Part number
IBM Enterprise	3592 Advanced Type C WORM	JY	60F format: 7 TB (6.37 TiB) 55F format: 7 TB (6.37 TiB) E08 format: 7 TB (6.37 TiB) E07 format: 4 TB (3.64 TiB)	46X7454
IBM Enterprise	3592 Advanced Type D WORM	JZ	60F format: 15 TB (13.64 TiB) 55F format: 15 TB (13.64 TiB) E08 format: 10 TB (9.1 TiB)	2727265
IBM Enterprise	3592 Advanced Type E WORM	JV	60F format: 20 TB (18.19 TiB)	02FJ980
IBM Enterprise	3592 Cleaning		Cleaning, 50 uses	18P7535

Notes:

1. Be sure to order bar code labels for all cleaning and data cartridges. Order volume serial (VOLSER) labels separately.
2. Cartridge capacities vary depending on tape drive and format. See Table 23 on page 39 for more detailed information.

Related information

“Tape cartridges” on page 37
Libraries that are installed with LTO tape drives use LTO tape cartridges. Libraries that are installed with 3592 tape drives use 3592 tape cartridges.

Ordering 3592 cartridges and media supplies using the 3599 model number

Large quantities of 3592 data cartridges can be ordered using the 3599 model number to specify the cartridge type and a combination of feature codes to specify quantities, labeling, and initialization options. You can also order cleaning cartridges in this way.

Table 54 on page 156 lists cartridges that can be ordered using the 3599 model number. It includes examples of ordering options for each cartridge type. Note that additional feature codes are required to completely specify all cartridge characteristics.

You can order the model numbers listed in Table 54 on page 156 from:

- An IBM Media Authorized Distributor (find the closest distributor at IBM Storage Media).
- Your IBM Sales Representative or any authorized IBM Business Partner.

Table 54. Model 3599 tape cartridge ordering options

3599 Model	Media ID/ Feature Code	Feature Code for Labeling, Initialization, and Quantity		Format	Individual Cartridge Capacity[2, 5]	Description
		Regular	RFID[1]			
011[4]	JA/9030	1020	1021	9082	640 GB (596.05 GiB)	20-pack 3592 Data cartridges, labeled and initialized
				9081	500 GB (465.66 GiB)	

Table 54. Model 3599 tape cartridge ordering options (continued)

3599 Model	Media ID/ Feature Code	Feature Code for Labeling, Initialization, and Quantity		Format	Individual Cartridge Capacity[2, 5]	Description
		Regular	RFID[1]			
				9080	300 GB (279.39 GiB)	
012[4]	JA/9030	2020	2021	N/A[3]	500 GB (465.66 GiB)	20-pack 3592 Data cartridges, labeled, not initialized
					300 GB (279.39 GiB)	
013[4]	JA/9030	3020	N/A	N/A	500 GB (465.66 GiB)	20-pack 3592 Data cartridges, not labeled and not initialized
					300 GB (279.39 GiB)	
014[4]	JB/9032	4020	4021	9084	1 600 GB (1490.12 GiB)	20-pack 3592 Extended Data cartridges, labeled and initialized
				9082	1 000 GB (931.32 GiB)	
				9081	700 GB (651.93 GiB)	
015[4]	JB/9032	5020	5021	N/A	700 GB (651.93 GiB)	20-pack 3592 Extended Data cartridges, labeled, not initialized
016[4]	JB/9032	6020	N/A	N/A	700 GB (651.93 GiB)	20-pack 3592 Extended Data cartridges, not labeled and not initialized
420	JC/9035	4211	4221	9084	4 TB (3.64 TiB)	20-pack 3592 Advanced Type C Data cartridges, labeled and initialized
520	JC/9035	5221	5231	N/A	4 TB (3.64 TiB)	20-pack 3592 Advanced Type C Data cartridges, labeled, not initialized
620	JC/9035	6200	N/A	N/A	4 TB (3.64 TiB)	20-pack 3592 Advanced Type C Data cartridges, not labeled and not initialized
425	JD/9036	4251	4261	9085	10 TB (9.1 TiB)	20-pack 3592 Advanced Type D Data cartridges, labeled and initialized

Table 54. Model 3599 tape cartridge ordering options (continued)

3599 Model	Media ID/ Feature Code	Feature Code for Labeling, Initialization, and Quantity		Format	Individual Cartridge Capacity[2, 5]	Description
		Regular	RFID[1]			
525	JD/9036	5251	5261	N/A	10 TB (9.1 TiB)	20-pack 3592 Advanced Type D Data cartridges, labeled, not initialized
625	JD/9036	6250	N/A	N/A	10 TB (9.1 TiB)	20-pack 3592 Advanced Type D Data cartridges, not labeled and not initialized
426	JE/9037	4262	N/A	9087	20 TB (18.19 TiB)	20-Pack 3592 Data Cartridges - Type E, labeled and initialized
526	JE/9037	5262	N/A	N/A	20 TB (18.19 TiB)	20-Pack 3592 Data Cartridges - Type E, labeled, not initialized
E11[4]	JJ/9050	1120	1121	9082	128 GB (119.21 GiB)	20-pack 3592 Economy cartridges, labeled and initialized
				9081	100 GB (93.13 GiB)	
				9080	60 GB (58.88 GiB)	
E12[4]	JJ/9050	1220	1221	N/A	60 GB (58.88 GiB)	20-pack 3592 Economy cartridges, labeled, not initialized
E13[4]	JJ/9050	1320	N/A	N/A	60 GB (58.88 GiB)	20-pack 3592 Economy cartridges, not labeled and not initialized
430	JK/9052	4300	4310	9084	500 GB (465.66 GiB)	20-pack 3592 Advanced Economy cartridges, labeled and initialized
530	JK/9052	5300	5310	N/A	500 GB (465.66 GiB)	20-pack 3592 Advanced Economy cartridges, labeled, not initialized
630	JK/9052	6300	N/A	N/A	500 GB (465.66 GiB)	20-pack 3592 Advanced Economy cartridges, not labeled and not initialized
435	JL/9054	4351	4361	9085	2 TB (1.8 TiB)	20-pack 3592 Advanced Economy cartridges, labeled and initialized
535	JL/9054	5351	5361	N/A	2 TB (1.8 TiB)	20-pack 3592 Advanced Economy cartridges, labeled, not initialized

Table 54. Model 3599 tape cartridge ordering options (continued)

3599 Model	Media ID/ Feature Code	Feature Code for Labeling, Initialization, and Quantity		Format	Individual Cartridge Capacity[2, 5]	Description
		Regular	RFID[1]			
635	JL/9054	6350	N/A	N/A	2 TB (1.8 TiB)	20-pack 3592 Advanced Economy cartridges, not labeled and not initialized
436	JM/9037	4362	N/A	9087	5 TB (4.55 TiB)	20-Pack 3592 Economy Data Cartridges - Type E, labeled and initialized
536	JM/9037	5362	N/A	N/A	5 TB (4.55 TiB)	20-Pack 3592 Economy Data Cartridges - Type E, labeled, not initialized
E21[4]	JR/9042	3120	3121	9082	128 GB (119.21 GiB)	20-pack 3592 Economy WORM cartridges, labeled and initialized
				9081	100 GB (93.13 GiB)	
				9080	60 GB (58.88 GiB)	
E22[4]	JR/9042	3220	3221	N/A	100 GB (93.13 GiB)	20-pack 3592 Economy WORM cartridges, labeled, not initialized
					60 GB (58.88 GiB)	
E23[4]	JR/9042	3320	N/A	N/A	100 GB (93.13 GiB)	20-pack 3592 Economy WORM cartridges, not labeled and not initialized
					60 GB (58.88 GiB)	
021[4]	JW/9040	2120	2121	9082	640 GB (596.05 GiB)	20-pack 3592 WORM cartridges, labeled and initialized
				9081	500 GB (465.66 GiB)	
				9080	300 GB (279.39 GiB)	
022[4]	JW/9040	2220	2221	N/A	500 GB (465.66 GiB)	20-pack 3592 WORM cartridges, labeled, not initialized
					300 GB (279.39 GiB)	

Table 54. Model 3599 tape cartridge ordering options (continued)

3599 Model	Media ID/ Feature Code	Feature Code for Labeling, Initialization, and Quantity		Format	Individual Cartridge Capacity[2, 5]	Description
		Regular	RFID[1]			
023[4]	JW/9040	2320	N/A	N/A	500 GB (465.66 GiB)	20-pack 3592 WORM cartridges, not labeled and not initialized
					300 GB (279.39 GiB)	
024[4]	JX/9044	2420	2421	9082	1 000 GB (931.32 GiB)	20-pack 3592 Extended WORM cartridges, labeled and initialized
				9081	700 GB (651.93 GiB)	
025[4]	JX/9044	2520	2521	N/A	700 GB (651.93 GiB)	20-pack 3592 Extended WORM cartridges, labeled, not initialized
026[4]	JX/9044	2620	N/A	N/A	700 GB (651.93 GiB)	20-pack 3592 Extended WORM cartridges, not labeled and not initialized
440[4]	JY/9046	4400	4410	9084	4 TB (3.64 TiB)	20-pack 3592 Advanced WORM cartridges, labeled and initialized
540[4]	JY/9046	5400	5410	N/A	4 TB (3.64 TiB)	20-pack 3592 Advanced WORM cartridges, labeled, not initialized
640[4]	JY/9046	6400	N/A	N/A	4 TB (3.64 TiB)	20-pack 3592 Advanced WORM cartridges, not labeled and not initialized
445[4]	JZ/9049	4455	4465	9085	10 TB (9.1 TiB)	20-pack 3592 Advanced Type D WORM cartridges, labeled and initialized
545[4]	JZ/9049	5451	5461	N/A	10 TB (9.1 TiB)	20-pack 3592 Advanced Type D WORM cartridges, labeled, not initialized
645[4]	JZ/9049	6450	N/A	N/A	10 TB (9.1 TiB)	20-pack 3592 Advanced Type D WORM cartridges, not labeled and not initialized
017	JA	7005	N/A	N/A	cleaning, 50 uses	5-pack 3592 Cleaning Cartridges, with media identification labels
017	JA	7006	N/A	N/A	cleaning, 50 uses	5-pack 3592 Cleaning Cartridges without media identification labels

Table 54. Model 3599 tape cartridge ordering options (continued)

3599 Model	Media ID/ Feature Code	Feature Code for Labeling, Initialization, and Quantity		Format	Individual Cartridge Capacity[2, 5]	Description
		Regular	RFID[1]			

Notes:

1. Radio frequency identification labels
2. For more details about individual cartridge capacities, see Table 23 on page 39.
3. N/A = Not applicable
4. This product is no longer available for order by this method. Refer to "Ordering 3592 cartridges and media supplies by part number" on page 155 to order this media type.
5. For cartridges that are not initialized, the actual cartridge capacity is dependent on the format used to write the cartridge.

