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IBM TS4500 R4 Tape Library Guide

Larry Coyne

Michael Engelbrecht

Simon Browne

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IBM TS4500 R4 Tape Library Guide

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Note: Before using this information and the product it supports, read the information in "Notices" on page vii.

Sixth Edition (March 2018)

This edition applies to the IBM TS4500 R4 Tape Library.

Contents

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Preface

The IBM® TS4500 (TS4500) tape library is a next-generation tape solution that offers higher storage density and integrated management than previous solutions.

This IBM Redbooks® publication gives you a close-up view of the new IBM TS4500 tape library. In the TS4500, IBM delivers the density that today's and tomorrow's data growth requires. It has the cost-effectiveness and the manageability to grow with business data needs, while you preserve existing investments in IBM tape library products.

Now, you can achieve both a low cost per terabyte (TB) and a high TB density per square foot, because the TS4500 can store up to 8.25 petabytes (PB) of uncompressed data in a single frame library or scale up at 1.5 PB per square foot to over 263 PB, which is more than 4 times the capacity of the IBM TS3500 tape library. The TS4500 offers these benefits:

► High availability dual active accessors with integrated service bays to reduce inactive service space by 40%. The Elastic Capacity option can be used to completely eliminate inactive service space.

► Flexibility to grow: The TS4500 library can grow from both the right side and the left side of the first L frame because models can be placed in any active position.

► Increased capacity: The TS4500 can grow from a single L frame up to an additional 17 expansion frames with a capacity of over 23,000 cartridges.

► High-density (HD) generation 1 frames from the existing TS3500 library can be redeployed in a TS4500.

► Capacity on demand (CoD): CoD is supported through entry-level, intermediate, and base-capacity configurations.

► Advanced Library Management System (ALMS): ALMS supports dynamic storage management, which enables users to create and change logical libraries and configure any drive for any logical library.

► Support for the IBM TS1155 while also supporting TS1150 and TS1140 tape drive: The TS1155 gives organizations an easy way to deliver fast access to data, improve security, and provide long-term retention, all at a lower cost than disk solutions. The TS1155 offers high-performance, flexible data storage with support for data encryption. Also, this enhanced fifth-generation drive can help protect investments in tape automation by offering compatibility with existing automation.

   The new TS1155 Tape Drive Model 55E delivers a 10 Gb Ethernet host attachment interface optimized for cloud-based and hyperscale environments.

   The TS1155 Tape Drive Model 55F delivers a native data rate of 360 MBps, the same load/ready, locate speeds, and access times as the TS1150, and includes dual-port 8 Gb Fibre Channel support.

► Support of the IBM Linear Tape-Open (LTO) Ultrium 8 tape drive: The LTO Ultrium 8 offering represents significant improvements in capacity, performance, and reliability over the previous generation, LTO Ultrium 7, while they still protect your investment in the previous technology.

► Support of LTO 8 Type M cartridge (M8): The LTO Program is introducing a new capability with LTO-8 drives. The ability of the LTO-8 drive to write 9 TB on a brand new LTO-7 cartridge instead of 6 TB as specified by the LTO-7 format. Such a cartridge is called an LTO-7 initialized LTO-8 Type M cartridge.

- ► Integrated TS7700 back-end Fibre Channel (FC) switches are available.
- ► Up to four library-managed encryption (LME) key paths per logical library are available.

This book describes the TS4500 components, feature codes, specifications, supported tape drives, encryption, new integrated management console (IMC), and command-line interface (CLI). You learn how to accomplish several specific tasks:

- ► Improve storage density with increased expansion frame capacity up to 2.4 times and support 33% more tape drives per frame.
- ► Manage storage by using the ALMS feature.
- ► Improve business continuity and disaster recovery with dual active accessor, automatic control path failover, and data path failover.
- ► Help ensure security and regulatory compliance with tape-drive encryption and Write Once Read Many (WORM) media.
- ► Support IBM LTO Ultrium 8, 7, 6, and 5, IBM TS1155, TS1150, and TS1140 tape drives.
- ► Provide a flexible upgrade path for users who want to expand their tape storage as their needs grow.
- ► Reduce the storage footprint and simplify cabling with 10 U of rack space on top of the library.

This guide is for anyone who wants to understand more about the IBM TS4500 tape library. It is particularly suitable for IBM clients, IBM Business Partners, IBM specialist sales representatives, and technical specialists.

Authors

This book was produced by a team working at the IBM Tucson Development Lab.

Larry Coyne is a Project Leader at the IBM International Technical Support Organization, Tucson, Arizona, center. He has 35+ years of IBM experience, with 23 years in IBM storage software management. He holds degrees in Software Engineering from the University of Texas at El Paso and Project Management from George Washington University. His areas of expertise include client relationship management, quality assurance, development management, and support management for IBM storage management software.

Michael Engelbrecht is a Senior Support Center Representative in IBM Global Technical Services in Johannesburg, South Africa. He has worked with IBM for 36 years and has worked as part of the Hardware Field Support team for Sub-Saharan Africa for the last 13 years, supporting all Removable Media Storage Systems (RMSS) products. He is the team leader of the Virtual Front-End team for the Middle East and Africa (MEA) regions, and a member of the Virtual EMEA PFE Team (VET) for Data Protection & Retention.He provides both hardware and software support on all RMSS products.

Simon Browne is a Technical Solutions Architect from IBM Global Technology Services® in Wellington, New Zealand. Simon has 26 years of experience in the IT industry with a background in Banking, Energy, and Government IT sectors, including the last 16 years at IBM. He has a background in Midrange and Mainframe Storage Management and has worked with many IBM Server and Storage products, including IBM System Storage® disk and tape, Storage Area Networks, IBM POWER® servers, IBM Spectrum™Protect, and IBM z® Systems with IBM Data Facility Storage Management Subsystem (DFSMS).

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Said Ahmad
Illarion Borisevich
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Khanh Ngo
Steve Nunn
Jason Peipelman
Rick West
IBM Systems

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Summary of changes

Summary of changes for *IBM TS4500 R4 Tape Library Guide*, SG24-8235, as created or updated in May 2018.

This section describes the technical changes that were made in this edition of the book and in previous editions. This edition might also include minor corrections and editorial changes that are not identified.

May 2018, minor update

Clarification in section 1.2.5, "Mainframe-ready" on page 22 and Table 1-14 on page 51that the TS4500 must have two integrated 16 Gb switches installed for IBM z/OS systems with an attached TS7700 support.

January 2018, Sixth Edition

This update reflects the addition of new and changed information.

New information

The book includes the following new information:
► LTO Ultrium 8 tape drive (Model 3588 F8C). Refer to "IBM LTO Ultrium 8 tape drive (Model 3588 F8C)" on page 118.
► LTO 8 Type M cartridge (M8): The LTO Program is introducing a new capability with LTO-8 drives. The ability of the LTO-8 drive to write 9 TB on a brand new LTO-7 cartridge instead of 6 TB as specified by the LTO-7 format. Such a cartridge is called an LTO-7 initialized LTO-8 Type M cartridge. Refer to "M8 format media" on page 121.

This update reflects the addition of new and changed information.

August 2017, Fifth Edition

New information

The book includes the following new information:
► TS1155 model 55E
► TS1155 model 55F
► New commands for Ethernet drives

July 2016, Fourth Edition

This update reflects the addition of new and changed information.

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New information

The book includes the following new information:

- ► High availability with dual active accessor and Elastic Capacity option
- ► Mainframe-ready for TS7700 attachment
- ► Integrated TS7700 Backend Switches
- ► Support for external TSSC/IMC
- ► Flexible growth options with new flex track design
- ► Encryption options

November 2015, Third Edition

This update reflects the addition of new and changed information.