Related information

"Tape cartridges" on page 37
Libraries that are installed with LTO tape drives use LTO tape cartridges. Libraries that are installed with 3592 tape drives use 3592 tape cartridges.

Ordering supplies for repairs

The Leader Pin Reattachment Kit is required for repairs to a 3592 tape cartridge.

This kit contains the tools required to reattach the leader pin to the tape. It includes the rewind tool, which can be used to add tension to a tape if the leader pin is displaced. To order the kit, contact an IBM Media Authorized Distributor. You can find the closest distributor at IBM Storage Media. Order as IBM® part number 18P8887.

Ordering bar code labels for tape cartridges

Each tape cartridge must have a bar code label with a unique volume serial (VOLSER) number. You can order these labels separately from IBM data cartridges and cleaning cartridges.

Bar code labels must meet the following specifications:

- IBM LTO Ultrium Cartridge Label Specification
- Label Specification for IBM 3592 Cartridges when used in IBM Libraries

Table 55. Authorized suppliers of custom bar code labels[1]

In the Americas	In Europe and Asia
EDP/Tri-Optic 6800 West 117th Avenue Broomfield, CO 80020 U.S.A. Telephone: 888-438-8362 or 303-464-3547 Fax: 888-438-8363 or 303-666-2166 http://www.tri-optic.com	

Table 55. Authorized suppliers of custom bar code labels[1] (continued)

In the Americas	In Europe and Asia
Netc, L.L.C.[2] 100 Corporate Drive Trumbull, CT 06611 U.S.A. Telephone: 203-372-6382 Fax: 203-372-0676 http://www.netclabels.com	Netc Europe Telephone.: +49-2151-970-900 Fax: +49-2151-970-908 Email: Vertrieb@netclabels.de http://www.netclabels.de
	Netc Asia Pacific Pty. Ltd. 7 Cordwood Drive Cooroy QLD 4563 Australia Telephone: +61 (0)7 5442 6263 Fax: +61 (0)7 5442 6522 http://www.netclabels.com.au

Notes:

1. These label providers have demonstrated the ability to produce finished bar code labels that meet the foregoing specifications and requirements. This information is provided for the convenience of users only and is not an endorsement or recommendation of such providers. IBM is not responsible for the quality of bar code labels that are procured from sources other than IBM. This information is applicable to bar code labels that are printed by the listed companies. IBM does not review the quality of any labels that are produced by software or services that are offered by such companies that allow users to print labels on their own printing equipment.
2. Netc is the only authorized supplier of radio frequency identification (RFID) labels. Orders for RFID labels must be placed through the U.S. office. Orders are shipped worldwide.

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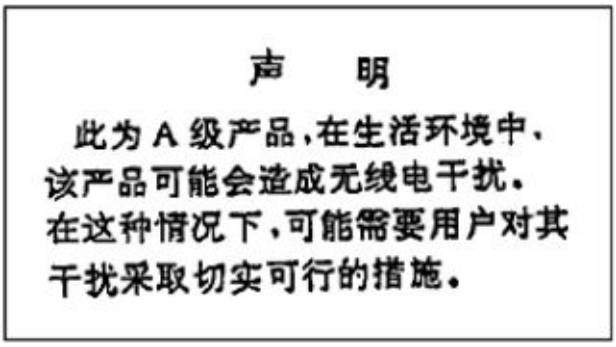

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Glossary

This glossary defines the special terms, abbreviations, and acronyms that are used in this publication and other related publications.

"A" on page 169	"B" on page 171	"C" on page 172	"D" on page 174	"E" on page 175	"F" on page 176	"G" on page 177	"H" on page 178	"I" on page 179	J	"K" on page 181	"L" on page 182	"M" on page 184
"N" on page 186	"O" on page 187	"P" on page 187	"Q" on page 189	"R" on page 189	"S" on page 190	"T" on page 194	"U" on page 195	"V" on page 196	"W" on page 196	"X" on page 197	"Y" on page 197	"Z" on page 197

If you do not find the term that you are looking for, see the IBM Terminology web site.

Numbers

2:1 or 3:1 compression
The relationship between the quantity of data that can be stored with compression as compared to the quantity of data that can be stored without compression. In 2:1 compression, twice as much data can be stored with compression as can be stored without compression. In 3:1 compression, three times as much data can be stored with compression as can be stored without compression.

2N
Twice the amount of a system's electrical power load. If the system has 2N power supplies, then there are two power supplies available for every load, which means greater redundancy and availability of electrical power. For example, the Enhanced Frame Control Assembly of the TS3500 offers a 2N power design with no single point of failure or single point of repair.

3588 Tape Drive
See *IBM 3588 Tape Drive Model F3A*, *IBM TS1030 Tape Drive Model F3B*, *IBM TS1040 Tape Drive Model F4A*, *IBM TS1050 Tape Drive Model F5A*, *IBM TS1040 Tape Drive Model F5C*, *IBM TS1060 Tape Drive Model F6A*, and *IBM TS1040 Tape Drive Model F6C*

3592 Tape Controller Model J70
See IBM 3592 Tape Controller Model J70.

3593 Tape System
The IBM 3953 Tape Frame Model F05 and the IBM 3953 Library Manager Model L05.

A

A
Ampere.

AAP
See *authorized assembler program*.

ac
See *alternating current*.

accessible cartridge storage slots
Within the TS3500, units that can contain tape cartridges and that are recognizable to the library by both a physical address (such as F01-C05-R19) and a SCSI element (logical) address (such as 1112(X'458'). Accessible cartridge storage slots do not include I/O station slots or the inaccessible slots that are reserved for the diagnostic cartridges. The quantity of accessible cartridge storage slots per frame varies, depending on the quantity of drives that are installed in the frame.

accessor controller
The logic card for the cartridge accessor. The accessor controller handles accessor motion requests, including calibrations, moves, and inventory updates. It also provides centralized management for other aspects of the entire library, including configuration, insert and eject operations, automatic drive cleaning, and determination of element status.

ac line voltage
The input voltage (in volts) that is required by the tape library for normal operation.

Activity screen
The primary screen on the touchscreen of the TS3500. The Activity screen gives the level of firmware in the library, shows whether the library is ready, not ready, or initializing, and tells the quantity of tape cartridges currently in the I/O stations. The screen also indicates the current activity that is being performed, the volume serial (VOLSER) number of the cartridge that are associated with the activity, and a history of previous activities. The Activity screen leads to the Main Menu.

adapter
See *adapter card*.

adapter card
A circuit board that adds function to a computer.

addressable cartridge storage slots
See *accessible cartridge storage slots*.

Advanced Interactive eXecutive (AIX)
A UNIX operating system that was developed by IBM that is designed and optimized to run on POWER® microprocessor-based hardware such as servers, workstations, and blades.

Advanced Library Management System (ALMS)
The next generation of IBM's patented Multi-Path Architecture. ALMS enables logical libraries to consist of unique drives and ranges of VOLSERs, instead of fixed locations. It offers the ability to assign tape drives to any logical library by using the IBM Tape Library Specialist web interfaceby using the TS4500 management GUI. Logical libraries can also be added, deleted, or easily changed without disruption.

aggregate sustained data transfer rate
For all of the drives in the tape library, the sum of their average throughput of uninterrupted data.

AIX
See *Advanced Interactive eXecutive*.

ALMS
See *Advanced Library Management System*.

AL_PA
See *Arbitrated Loop Physical Address*.

alphanumeric
Pertaining to a character set that contains letters, numerals, and other characters, such as punctuation marks.

alternating current (ac)
An electric current that reverses its direction at regularly recurring intervals.

amp
Ampere.

ampere (A, amp)
A unit of measure for electric current that is equivalent to a flow of 1 coulomb per second, or to the current produced by 1 volt applied across a resistance of 1 ohm.

Arbitrated Loop Physical Address (AL_PA)
An 8-bit value that is used to identify a device in an arbitrated loop. Device ports communicate by using AL_PAs.

audit
The process of moving cartridges in an HD slot to scan each barcode label.

authorized assembler program (AAP)
A training program for selected IBM Business Partners that enables them to purchase incomplete machines and parts, and provides them with the knowledge to assemble the components into a final configured product for sale to their customers.

automatic cleaning
A method by which the library automatically responds to any tape drive's request for cleaning by beginning the cleaning process. An operator enables automatic cleaning by using the menus on the library's touchscreen or the web interface.

automatic inventory
A survey of the location of cartridges in the library. The inventory is performed when the library is powered on, or whenever the front door of any frame is opened and closed during operation.

B

backhitch
When the speed of the host server is slower than the speed of the drive, the action of stopping the tape, rewinding some distance, and restarting.

backup
The short-term retention of records that are used for restoring essential business and system files when vital data is lost because of program or system errors or malfunctions.

Backup recovery and media services (BRMS)
A software program that runs on OS/400 and allows a business to plan, control, and automate the backup, recovery, and media management services for its AS/400 systems.

bar code
A code that represents characters by sets of parallel bars of varying thickness and separation. The bars are read optically by transverse scanning.

bar code label
A slip of paper that bears a bar code and having an adhesive backing. The bar code label must be affixed to a tape cartridge to enable the library to identify the cartridge and its volume serial number.

bar code reader
On the dual-gripper transport mechanism of the library, a laser device that is specialized for scanning and reading bar codes and converting them into either the ASCII or EBCDIC digital character code. The bar code reader reads the bar code on the labels of cartridges or at the rear of empty storage slots.

base frame
The primary unit of the TS3500 tape libraryTS4500 tape library. The base frame is distinguished from an expansion frame by its I/O stations and operator paneldisplay panel. The base frame includes a rail assembly for the cartridge accessor and up to 1216 tape drives.

beacon light-emitting diode (LED)
A LED that is visible through the side panel of each shuttle station that indicates station location and is typically used in service operations.

A LED on any frame with an I/O station that is used to identify a frame that is in service or needs service, or to identify a frame for other reasons to someone at the storage library.

bel
Ten decibels.

bit
Either of the digits 0 or 1 when used in the binary numbering system.

bpi
Bits per inch.

bridge
A storage controller that forms a bridge between two external I/O buses.

British thermal unit (Btu)
The quantity of heat that is required to raise the temperature of one pound of water 1 degree Fahrenheit at a specified temperature.

browser
A client program that initiates requests to a web server and displays the information that the server returns.

BRSM
See *Backup recovery and media services*.

Btu
See *British thermal unit*.

bulk load
To manually insert large quantities of tape cartridges into a tape library's empty storage slots.

bus
See *SCSI bus*.

byte
A string that consists of a number of bits (usually 8) that are treated as a unit and represent a character. A byte is a fundamental data unit.

C

calibration
Adjustment, tuning.

calibration sensor
On the cartridge accessor of the TS3500 tape libraryTS4500 tape library, the component that provides the means to find certain positions within the library precisely during the calibration operation.

Call Home
A feature that allows the TS3500 tape libraryTS4500 tape library to report failures to a support center.

CAN
See *Controller Area Network*.

CAP
See *cartridge assignment policy*.

capacity
See *media capacity*.

Capacity expansion feature
Applys only to the base frame of the TS3500 tape libraryTS4500 tape library, the cartridge storage slots that are on the interior of the front door and enabled for more storage. The Capacity Expansion Feature increases the maximum quantity of storage slots in the base frame.

Capacity on Demand
A feature that adds capacity to the library and that is only available through the field. See also *High Density Capacity on Demand*.

cartridge
See *tape cartridge*.

cartridge accessor
The mechanism in the TS3500 tape libraryTS4500 tape library that moves cartridges between the storage slots, tape drives, and the I/O stations. The accessor includes the X-axis motion assembly, Y-axis motion assembly, pivot assembly, cartridge gripper, bar code reader, and calibration sensor.

cartridge assignment policy (CAP)
With the TS3500 tape library, a method that is used to automatically assign cartridges to a logical library by using beginning and ending volume serial number ranges that are set by the user. See also *VOLSER ranges*.

cartridge cache
Non-HD slots (Tier 0) selected as preferred locations for frequently used cartridges. The library firmware tracks the most recent usage of each cartridge as a means to arbitrate which cartridges should be maintained in the cartridge cache.

cartridge gripper
An electromechanical device on the cartridge accessor of the TS3500 tape libraryTS4500 tape library that gets or puts cartridges from or to a storage slot, tape drive, or I/O station. Two grippers (Gripper 1 and Gripper 2) are on the pivot assembly of the accessor. One gripper can grip a single cartridge.

cartridge inventory time
The amount of time that is required for the TS3500 tape libraryTS4500 tape library to determine whether each cartridge storage slot in the library is empty or full.

cartridge manual rewind tool
A device that can be fitted into the reel of a cartridge and used to rewind tape into or out of the cartridge.

cartridge memory
See *LTO cartridge memory*.

cartridge move time
The time that is required for a cartridge accessor to pick a cartridge from a slot (or drive), move the cartridge to a drive (or slot), pivot (if required), and insert the cartridge into the drive (or slot).

cartridge storage slot
One of several containers that are mounted inside the frames of the TS3500 tape libraryTS4500 tape library and are used to store tape cartridges. See also *HD slot*.

caster
One of four wheels that are mounted in swivel frames and used to support the weight of the library.

CETool
Used with the TS3500 tape library, CETool is a software program that is used by IBM Service personnel (also known as customer engineers or CEs) to update library and drive firmware, configure Call Home, collect library and drive logs, backup and restore the configuration for non-volatile random access memory (NVRAM), and perform other service-related tasks.

cell top cap
On each column of the storage slots within the TS3500 tape libraryTS4500 tape library, a plastic component to which a bar code label holder can be attached. The library uses the bar code label to establish the boundary of a logical library.

circuit board
A thin plate on which chips and other electronic components are placed. Computers consist of one or more boards, often called cards, or adapters.

cleaning cartridge
A tape cartridge that is used to clean the heads of a tape drive. Contrast with *data cartridge*.

clearance
The distance by which one object clears another or the clear space between them.

compression
The process of eliminating gaps, empty fields, redundancies, and unnecessary data to shorten the length of records or blocks.

configure
To describe to a system the devices, optional features, and programs that are installed on the system.

controller
A device that coordinates and controls the operation of one or more input/output devices (such as sensors and actuators), and synchronizes the operation of such devices with the operation of the system as a whole.

control path
(1) Designated by the operator of the TS3500 tape libraryTS4500 tape library, a logical path into the library through which a server sends standard SCSI Medium Changer commands to control a specific logical library.

(2) A tape drive that is designated by the operator of the TS3500 tape libraryTS4500 tape library to manage communication to and from a server and the library.

control path failover
In the event of a command failure, an optional feature of the TS3500 tape libraryTS4500 tape library that enables the host device driver to resend the command to an alternate control path for the same logical library. The device driver initiates error recovery and continues the operation on the alternate control path without interrupting the application.

current
The quantity of charge per unit of time. Measured in amperes (amps, A).

D

daisy-chain
To serially interconnect a series of SCSI connectors for multiple devices on the SCSI bus.

data
Any representations such as characters or analog quantities to which meaning is, or might be, assigned.

data cartridge
A tape cartridge dedicated to storing data. Contrast with *cleaning cartridge*.

data compression
See *compression*.

Data Facility Storage Management Subsystem (DFSMS)
An operating environment that helps automate and centralize the management of storage. To manage storage, DFSMS provides the storage administrator with control over data class, storage class, management class, storage group, and automatic class selection routine definitions.

data transfer element (DTE)
In SCSI terms, a tape drive.

data transfer element (DTE) address
In SCSI terms, the physical location of a tape drive.

data transfer rate
The average number of bits, characters, or blocks per unit of time that pass between corresponding equipment in a data transmission system. The rate is expressed in bits, characters, or blocks per second, minute, or hour.

dB
Decibel.

dc
Direct current.

decibel
A unit of measure that expresses the ratio of two amounts of electric or acoustic signal power that is equal to 10 times the common logarithm of this ratio.

decrypt
To decipher data.

In Cryptographic Support, to convert ciphertext into plaintext. See also *encrypt*.

degauss
To make a magnetic tape nonmagnetic by the use of electrical coils that carry currents that neutralize the magnetism of the tape.

degausser
A device that makes magnetic tape nonmagnetic.

destage
The movement of a cartridge from the cartridge cache to an HD slot. A destage occurs automatically when the cartridge cache is full.

device
Any hardware component or peripheral device, such as a tape drive or tape library, that can receive and send data.

device driver
A file that contains the code that is needed to use an attached device.

DFSMS
See *Data Facility Storage Management Subsystem*.

diagnostic cartridge
A tape cartridge that enables the detection and isolation of errors in programs and faults in equipment.

differential
See *high voltage differential*.

Direct flight
An automation technology that passes tape cartridges over intermediary libraries in a TS3500 tape library shuttle complex.

disable
To make nonfunctional.

door safety switch
On each frame of the TS3500 tape libraryTS4500 tape library, a mechanism that automatically turns off the power to the cartridge accessor whenever you open the front door.

drive
See *tape drive*.

drive head
The component that records an electrical signal onto magnetic tape, or reads a signal from tape into an electrical signal.

DTE
See *data transfer element*.

dual-gripper transport mechanism
On the cartridge accessor of the TS3500 tape libraryTS4500 tape library and mounted on the pivot assembly, the device that contains the two grippers that get and put cartridges into storage slots, drives, or the I/O stations.