New information

The book includes the following new information:

- ► IBM TS1070 tape drive (Model 3588 F7C)
- ► Up to 128 tape drives
- ► Scalability to 18 frames
- ► Redeployment of S24 and S54 frames from TS3500 to TS4500
- ► Mixed media types within the same TS4500 library
- ► Automatic media verification
- ► Flexible remote authentication
- ► Primary control system failover
- ► SNMP query configuration

Changed information

This book includes the changed information for 2.9, "IBM Spectrum Archive" on page 138.

January 2015, Second Edition

This update reflects the addition of new and changed information.

New information

The book includes the following new information:

- ► IBM TS1155 and TS1150 tape drive
- ► IBM TS1100 tape drives for the TS4500 tape library
- ► IBM LTO Ultrium tape drives for the TS4500 tape library

Changed information

This book includes the changed information for "Linear Tape File System (LTFS)" on page 139.

IBM TS4500 tape library

The IBM TS4500 tape library is a next-generation storage solution that is designed to help midsize and large enterprises respond to storage challenges. Several of these challenges include the high data volume, growth in data centers, increasing cost of data center storage footprints, difficulty migrating data across vendor platforms, and increased complexity of IT training and management as staff resources shrink.

The TS4500 tape library combines reliable, automated tape handling and storage with high performance in an open systems and enterprise environment. Incorporating the IBM Linear Tape-Open (LTO) Ultrium tape and 3592 drives, the TS4500 tape library offers outstanding retrieval performance with typical cartridge move times of less than 3 seconds.

The TS4500, installed with the High Availability (HA) option, provides dual active accessors for redundancy, and can double the robot performance during tape move operations. The HA option on TS4500 has no dedicated service bays and provides the Elastic Capacity option for the use of the storage slots in these integrated service bays.

The TS4500 tape library can be deployed as a single frame library and upgraded to a maximum of 18 frames, with a combination of either LTO and 3592 frames. This single frame library can be partitioned into multiple logical libraries. This feature makes the TS4500 tape library an excellent choice for consolidating tape workloads from multiple heterogeneous open systems servers.

The TS4500 protects investment by providing for redeployment of S24 and S54 frames from the TS3500 onto the TS4500.

The library provides outstanding reliability and redundancy through the provision of redundant power supplies in each drive frame, control and data path failover, dual grippers within the cartridge accessor, and dual active accessors. Both library and drive firmware can be upgraded nondisruptively, without interrupting normal operations. Encryption is supported on the following tape drives:

► LTO Ultrium 8 tape drive (Model 3588 F8C)
► LTO Ultrium 7 tape drive (Model 3588 F7C)
► LTO Ultrium 6 tape drive (Model 3588 F6C)
► LTO Ultrium 5 tape drive (Model 3588 F5C)
► TS1155 tape drive (Model 3592 55E)

- ► TS1155 tape drive (Model 3592 55F)
- ► TS1150 tape drive (Model 3592 EH8)
- ► TS1140 tape drive (Model 3592 EH7)

Three encryption methods are supported:

- ► Application-managed encryption (AME)
- ► Library-managed encryption (LME)
- ► System-managed encryption (SME) for IBM z/OS® TS7700 support

This chapter includes the following topics:

- ► Overview of the IBM TS4500 tape library
- ► TS4500 product description
- ► TS4500 tape library components
- ► Feature codes for the TS4500
- ► Host platforms and device drivers
- ► Specifications

TS4500 Release 4 added new functions, which include:

- ► TS1155 model 55E
- ► TS1155 model 55F

TS4500 Release 4.1 added new functions, which include:

- ► LTO Ultrium 8 tape drive (Model 3588 F8C)

1.1 Overview of the IBM TS4500 tape library

The IBM TS4500 is a highly scalable, stand-alone tape library that provides high-density tape storage and high-performance, automated tape handling for open systems and enterprise environments.

Figure 1-1 shows a three-frame version of the TS4500 tape library. An individual library can consist of one L frame and up to 17 expansion frames, and it can include up to 128 tape drives with more than 23,000 tape cartridges, as shown in Figure 1-2 on page 5.