E

eject
To remove or force out from within.

electronic mail
Correspondence in the form of messages that are transmitted between user terminals over a computer network.

element address
The SCSI term for the host's view of a cartridge location.

e-mail
See *electronic mail*.

enable
To make functional.

encrypt
In Cryptographic Support, to systematically scramble information so that it cannot be read without knowing the coding key. See also *decrypt*.

encryption
The conversion of data into a cipher. A key is required to encrypt and decrypt the data. Encryption provides protection from persons or software that attempt to access the data without the key.

encryption key manager
A software program that assists IBM-encrypting tape drives in generating, protecting, storing, and maintaining encryption keys, which encrypt information that is written to and decrypt information that is read from tape media.

enhanced frame control assembly
The power structure for models L23, D23, L53, and D53. The assembly combines drive power, library power, and dual ac power cord capabilities into a 2N power design with no single point of failure or single point of repair.

enhanced node cards
Node cards with increased synchronous dynamic and nonvolatile random-access memory (RAM).

error-recovery procedures (ERP)
Procedures that are designed to help isolate and, where possible, to recover from errors in equipment. The procedures are often used with programs that record the statistics of machine malfunctions.

Ethernet
A 10-Mbps base band local area network that allows multiple stations to access the transmission medium at will without prior coordination, avoids contention by using carrier sense and deference, and resolves contention by using collision detection and delayed retransmission.

Expanded I/O Station
On the front door of the TS3500 tape library, the lower compartment into which you insert and remove cartridges into and from the library. Both stations are accessed by the cartridge accessor.

expansion frame
A unit that can be added to the base frame of the TS3500 tape libraryTS4500 tape library. The expansion frame includes a rail assembly for the cartridge accessor and up to 1216 tape drives or HD storage slots.

F

FCA
See *frame control assembly*.

FCB
Frame control box. See *frame control assembly*.

Fibre Channel
A high-speed, full-duplex, serial communications technology capable of interconnecting LTO tape drives and 3592 tape drives to servers that are separated by as much as 11 kilometers (7 miles). Fibre Channel technology combines features of the input/output (I/O) and networking interfaces.

Fibre Channel address
For a tape drive that uses a Fibre Channel interface, an identifier (such as an AL_PA or Loop ID) that enables other device ports to communicate with that drive.

Fibre Channel cable
The cable that connects a Fibre Channel tape drive to another device. The conductive element within the cable is constructed of either copper wires or optical fibers. Generally, copper wires are used for short distances (up to 30 meters or 98 feet); optical fibers are used for longer distances. Fiber-optic cabling is referred to by mode or the frequencies of light waves that are carried by a particular cable type. Multi-mode fiber cables are used for distances up to 500 meters (1640 feet) and with short-wave (780 nanometer) laser light. Single-mode fiber cables are used for distances greater than 500 m (1640 feet) and with long-wave (1300 nanometer) laser light.

fiber optics
A branch of optics that deal with the transmission of light through fibers or thin rods of glass or some other transparent material of high refractive index.

FICON/ESCON-enabled products
Any of the IBM tape products that are equipped with Fibre Channel (FICON®) or Enterprise System Connection (ESCON) interfaces to allow attachment to the System z server (mainframe host).

field replaceable unit (FRU)
Any piece of hardware that is complete, contained, and manufactured or assembled as a whole unit and can be replaced in the field by a customer engineer (CE).

file
A named set of records that are stored or processed as a unit.

file transfer protocol (FTP)
In the Internet suite of protocols, an application layer protocol that uses TCP and Telnet services to transfer bulk-data files between machines or hosts.

firmware
Proprietary code that is delivered as part of an operating system. Firmware is more efficient than software loaded from an alterable medium and is more adaptable to change than pure hardware circuitry. An example of firmware is the Basic Input/Output System (BIOS) in read-only memory (ROM) on a PC motherboard.

floating home cell
The concept of actively managing cartridge placement by picking an optimal new home for cartridges that are being demounted. HD libraries use a floating home cell approach for the entire library.

frame
In Fibre Channel technology, a unit of transmission that includes delimiters, control characters, information, and checking characters.

See *library frame*.

frame control assembly (FCA)
The assembly is a group of parts that consists of a frame control box (FCB), one or two 37 V power supplies for the cartridge accessor, operator panel, and I/O stations, and an MCC card pack that runs the firmware that controls the ac and dc power distribution. The assembly also provides an RS-422 communication port to each tape drive in a frame. The FCB contains 3 circuit protectors, 10 ac outlets for powering the tape drives and all other components in that frame, and a receptacle for the incoming main ac power.The assembly consists of one Library Control Card (LCC), internal library communication cables, and two 12 V power supplies.

front door
At the front of each frame in the TS3500 tape libraryTS4500 tape library, the swinging barrier by which entry is closed or opened to the frame.

FRU
See *field replaceable unit*.

FTP
See *file transfer protocol*.

FTP site
Any electronic repository of information that uses the File Transfer Protocol (FTP) for transferring files to and from servers. Use of an FTP site requires a user ID and possibly a password.

full capacity expansion
A feature that increases the initial capacity of the TS3500 tape library models. Model L22, L23, L52, and L53 frames. Models L22 and L23 increase from 58 to 199 or 260 cartridge slots for 3592 tape cartridges. Models L52 and L53 increase from 64 to 219 or 287 cartridge slots for LTO tape cartridges.

full duplex
Simultaneous transmission and reception of data between two nodes of a network.

G

GB
See *gigabyte*.

Gb
See *gigabit*.

Gbps
Gigabits per second. One gigabit equals 1 000 000 000 bits.

get
(1) In library operation, the act of a cartridge gripper that is retrieving a tape cartridge from a storage slot, drive, or I/O station.

(2) In Simple Network Management Protocol (SNMP), a request for information about the library that the operator issues through a monitoring server and is transmitted by SNMP.

get-response
The information that is provided in response to an SNMP get request.

GiB
One gibibyte (GiB) = 1,073,741,824 bytes.

gigabit (Gb)
1 000 000 000 bits.

gigabyte (GB)
1 000 000 000 bytes.

H

HA
See *high availability*.

HACMP
See *High Availability Clustered Multiprocessing*.

HBA
See *host bus adapter*.

HD CoD
See *High Density Capacity on Demand*.

HD frame
See *High density frame*.

HD slot
See *High density slot*.

HD2 frame
See *High density frame*.

head
See *drive head*.

heat output
The amount of heat (in kBtu/hr) that the TS3500 tape libraryTS4500 tape library dissipates during normal operation.

hertz (Hz)
A unit of frequency equal to cycle per second.

heterogeneous
Of unlike kind.

hex, hexadecimal
(1) Pertaining to a selection, choice, or condition that has 16 possible different values or states.

(2) Pertaining to a fixed-radix numeration system, with radix of 16.

(3) Pertaining to a system of numbers to the base 16; hexadecimal digits range from 0 through 9 and A through F, where A represents 10 and F represents 15.

high availability (HA)
A product that contains redundancy to continue work in the case of a set of (but not all possible) failures. A library that is HA contains two separate cartridge accessors.

High Availability Clustered Multiprocessing (HACMP)
An IBM AIX solution that automatically detects system or network failures and eliminates a single point of failure by managing failover to a recovery processor. High availability clustering refers to the linking of two or more computers, one of which can provide operation if the other one fails.

High Density Capacity on Demand
Applicable only to expansion frame models Sx4 and Sx5, a feature that adds licensed capacity to the library.

High density frame
An expansion frame that contains HD slots. An HD2 frame is a second-generation HD frame that can be installed in the leftmost position (frame 1) of the library and can be utilized as an integrated service bay. All expansion frames that are installed to the left of the TS4500 base frame, or that are serving as a TS4500 service bay, must be HD2 frames. Drive-capable HD2 frames support up to 16 HD2-compatible tape drives when positioned as frame number 2 or higher. Models L25, L55, D25, D55, S25, and S55 are all HD2 frames. Non-HD2 frames cannot be upgraded to HD2 frames.

High density slot
A four-deep or five-deep container for cartridges in an HD frame.

High Voltage Differential (HVD)
A logic signaling system that enables data communication between a supported server and the TS3500 tape library. HVD signaling uses a paired plus and minus signal level to reduce the effects of noise on the SCSI bus. Any noise that is injected into the signal is present in both a plus and minus state, and is thereby canceled. Synonymous with *differential*.

homogeneous
Of the same kind.

host
The controlling or highest-level system in a data communication configuration. Synonymous with *server*.

host bus adapter (HBA)
An adapter that provides I/O processing and physical connectivity between a server and storage.

host cleaning
A method that enables the host (server) to detect the need to clean a tape drive and to control the cleaning process. Host cleaning with a cleaning cartridge is only supported when automatic cleaning is disabled, and only for the logical library in which each cleaning cartridge is stored.

HTTP
See *Hyper Text Transfer Protocol*.

hub
A communications device to which nodes on a multi-point bus or loop are physically connected. Hubs are commonly used in Fibre Channel networks to improve the manageability of physical cables. They maintain the logical loop topology of the network of which they are a part, while they create a "hub and spoke" physical star layout. Unlike switches, hubs do not aggregate bandwidth. They typically support the addition or removal of nodes from the bus while it is operating.

HVD
See *High voltage differential*.

Hyper Text Transfer Protocol (HTTP)
The primary Internet protocol that is used to connect to most web servers. HTTP delivers content for web pages or downloads files.

Hz
Hertz.

I

IBM 3592 Tape Controller Model J70
In the 3953 Tape Frame Model F05, a device that links the IBM eServer™ zSeries server (mainframe host), the L05 Library Manager, and the tape drives in the tape library.

IBM Tape Library Specialist web interface
A platform-independent, web-based interface that allows a user to configure and monitor the TS3500 tape library from a remote location.

IBM TS3500 tape library
Also known as the 3584 Tape Library, a device that can be attached to one or more supported servers and used to write data to and from magnetic tape. The library can include up to 16 frames and 192 drives, and any combination of LTO tape drives in LTO frames, and 3592 tape drives in 3592 frames.