Figure 1-1   TS4500 introduction

The TS4500 tape library provides the following capabilities, which are described in more detail in the following chapters:

► High availability dual active accessors with integrated service bays to reduce inactive service space by 40%. The Elastic Capacity option can be used to completely eliminate inactive service space.

► All of the frames include high-density (HD) slot technology.

► Additional HD2 frame models can be placed in any active position so that the library can grow from both the right side and the left side of the first L frame.

► HD generation 1 frames from the existing TS3500 library can be redeployed into a TS4500. These frames must be installed to the right of the Lx5 frame, and Feature Code (FC) 1742 must be installed on each frame before they can exist in a TS4500 library string.

► Advanced Single Deep Cell technology.

► Integrated management console (IMC) with support for an external IBM TotalStorage System Console (TSSC) and IMC.

► Web based user interface for improved usability.

► Updated control system.

► Input/output (I/O) magazine to allow individual cartridge handling to be performed independently of the library.

► Top-rack space to house extra tape solution components within the library footprint.

- ► Support for HD2-compatible models of the TS1155 (3592 55E and 3592 55F), TS1150 (3592 EH8), TS1140 (3592 EH7), LTO Ultrium 8 (3588 F8C), LTO Ultrium 7 (3588 F7C), LTO Ultrium 6 (3588 F6C), and LTO Ultrium 5 (3588 F5C) tape drives.
- ► Integrated TS7700 back-end Fibre Channel (FC) switches.
- ► Up to four library-managed encryption (LME) key paths per logical library.
- ► The TS4500 tape library is available with several tape drives, frame models, and feature options to meet your specific needs. Additional features of the TS4500 tape library are highlighted in the following list:
- ► Advanced Library Management System (ALMS)
- ► Ability to attach multiple simultaneous heterogeneous servers
- ► Remote management with the TS4500 management GUI or the TS4500 command-line interface (CLI)
- ► Remote monitoring by using Simple Network Management Protocol (SNMP), email, or syslog
- ► SNMP query configuration
- ► Media health verification
- ► Multipath architecture
- ► Drive and media exception reporting
- ► Host-based path failover
- ► Up to 288 I/O slots (36 I/O slots standard for LTO libraries and 32 I/O slots standard for 3592 libraries with extra I/O slots that are available as a feature add-on for all D25 and D55 frames)

1.2 TS4500 product description

The IBM TS4500 tape library (Machine Type 3584) is a modular tape library that consists of a high-density base frame and up to 17 high-density 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 up to two cartridge accessors. You can install a single-frame base library (Figure 1-1 on page 3) and grow it to 18 frames, tailoring the library to match your system capacity requirements.

Table 1-1 lists the supported combinations of frames, tape drives, and their capabilities.

Table 1-1   TS4500 tape library capabilities

Models	Drives in frames	Maximum cartridges	Maximum native capacity
L25, D25, S25, and S24	3592 tape drives	17,550	263 petabytes (PB)
L55, D55, S55, and S54	LTO tape drives	23,170	278 petabytes (PB)
Note: The maximum native capacity figures are based on library configurations with one base frame with all LTO-8 or TS1155 tape drives, and 17 storage-only HD frames.			

Figure 1-2 shows the TS4500 with a maximum configuration of 18 frames.

Figure 1-2   Maximum TS4500 tape library configurations

Eight types of frames are supported in the current TS4500 tape library range. Each frame is identified by a three-character model number (L25, D25, L55, D55, S25, S55, S24, and S54), which describes the nature of the frame.

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 additional frames, which are 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 can be supported by a single cartridge accessor, or by dual active accessors, with the High Availability feature installed. The TS4500 tape library can contain a mix of 3592 and LTO frames.

The TS4500 tape library supports first generation (S54 and S24) frames (HD1) and second-generation high-density (HD2) frames. HD2 frames, like the first-generation HD1 frames, offer increased capacity without increasing the frame size or required floor space, by using high-density storage slots for tape cartridges.