IBM TS4500 tape library
Also known as the 3584 tape library, a device that can be attached to one or more supported servers and used to write data to and from magnetic tape. The library can include up to 4 frames and 64 drives.

IBM TotalStorage™ Productivity Center (TPC)
A software solution that manages storage infrastructures in Open Systems environments.

ID
Identifier.

IEE
See *import/export element*.

IEEA
See *import/export element address*.

IEEE
Institute of Electrical and Electronics Engineers.

IMC
See *Integrated management console (IMC)*.

import/export element (IEE)
In SCSI terms, an I/O slot.

import/export element address (IEEA)
In SCSI terms, the location of an I/O slot.

inaccessible cartridge storage slot
In the TS3500 tape library, a cartridge storage slot that is designated for the diagnostic cartridge, which is used during service procedures. The Models L22, L23, L32, L52, and L53 base frames each contain one inaccessible cartridge storage slot for a diagnostic cartridge at physical address F01,C01,R01. Also, the first expansion frame of a different media type (3592 or LTO) in a mixed media library contains one inaccessible cartridge slot for a diagnostic cartridge at physical addresses Fxx,C01,R01 (where xx equals the first expansion frame for the second type of media).

independent software vendor (ISV)
A company that makes and sells software products that run on one or more computer hardware or operating system platforms.

initial program load (IPL)
(1) The initialization procedure that causes an operating system to commence operation.

(2) The process by which a configuration image is loaded into storage at the beginning of a work day or after a system malfunction.

(3) The process of loading system programs and preparing a system to run jobs.

initialize
To format a magnetic tape, write a label (VOLSER) on the tape, and leave the tape empty except for the system files that contain the structure information. All former contents of the tape are lost.

initializing
The act of performing an inventory on the TS3500 tape libraryTS4500 tape library.

initiator
In SCSI terms, a SCSI device that requests an I/O process to be performed by another SCSI device (a target). In many cases, an initiator can also be a target.

input/output (I/O) station
On the front door of the TS3500 tape library, one or two TS4500 tape library, two compartments into which you insert and remove cartridges into and from the library. Both stations are accessed by the cartridge accessor.

inrush current
The momentary peak current (in amperes) into the TS3500 tape libraryTS4500 tape library when the ac line voltage is first applied.

insert
Pertaining to the TS3500 tape libraryTS4500 tape library, a term that is used to describe the act of putting a tape cartridge into an I/O station or storage slot.

install
(1) To set up for use or service.

(2) The act of adding a product, feature, or function to a system or device either by a singular change or by the addition of multiple components or devices.

Integrated management console (IMC)
With the TS4500 tape library, a built-in platform for tools that are used to manage the library.

interchange
The ability to process (read or write) given tape data on any one of a set of tape devices that support the form factor and recording format of the tape data.

interchange application
The preparation of tapes for use on other systems or devices, either local or remote, or the use of tape data that is prepared by another system.

intermediate capacity expansion
A feature that increases the initial capacity of Lxx frames. Models L22 and L23 increase from 58 to 117 cartridge slots for 3592 tape cartridges. Models L52 and L53 increase from 64 to 129 cartridge slots for LTO LTO tape cartridges. Models Lx5 increase from 100 to 200 slots.

Internet
The worldwide collection of interconnected networks that use the Internet suite of protocols and permit public access.

interposer
An adapter-like device that allows a connector of one size and style to connect to a mating connector of a different size and style.

inventory
(1) A survey of tape cartridges in the library and frames.

(2) To make an inventory of.

I/O station
See *input/output station*.

IPL
Initial program load.

ISV
See *independent software vendor*.

K

kBtu
KiloBtu.

Kerberos
A network authentication protocol that allows nodes communicating over a non-secure network to prove their identity to one another in a secure manner. It is designed to provide strong authentication for client/server applications by using secret-key cryptography.

key label
An alias to a encryption key (cipher) used by the encryption key manager.

key manager
In cryptography, a software application that manages one or more secret encryption keys.

key manager address
In cryptography, the IP address of an encryption key manager.

keystore
A database of private keys and their associated digital certificate chains that are used to authenticate the corresponding public keys.

KiB
One kibibyte (KiB) = 2^{10} bytes = 1,024 bytes.

KiloBtu
1 000 Btu's.

KiloVolt
1 000 volts.

kilowatt
1 000 watts.

kVA
KiloVolt.

kW
Kilowatt.

L

label
See *bar code label* or *radio frequency identification label*.

label area
On the LTO tape cartridge or 3592 tape cartridge, a recessed area next to the write-protect switch where a bar code label must be affixed.

LAN
See *local area network*.

LCD
See *liquid crystal display*.

LDAP
See *lightweight directory access protocol*.

leader pin
On the LTO tape cartridge and 3592 tape cartridge, a small metal column that is attached to the end of the magnetic tape. During the processing of the tape, the leader pin is grasped by a threading mechanism, which pulls the pin and the tape out of the cartridge, across the drive head, and onto a take-up reel. The head can then read or write data from or to the tape.

leveling jackscrews
On the bottom of the TS3500 tape libraryTS4500 tape library, one of four screw-operated jacks for raising or lowering the library.

library frame
The basic unit of the TS3500 tape libraryTS4500 tape library. The frame includes the hardware support structure, covers, mechanisms, and parts. Two types of frames are available: base frames (Models Lxx) and expansion frames (Models Dxx and Sxx).

Library Manager
See *IBM 3953 Library Manager Model L05*.

library power switch
On the front of the TS3500 tape libraryTS4500 tape library, a toggle switchbutton that switches the power to the library on and off.

license key
A key or password that is required to enable advanced function.

lightweight directory access protocol (LDAP)
A set of protocols that are used to access information directories. LDAP, an open protocol, is based on the standards that are contained within the X.500 standard, but is simpler. And unlike X.500, LDAP supports TCP/IP, which is necessary for any type of Internet access.

Linear Tape-Open (LTO)
A type of tape storage technology that was developed by the IBM Corporation, Hewlett-Packard, and Certance. LTO technology is an "open format" technology, which means that its users have multiple sources of product and media. The "open" nature of LTO technology enables compatibility between different vendors' offerings by ensuring that vendors comply with verification standards. The LTO technology is implemented in two formats: the Accelis format focuses on fast access; the LTO format focuses on high capacity. The LTO format is the preferred format when capacity (rather than fast access) is the key storage consideration.

line frequency
The frequency (in hertz) of the ac line voltage that the TS3500 tape libraryTS4500 tape library requires for normal operation.

link
In Fibre Channel technology, the physical (optical) connection between two nodes of a network, which includes the combination of the link connection (the transmission medium) and two link stations, one at each end of the link connection.

liquid crystal display (LCD)
A low-power display technology that is used in computers and other I/O devices.

load
Pertaining to the TS3500 tape libraryTS4500 tape library and following the insertion of a tape cartridge into a cartridge storage slot, the act (performed by the cartridge accessor) of transferring the cartridge from the storage slot to the drive and of positioning the tape (performed by the tape drive) for reading or writing by the drive head.

load and unload cycle
The act of inserting a cartridge into a tape drive, loading the tape to load point, rewinding the tape into the cartridge, and ejecting the cartridge from the drive.

load point
The beginning of the recording area on magnetic tape.

load-to-ready time
After a cartridge is inserted into a drive, the amount of time between when the drive threads the tape and when the drive becomes ready to accept server commands.

local area network (LAN)
(1) A computer network that is on a user's premises within a limited geographical area. Communication within a local area network is not subject to external regulations; however, communication across the LAN boundary might be subject to some form of regulation.

(2) A network in which a set of devices is connected to other sets of devices for communication and that can be connected to a larger network.

local authentication
The process of validating a user identity to the system according to the local operating system account to which the user logged in. If the user is authenticated, the user is mapped to a principal.

logical library
With the TS3500 tape library, a set of cartridge storage slots and tape drives that are defined as a library by an operator.With the TS4500 tape library, a set of tape drives and tape cartridges that are defined as a library by an operator. The ability to create logical libraries makes it possible for similar and dissimilar hosts (servers) to share its robotics. As a result, hosts can simultaneously run separate applications in separate logical libraries.

logical library bar code label
A specially coded label that can be affixed to the tops of storage slot columns and drives inside the TS3500 tape library. The tape library reads the labels and uses them to establish the boundaries of one or more logical libraries.

logical library configuration
A way of using the TS3500 tape libraryTS4500 tape library so that its robotics are shared by homogenous (similar) and heterogeneous (dissimilar) servers. The TS3500 tape libraryTS4500 tape library can be partitioned into individual logical libraries that independently communicate with individual servers using individual control paths.

logical unit number (LUN)
A number that is associated with the target address of a drive. The server uses the number to identify the address of the drive.

loop ID
In Fibre Channel technology, the identifier that the TS3500 tape libraryTS4500 tape library assigned to an LTO or 3592 tape drive. The ID is based on the drive's physical location within the library and is used by other devices in the topology to communicate.

Low Voltage Differential (LVD)
A low-noise, low-power, and low-amplitude electrical signaling system that enables data communication between a supported server and the TS3500 tape library. LVD signaling uses two wires to drive one signal over copper wire. The use of wire pairs reduces electrical noise and crosstalk.

LTO
See *Linear Tape-Open*.

LTO cartridge memory (LTO-CM)
Within each LTO data cartridge, an embedded electronics and interface module that can store and retrieve a cartridge's historical usage and other information.

LTO-CM
See *LTO cartridge memory*.

LUN
See *logical unit number*.

LVD
See *Low Voltage Differential*.

M

m
Meter.

magnetic tape
A tape with a magnetizable surface layer on which data can be stored by magnetic recording.

Management Information Base (MIB)
Units of managed information that specifically describe an aspect of a system, such as the system name, hardware number, or communications configuration. A collection of related MIB objects is defined as an MIB. The TS3500 tape libraryTS4500 tape library can use the MIB to interpret problem alerts that are transmitted by SNMP traps.

management GUI
See *TS4500 management GUI*.

manual cleaning
A method by which an operator selects a menu option from the touchscreen of the TS3500 tape library or IBM Tape Library Specialist web interfacefrom the TS4500 management GUI to perform the cleaning procedure on one or more of its tape drives.

master console
See *system console*.

MB
See *megabyte*.

Mbps
Megabits per second.

MCA
See *Medium Changer assembly*.

MCC
See *Medium Changer card pack*.

MCP
See *Medium Changer card pack*.

mebibyte (MiB)
1·048·576 bytes.

media
The plural of *medium*.

media capacity
The amount of data that can be contained on storage media and expressed in bytes of data.

media-type identifier
Pertaining to the bar code on the bar code label of the IBM LTO tape cartridge, a two-character code (Lx), that represents information about the cartridge. L identifies the cartridge as one that can be read by devices that incorporate LTO technology; x indicates the generation of cartridge; T, U, V, and Wrepresent different generations of WORM cartridges.

medium
A physical material in or on which data might be represented, such as magnetic tape.

Medium Changer assembly (MCA)
In the enhanced frame control assembly power structure, the device that facilitates communication between host applications and the library. The MCA is located above the drives and the fixed power trays in model L23, D23, L53, and D53 frames. It houses two Ethernet ports for connection to the Tape Library Specialist web interface or a system console.

Medium Changer card pack (MCC or MCP)
In the TS3500 Tape Library, a circuit board that provides a communication path to each tape drive (using the RS-422 interface) so that library commands can be funneled from the tape drives to the accessor. It includes one RS-422 interface that is allotted for each drive in the frame. It also provides management and service interfaces to outside servers. For each library frame that contains at least one drive, there is one MCP. The electronics of the card pack are located in the FCB.

Medium Changer Device
In SCSI terms, an instrument that moves removable storage units from and to storage slots and tape drives. The TS3500 tape libraryTS4500 tape library is a Medium Changer Device.

megabyte (MB)
1 000 000 bytes.

metal-particle tape
In the LTO and 3592 tape cartridges, tape that uses small, pure metal particles (rather than oxide coatings) in the magnetic layer.

meter
In the metric system, the basic unit of length; equal to approximately 39.37 inches.

MiB
One mebibyte (MiB) = 1,048,576 bytes.

MIB
See *Management Information Base*.

middleware
A vague term that refers to the software between an application program and the lower-level platform functions.

micron
One millionth of a meter (.000001 m).

Microsoft Systems Management Server (SMS) and Clustered Server Environments
A solution from Microsoft that automatically detects system or network failures in Windows operating systems and eliminates a single point of failure by managing failover to a recovery processor.

mid-range systems
A set of multi-user servers with a hard disk capacity of between 50 GB - 250 GB.

mixed drive types
The concept of using both LTO and 3592 tape cartridges in the TS3500 tape libraryTS4500 tape library. A library can consist of frames that house all LTO tape cartridges or all 3592 tape cartridges, but the two types of cartridges cannot be mixed in a single frame. However, both types of cartridges might be inserted or removed from the library through the base frame, if a lower I/O station is installed for the 3592 tape cartridges.

mixed media configuration
Different media and drive technologies, such as the LTO tape drive and the 3592 tape drive. LTO 1, LTO 2, and LTO 3 drives and media are not considered mixed media, but are considered different generations of the same type of media.

Model J1A
See *IBM 3592 tape drive Model J1A*.

mount
The act of making a tape available for processing by a specific tape device. A mount consists of removing the cartridge from a drive, returning it to its storage slot, collecting another cartridge from a storage slot, moving it to the drive, and loading it into the drive.

mount/demount cycle
See *mount*.

mounted
The state of a tape while it is available for processing by a specific tape device.

mount throughput
The number of cartridges that a tape library can mount in a one-hour period.

N

N
A measure of the electrical power load in a system. If there are N loads in the system, N power supplies are required to power all of the loads.

N/A
Not applicable.

native data capacity
The amount of data that can be stored without compression on a tape cartridge.

NetView®
(1) Pertaining to an IBM licensed program that is used to monitor a network, manage it, and diagnose its problems. The NetView licensed program can be used to provide network management services for OSI Communications Subsystem. (2) A network management product that can provide automated operations and rapid notification of events.

network
A configuration of data processing devices and software that is connected for information interchange.

network server
In a local area network, a personal computer that provides access to files for all of the workstations in the network.

node
In Fibre Channel technology, a communicating device.

node card
Within the TS3500 tape libraryTS4500 tape library, one of four circuit assemblies (accessor controller card, motor driver assembly, Medium Changer card pack, and operator panel assembly) that communicate with each other.

nominal
Approximate.

nominal power
The amount of power (in kilowatts) that the TS3500 tape libraryTS4500 tape library dissipates during normal operation.

non-addressable cartridge storage slot
See *inaccessible cartridge storage slot*.

nondisruptive firmware update
The ability to update drive or library firmware without scheduling downtime. The TS3500 tape libraryTS4500 tape library gives the ability to perform a nondisruptive update for its library firmware, as well as firmware for all 3592 tape drives and LTO 2 and later LTO tape drives.

non-volatile memory
Types of memory that retain their contents when the power is turned off. ROM is nonvolatile, whereas RAM is volatile.

not ready
The condition that exists when the TS3500 tape libraryTS4500 tape library is not ready for operation with the host.

O

Oersted
The unit of magnetic field strength in the unrationalized centimeter-gram-second (cgs) electromagnetic system. The Oersted is the magnetic field strength in the interior of an elongated, uniformly wound solenoid that is excited with a linear current density in its winding of 1 abampere per 4π centimeters of axial length.

operating environment
The temperature, relative humidity rate, and wet bulb temperature of the room in which the TS3500 tape libraryTS4500 tape library routinely conducts the processing.

operating system
The master computer control program that translates the user's commands and allows software application programs to interact with the computer's hardware.

operator panel
A functional unit that controls the TS3500 tape library. The unit's LCD touchscreen provides information about the operation of the library.

operator panel controller
Within the TS3500 tape library, a circuit board that facilitates communication between the accessor controller and the operator panel. The controller provides input to and output from the LCD, and senses and locks the I/O stations. In addition, the LCD activity and service menus are executed in the operator panel controller with support from the accessor controller and the drives (by using the Medium Changer card packs).

optimized dual gripper
An electromechanical device that is mounted on the pivot assembly and gets or puts cartridges from or to a storage slot, tape drive, or I/O station.

P

partition
A fixed-size division of storage.

patch panel
Located at the rear of the base or expansion frame in a TS3500 tape libraryTS4500 tape library, an optional unit that houses the fiber cable connections between the servers and the individual drives.

Pause key
On the display paneltouchscreen of the TS3500 tape libraryTS4500 tape library, a buttontouch key that causes the cartridge accessor to park itself and provide clear access to the library's interior when you power off the library or open the front door. The pause buttonpause key enables quick recovery when you power on the library or close the front door.

PB
Petabyte.

PDF
See *Portable Document Format*.

Petabyte
1·000·000·000·000·000 bytes.

ping
(1) A command that calls an IP address.

(2) The act of issuing a command that calls an IP address.

pivot assembly
On the cartridge accessor of the TS3500 tape libraryTS4500 tape library, a group of parts that provides a mounting platform for the gripper mechanism and the bar code reader. The pivot assembly can rotate 180° about the vertical axis.

point load
On a floor, one or more locations where the weight of an object is concentrated.

point-to-point topology
In communications, the physical or logical arrangement of nodes in a network to facilitate data transmission between two locations without the use of any intermediate display station or computer.

port
(1) A system or network access point for data entry or exit.

(2) A connector on a device to which cables for other devices such as display stations and printers are attached.

(3) The representation of a physical connection to the link hardware. A port is sometimes referred to as an adapter; however, there can be more than one port on an adapter.

Portable Document Format (PDF)
A standard that is specified by Adobe Systems, Incorporated, for the electronic distribution of documents. The PDF files are compact, can be distributed globally (via e-mail, the Web, intranets, or CD-ROM), and can be viewed with the Acrobat Reader, which is software from Adobe Systems that can be downloaded at no cost from the Adobe Systems home page.

power cord
A cable that connects a device to a source of electrical power.

power cord plug
On a power cord, the male fitting for making an electrical connection to a circuit by insertion into a receptacle.

power distribution unit (PDU)
A unit that provides ac distribution within a TS3500 tape libraryTS4500 tape library frame by supplying multiple internal ac outlets from a single external ac power cord.

power off, powered off
(1) To remove electrical power from a device.

(2) The state of a device when power has been removed from it.

power on, powered on
(1) To apply electrical power to a device.

(2) The state of a device when power is applied to it.

power-on indicator
Above the power buttonBeside the library power switch on the operator panel, a green light that, when lit, indicates that dc power is available within the TS3500 tape libraryTS4500 tape library.

power receptacle
The mounted female electrical fitting that contains the live parts of the circuit.

power supply
The electrical component of a computer system that converts standard ac current to the lower voltage dc current used by the computer. The amount of current a power supply can provide is rated in amperes.

power switch
See *library power switch*.

prestage
The movement of a cartridge from an HD slot to a cartridge cache. See also *destage*.

protocol
The meanings of, and the sequencing rules for, requests and responses that are used for managing a network, transferring data, and synchronizing the states of network components.

put
Pertaining to the TS3500 tape libraryTS4500 tape library, to place, by means of a robotic device, a tape cartridge into a storage slot, drive, or I/O station.