In addition, HD2 frames provide the following enhancements:

► HD2 frames 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 (3588 F8C, 3588 F7C, 3588 F6C, 3588 F5C, 3592 EH8, and 3592 EH7) when positioned as frame number 2 or higher.

Generation 1 HD frames from the TS3500 (Model S24 and S54) can be redeployed into a TS4500. These HD1 frames must be installed to the right of the Lx5 frame and require FC 1742 to be ordered for each S24 or S54 (Sx4) frames, before they can exist in a TS4500 library string.

The L25 and L55 (Lx5) frames and D25 and D55 (Dx5) frames are HD2, drive-capable frames, which means that they contain high-density cartridge storage slots, and slots to house up to 16 tape drives. The S25, S55 (Sx5) HD2 frames and the S54, S24 (Sx4) HD1 frames are storage-only frames, which means that they contain high-density cartridge storage slots, but no tape drives. All HD frames provide internal light-emitting diode (LED) lighting.

The TS4500 also supports the addition of a top rack frame. The top rack, 3584 Model TR1, provides an extra 10U of rack space on any frame in a library without requiring more floor space.

Table 1-2 lists the frames that are supported by the library and their specific media type and capacity.

Table 1-2   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 I/O stations and two 16-slot magazines ► 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 I/O stations and two 18-slot magazines ► 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 quipped with two I/O stations and two 16-slot magazines ► Optionally equipped with top rack (Model TR1)
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 I/O stations and two 18-slot magazines ► Optionally equipped with top rack (Model TR1)
S25	Storage-only expansion frame	3592	798 storage slots	1,000 storage slots	► Optionally equipped with top rack (Model TR1)
S55	Storage-only expansion frame	LTO	1,054 storage slots	1,320 storage slots	► Optionally equipped with top rack (Model TR1)

Frame model	Type	Media type	Capacity		Other
			Frame position 1	**Frame position 2+**	
S24	Storage-only expansion frame	3592	Not supported	1,000 storage slots	► Optionally equipped with top rack (Model TR1)
S54	Storage-only expansion frame	LTO	Not supported	1,320 storage slots	► Optionally equipped with top rack (Model TR1)

1.2.1 TS4500 tape library frames for IBM LTO Ultrium Fibre Channel drives

The TS4500 tape library models L55 and D55 integrate the HD2 versions of the LTO-8, LTO-7, LTO-6, and LTO-5 (8 Gbps dual-port Fibre Channel) tape drives. The TS4500 models S55 and S54 are high capacity storage-only frames for LTO cartridge slots.

The Model L55 frame includes the frame control assembly with two power supplies (for redundancy), an optimized dual-gripper cartridge accessor, on-demand storage slot capacity, and two I/O stations with two 18-slot magazines.

TS4500 tape library Model L55

The L55 frame can be installed on its own as a complete library enclosure, as shown in Figure 1-3 on page 8, or up to 17 expansion frames can attach to it. This frame provides the major library components for the whole library, whether it has a single frame or multiple frames. It also provides cartridge storage capacity for LTO media, and it can be equipped with the HD2 versions of the LTO-8, 7, 6 and 5 dual-ported drives that facilitate 8 Gbps Fibre Channel connectivity.