Q

quiesce
To put a device into a temporarily inactive or inhibited state, but not remove it from the system.

R

RABF
See *recursive accumulating backhitchless flush*.

radio frequency identification labels
An adhesive bar code label with an embedded radio frequency identification tag that can be used to track tape cartridges.

rail system
Within the TS3500 tape libraryTS4500 tape library, the support structure over which the cartridge accessor moves.

read
To acquire or interpret data from a storage device, from a data medium, or from another source.

ready
The operating condition that the TS3500 tape libraryTS4500 tape library is in when the host applications can interact with it.

recursive accumulating backhitchless flush (RABF)
A non-volatile caching technique that are used by the 3592 tape drives.

rekey
In cryptography, the process of encrypting a data key a second time by using the public key of another party to create another externally encrypted data key. The cartridge can then be shipped to a business partner that holds the corresponding private key that allows the data key to be unwrapped and the tape can be decrypted on a different encryption-capable 3592 tape drive.

relative humidity
The ratio of the amount of water vapor present in the air to the greatest amount possible at the same temperature.

remote authentication
The process of validating the user ID and password that are supplied by a user for a remote system to which the user requires access. If the user is authenticated, the user is mapped to a principal.

remote support
See *Call Home*.

Remote Technical Assistance Information Network (RETAIN)
Used by IBM Service Representatives, an internal host-based software application that contains records of service problems with IBM hardware and software, and tips on how to deal with the problems.

remove
Pertaining to the TS3500 tape libraryTS4500 tape library, a term that is used to describe the act of taking a tape cartridge out of an I/O station.

repeater
A device that regenerates signals to extend the range of transmission between data stations or to interconnect two branches. A repeater is a node of a local area network.

RETAIN
See *Remote Technical Assistance Information Network*.

RFID
See *radio frequency identification labels*.

robotics
The cartridge accessor and any associated mechanisms that move a tape cartridge within the TS3500 tape library.

RS-422 interface
An electrical interface standard that is approved by the Electronic Industries Association (EIA) for connecting serial devices. The RS-422 standard, which supports higher data rates and greater immunity to electrical interference, is an alternative to the older RS-232 interface and uses individual differential signal pairs for data transmission. Depending on data transmission rates, RS-422 can be used at distances to 1,275 m (4,000 ft). The RS-422 interface also supports multi-point connections.

S

SAN
See *Storage Area Network*.

SARS
See *Statistical Analysis and Reporting System*.

SC1
Model SC1. See *Shuttle connection*.

scratch cartridge
A labeled cartridge that is blank or contains no valid data, that is not currently defined, and that is available for use.

scratch encryption policy
A means of identifying to an ecryption-enabled tape drive which scratch cartridges will be encrypted on the next attempt to write from the beginning of the tape. A scratch encryption policy specifies what scratch cartridges to encrypt; it does not indicate which cartridges are currently encrypted. When used with library-managed encryption, a policy optionally lets you control cartridge encryption by VOLSER ranges in all logical libraries.

SCSI
See *Small Computer Systems Interface*.

SCSI-2
A variation of the SCSI interface. See *Small Computer Systems Interface*.

SCSI bus
(1) A collection of wires through which data is transmitted from one part of a computer to another.

(2) A generic term that refers to the complete set of signals that define the activity of the Small Computer Systems Interface (SCSI).

SCSI address
See *SCSI ID*.

SCSI connector
One of the set of all female and male connectors on the SCSI bus.

SCSI device
Anything that can connect into the SCSI bus and actively participate in bus activity.

SCSI element address
A value that defines a logical location in the TS3500 tape libraryTS4500 tape library to the SCSI interface. This logical address is represented on the operator panel or IBM Tape Library Specialist web interface as `xxxx(yyyh)`, where `xxxx` is a decimal value and `yyyh` is a hexadecimal value. It is assigned by the library and used by the server when the server processes SCSI commands. The SCSI

element address is not unique to a storage slot, drive, or I/O slot; it varies, depending on the quantity of drives in the library, whether the Capacity Expansion feature is installed, and whether an Expanded I/O Station is included.

SCSI ID
The hexadecimal representation of the unique address (0-F) that is assigned to a SCSI device. This identifier would normally be assigned and set in the SCSI device during system installation.

search time
The average time that it takes for a tape drive to locate the starting point of a block of data.

secure sockets layer (SSL)
Protocol for transmitting private documents by using the internet. SSL uses a cryptographic system that uses two keys to encrypt data - a public key that is known to everyone and a private or secret key that is known only to the recipient of the message. Many web sites use the protocol to obtain confidential user information, such as credit card numbers. By convention, URLs that require an SSL connection start with https: instead of http:.

sequential access
The processing of information on a tape cartridge in a manner that requires the device to access consecutive storage locations (logical blocks) on the medium.

Sequential Access Device
In SCSI terms, a tape drive.

serial number
See *volume serial number*.

server
A functional unit that provides services to one or more clients over a network. Examples include a file server, a print server, and a mail server. The IBM System p, IBM System i, HP, and Sun are servers. Synonymous with *host*.

service clearance
Surrounding the TS3500 tape libraryTS4500 tape library, the space that is required for an IBM Service Representative to perform maintenance on the unit.

service location protocol
(SLP) Protocol that provides a framework to allow networking applications to discover the existence, location, and configuration of networked services in enterprise networks. With SLP, the user needs to know the description of the service that he is interested in only. SLP is then able to return the URL of the service that the user wants.

service ratings
The values for criteria that is associated with an electrical power cord. The criteria include maximum voltage, current, phases, and wires.

ship group
The group of supplies, cords, or documentation that is shipped with the TS3500 tape libraryTS4500 tape library.

shipping environment
The temperature, relative humidity rate, and wet bulb temperature of the environment to which the TS3500 tape libraryTS4500 tape library is exposed when being transferred from one location to another.

short-wave cable
In Fibre Channel technology, a laser cable that uses a wavelength of 780 nanometers and is only compatible with multi-mode fiber.

shuffle
In HD frames, the process of moving cartridges in lower tiers into the gripper or other available slots to access cartridges in higher tiers.

shuttle car
The mechanism that carries one tape cartridge through the shuttle connection to another library string. Each shuttle car carries one tape cartridge at a time.

shuttle complex
Two or more parallel high density (HD) library strings that are interconnected by one or more shuttle connections.

shuttle connection
Also referred to as Model SC1, the shuttle connection is comprised of one shuttle car, two or more shuttle stations, and one or more spans between these shuttle stations. Each shuttle connection supports one shuttle car.

shuttle span
One or more shuttle spans are linked together to form a shuttle connection between HD frames in parallel library strings. Shorter shuttle spans support distances between library strings ranging from 762 mm (30 in) to 1 524 mm (60 in). Longer shuttle spans support distances between library strings that range from 1 524 mm (60 in) to 2 743.2 mm (108 in).

shuttle station
The shuttle station mounts on top of an HD frame. It consists of a base pad and a shuttle slot. The shuttle slot docks into the base pad. When the shuttle slot is all the way down into the frame station, it can accept or deliver a cartridge. Each shuttle station has its own import/export element (IEE) address.

Simple Network Management Protocol (SNMP)
In the Internet suite of protocols, a network management protocol that is used to monitor routers and attached networks. SNMP is an application layer protocol. Information on devices that are managed is defined and stored in the application's Management Information Base (MIB).

single-phase power
Pertaining to the TS3500 tape libraryTS4500 tape library, electricity that is transmitted via three wires (line, neutral, and ground), with a line-to-neutral voltage of 200-240 V ac.

SLP
See *Service Location Protocol*.

Small Computer Systems Interface (SCSI)
A standard that is used by computer manufacturers for attaching peripheral devices (such as tape drives, hard disks, CD-ROM players, printers, and scanners) to computers (servers). Pronounced "scuzzy." Variations of the SCSI interface provide for faster data transmission rates than standard serial and parallel ports (up to 160 megabytes per second). The variations include:

- Fast/Wide SCSI: Uses a 16-bit bus, and supports data rates of up to 20 MBps.
- SCSI-1: Uses an 8-bit bus, and supports data rates of 4 MBps.
- SCSI-2: Same as SCSI-1, but uses a 50-pin connector instead of a 25-pin connector, and supports multiple devices.
- Ultra SCSI: Uses an 8- or 16-bit bus, and supports data rates of 20 or 40 MBps.
- Ultra2 SCSI: Uses an 8- or 16-bit bus and supports data rates of 40 or 80 MBps.
- Ultra3 SCSI: Uses a 16-bit bus and supports data rates of 80 or 160 MBps.
- Ultra160 SCSI: Uses a 16-bit bus and supports data rates of 80 or 160 MBps.

SMI-S
See *Storage Management Initiative - Specification*.

SMI-S Agent for Tape
See *Storage Management Initiative - Specification (SMI-S) Agent for Tape*.

SNMP
See *Simple Network Management Protocol*.

soft addressing
A method of creating or changing Loop IDs for drives in the TS3500 tape libraryTS4500 tape library. With soft-addressing, the drives automatically arbitrate the AL_PAs with other Fibre Channel devices on the loop. This method avoids conflicts over the address.

Specialist web interface
A platform-independent, web-based interface that allows a user to configure and monitor the TS3500 tape library from a remote location.

See also *TS4500 management GUI*.

speed matching
The ability of the LTO 2 and later LTO tape drives to adjust their native data rate as closely as possible to the net host data rate (after data compressibility is factored out).

SSL
See *Secure Sockets Layer*.

stand-alone
Pertaining to operation that is independent of any other device, program, or system.