HD2 expansion frames can be added to either the left or right of the L55 frame. HD1 frames can be added only to the right side of L55 frame (Figure 1-3).
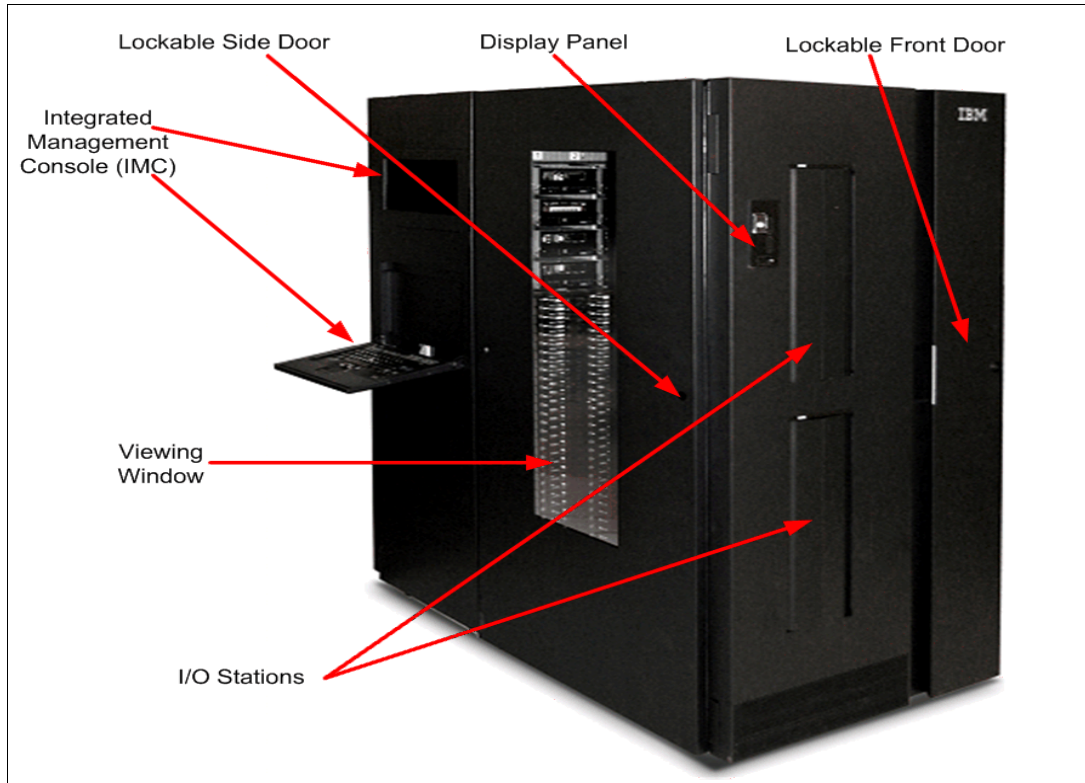
Figure 1-3   TS4500 tape library L55/L25 base frame

The number of LTO cartridge storage slots ranges from 100 to 882. With the minimum configuration, 100 slots are available for use. The maximum of 882 slots is already physically installed and accessed by the addition of capacity on demand (CoD) license keys.

Many CoD feature codes exist for the L55 frame, and the number of available slots depends on the frame position.

The Intermediate Capacity feature (FC 1643) gives a maximum total number of usable cartridge slots of 200. This feature is a prerequisite for the Base Capacity on Demand (FC 1644), which gives the maximum capacity of 400 cartridge slots. FC 1644 is required to attach an optional expansion frame. Both FC 1643 and FC 1644 are prerequisites to install the HD CoD for L55 (FC 1648), which gives the maximum capacity of between 730 and 882 slots.

Depending on the frame position, the maximum number of LTO drives that can be installed is 16. Four generations of HD2-compatible LTO drives exist: the LTO Ultrium 8 tape drive (Model 3588 F8C), LTO Ultrium 7 tape drive (Model 3588 F7C), LTO Ultrium 6 tape drive (Model 3588 F6C), and the LTO Ultrium 5 tape drive (Model 3588 F5C), which can be installed in the L55 frame. Drive slots are fixed. Adding drives to the L55 frame does not affect the number of available storage slots.