Statistical Analysis and Reporting System (SARS)
Firmware that is built into the 3592 tape drives and the LTO tape drives and is used by the drive during problem determination to identify which single-character display code, ASC/ASCQ, and/or TapeAlert to report.

StE
See *storage element*.

Storage Area Network (SAN)
A high-speed subnetwork of shared storage devices. A SAN's architecture makes all storage devices available to all servers on a LAN or WAN. As more storage devices are added to a SAN, they too are accessible from any server in the larger network. Because stored data does not reside directly on any of a network's servers, server power is used for business applications, and network capacity is released to the user.

storage element (StE)
In SCSI terms, a cartridge storage slot.

storage environment
The temperature, relative humidity rate, and wet bulb temperature of the environment in which the TS3500 tape libraryTS4500 tape library is non-operational and being stored for future use.

Storage Management Initiative - Specification (SMI-S)
A design specification of the Storage Management Initiative (SMI) that was started by the Storage Networking Industry Association (SNIA). The SMI-S specifies a secure and reliable interface that allows storage management systems to identify, classify, monitor, and control physical and logical resources in a Storage Area Network (SAN).

Storage Management Initiative - Specification (SMI-S) Agent for Tape
Software that is used by management software to communicate with storage devices in a SAN environment. The SMI-S Agent for Tape communicates by using the Web-Based Enterprise Management (WBEM) protocol, which allows management software to communicate with the TS3500 tape libraryTS4500 tape library.

sustained data transfer rate
Between the server and the tape drive, the average transfer rate of data across the SCSI interface to and from the tape drive during a transition from one end of the tape to the other end.

switch
A network infrastructure component to which multiple nodes attach. Unlike hubs, switches typically can switch node connections from one to another. A typical switch can facilitate several simultaneous bandwidth transmissions between different pairs of nodes.

system console
A service tool that monitors the tape library and other components for early detection of unusual conditions and for error information that the components send to IBM's Remote Technical Assistance Information Network (RETAIN).

T

TapeAlert
A patented technology from Hewlett-Packard that monitors the status of a tape device and media, and detects problems as they occur.

TapeAlert flags
Status and error messages that are generated by the TapeAlert utility and display on the host console. The messages indicate the type of problem and tell how to resolve it.

tape cartridge
A removable storage device that consists of a housing that contains a belt-driven magnetic tape wound on a supply reel and a takeup reel.

tape drive
A data-storage device that controls the movement of the magnetic tape in a compatible tape cartridge. The tape drive houses the mechanism (drive head) that reads and writes data to the tape.

tape frame
See *IBM 3953 Tape Frame Model F05*.

Tape System Service Application (TSSA)
A set of software tools that reside on the integrated management console (IMC) that aid in both local service and remote support of the attached TS4500 tape library. These tools are identical to those tools provided by the IBM TS3000 system console (TSSC), an externally rack-mounted system console.

target
A SCSI device that performs an operation that is requested by the initiator. A target can also be an initiator.

TB
Terabyte.

TCP/IP
See *transmission control protocol/Internet protocol*.

terabyte
$1^{\prime}000^{\prime}000^{\prime}000^{\prime}000$ bytes.

terminate, termination
To prevent unwanted electrical signal reflections by applying a device (a terminator) that absorbs the energy from the transmission line.

terminator
(1) A part that is used to end a SCSI bus.

(2) A single-port, 75-Ω device that is used to absorb energy from a transmission line. Terminators prevent energy from reflecting back into a cable plant by absorbing the radio frequency signals. A terminator is shielded, which prevents unwanted signals from entering or valid signals from leaving the cable system.

tier
The depth of a cartridge location in an HD slot.

Tivoli Storage Manager (TSM)
An IBM client/server product that provides storage management and data access services in a heterogeneous environment. TSM supports various communication methods, provides administrative facilities to manage the backup and storage of files, and provides facilities for scheduling backups.

Tivoli Storage Productivity Center (TPC)
A software solution that manages storage infrastructures in Open Systems environments.

topology
In communications, the physical or logical arrangement of nodes in a network, especially the relationships among nodes and the links between them.

Total Productivity Center (TPC)
See *IBM Total Productivity Center*.

touch keys
On the touchscreen of the TS3500 tape library, an array of small, touch-sensitive keypads that lets you select and navigate through menus. To acknowledge that it has been pressed, a touch key initiates an audible beep (if enabled) whenever you press it. The audible beep is the default.

touchscreen
See *liquid crystal display*.

TPC
See *IBM Total Productivity Center*.

track
A linear or angled pattern of data written on a tape surface.

transfer rate
See *data transfer rate*.

transmission control protocol/Internet protocol (TCP/IP)
(1) The Transmission Control Protocol and the Internet Protocol, which together provide reliable end-to-end connections between applications over interconnected networks of different types.

(2) The suite of transport and application protocols that run over the Internet Protocol.

TS4500 management GUI
A web-based interface that allows users to configure, administer, monitor, and manage the TS4500 tape library locally from the IMC or from a remote location. See also *TS4500 integrated management console (IMC)*.

TSM
See *Tivoli Storage Manager*.

TSSA
See *Tape System Service Application*.

two-node arbitrated loop
In Fibre Channel technology, the connection of two nodes that communicate directly (without the use of a switch) and use the same protocol.

two-node switched fabric loop
In Fibre Channel technology, the connection of two or more nodes that might not use the same protocol and communicate by using a switch.

two-phase power
Pertaining to the TS3500 tape libraryTS4500 tape library, electricity that is transmitted via three wires (line, line, and ground), with a line-to-line voltage of 200-240 V ac. Sometimes referred to as *single phase power*.

U

Ultra SCSI
See *Small Computer Systems Interface*.

Ultra160 SCSI
See *Small Computer Systems Interface*.

Ultra2 SCSI
See *Small Computer Systems Interface*.

Ultra3 SCSI
See *Small Computer Systems Interface*.

Ultra320 SCSI
See *Small Computer Systems Interface*.

uniform resource locator (URL)
The address of an item on the World Wide Web. It includes the protocol followed by the fully qualified domain name (sometimes called the host name) and the request. The web server typically maps the request portion of the URL to a path and file name. For example, if the URL is http://

www.networking.ibm.com/nsg/nsgmain.htm, the protocol is http; the fully qualified domain name is www.networking.ibm.com; and the request is /nsg/nsgmain.htm.

unload
Pertaining to the TS3500 tape libraryTS4500 tape library, a term that is used to describe the act of the drive unthreading the tape from the internal tape path and returning the leader block to the tape cartridge.

URL
See *uniform resource locator*.

V

V
Volt.

V ac
Volts ac (alternating current).

vital product data (VPD)
Pertaining to the TS3500 tape libraryTS4500 tape library, information about a product such as a library, drive, or node card. The VPD might include a machine type, model number, serial number, part number, or level of firmware.

void
In character recognition, the inadvertent absence of ink within a character outline.

VOLSER
Volume serial number.

VOLSER ranges
With the TS4500 tape library, a method that is used to automatically assign cartridges to a logical library by using beginning and ending volume serial number ranges that are set by the user. See also *Cartridge assignment policy*.

volt
The SI (international) unit of potential difference and electromotive force, formally defined to be the difference of electric potential between two points of a conductor that is carrying a constant current of 1 ampere, when the power dissipated between these points is equal to 1 watt.

volume serial number (VOLSER)
A number that a computer assigns to a tape cartridge when it prepares (initializes) the cartridge for use.

VPD
See *vital product data*.

W

W
Watts.

watt
A metric unit of measure of power; the power that is required to keep a current of 1 ampere flowing under a potential drop of 1 volt; about 1/736 of 1 horsepower.

Web
See *World Wide Web*.

wet bulb temperature
The temperature at which pure water must be evaporated adiabatically at constant pressure into a sample of air to saturate the air under steady-state conditions. Read from a wet-bulb thermometer.

World Wide Node Name
In Fibre Channel technology, the fixed, 64-bit name that is assigned to a device by its manufacturer and used to identify participants in a topology. The World Wide Node Name is unique if the manufacturer registered a range of addresses with the IEEE.

World Wide Port Name
Within a parent node, a unique 64-bit name that is assigned to a node port. The World Wide Port Name aids the accessibility of the port.

World Wide Web
A network of servers that contain programs and files. Many of the files contain hypertext links to other documents available through the network.

WORM
See *write once read many*.

write
To make a permanent or transient recording of data in a storage device or on a data medium.

write once read many (WORM)
A technology that allows data to be written only once to LTO 3 and later LTO tape cartridges and all 3592 tape cartridges. After the data is written, it cannot be altered, but can be read any number of times.

write protected
A tape cartridge is write protected if some logical or physical mechanism causes the device that is processing the tape to prevent the program from writing on the tape.

write-protect switch
On LTO and 3592 tape cartridges, a switch that prevents accidental erasure of data. Pictures of a locked and unlocked padlock appear on the switch. When you slide the switch to the locked padlock, data cannot be written to the tape. When you slide the switch to the unlocked padlock, data can be written to the tape.

X

X-axis and Y-axis motion assemblies
Within the TS3500 tape libraryTS4500 tape library, a group of parts that provides the motive force to move the accessor side to side (on the X-axis) and up and down (on the Y-axis).

Y

Y-axis motion assembly
See *X-axis and Y-axis motion assemblies*.

Z

zoning
A method of subdividing a storage area network into disjoint zones, or subsets of nodes on the network. Storage area network nodes outside a zone are invisible to nodes within the zone. Moreover, with switched SANs, traffic within each zone might be physically isolated from traffic outside the zone.

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Part Number:

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