Figure 1-4 shows the drive slots and HD slots.
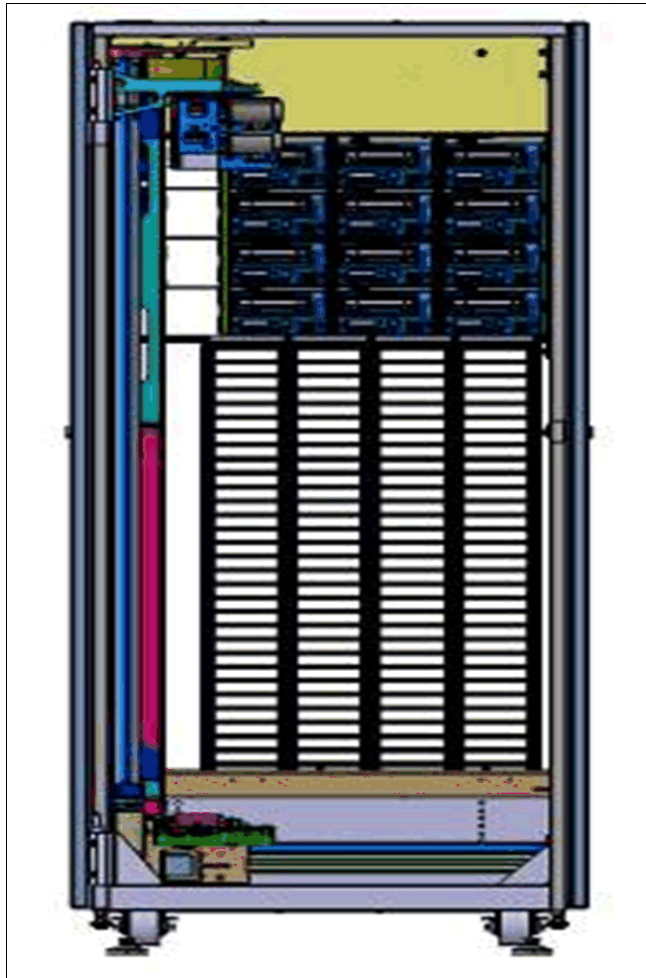
Figure 1-4   L55/L25 frame internal

When capacity on demand (CoD) features are installed, the position and configuration of the frame affect the total available capacity of the L55.

Table 1-3 shows the available storage capacity, which is based on the frame positions and configurations.

Table 1-3   Quantity of storage slots in the L55 frame

Licensed features	Frame position	Quantity of drives	Quantity of I/O slots	Quantity of storage slots
Entry	1	1 - 12	36	100
Intermediate	1	1 - 12	36	200
Base	1	0 - 12	36	400
Base	2+	0 - 16	36	400
HD CoD	1	0 - 12	36	730
HD CoD	2+	0 - 16	36	882

The L55 frame comes standard with two I/O stations. Each I/O station houses a cartridge magazine that allows individual cartridge handling to be performed independently of the tape library. The cartridge magazine for each I/O station on LTO frames can hold up to 18 cartridges, providing a total of 36 I/O slots. The TS4500 tape library Model L55 imports or exports cartridges from the library, without requiring reinventory, or interruption of library operations. The lockable library door can be opened for bulk-loading LTO tape cartridges. Reinventory of the cartridges in tier 0 and tier 1 is performed in less than 60 seconds per frame, each time that the library door is closed. A bar code reader that is mounted on the autochanger is used to scan the cartridge bar code labels during inventory.

> **Important:** If a bulk load is performed, the top two rows on tier 1 must remain empty to allow for the initial inventory.

On an HD frame after initial inventor, the inventory will checks tier 1 bar code labels only, and will checks the other tier labels only if tier 1 changed.

A door lock is included to restrict physical access to the cartridges in the library, and a door open sensor is equipped to prevent accessor movement while the door is open.

> **Note:** The left and right side doors also contain the door lock and open sensor.

Included in the L55 frame is the integrated management console (IMC), which is a built-in platform for tools that are used to manage the TS4500 tape library. The IMC, which includes an LCD panel and a keyboard with a touchpad, can be mounted on either end of your TS4500 tape library. Details of the IMC and other components are described in 4.1, "Integrated management console (IMC)" on page 160.

TS4500 tape library Model D55

The D55 frame, as shown in Figure 1-5 on page 11, has the same footprint as the Model L55.

The D55 frame cannot be installed on its own. It must be connected to a library with a base frame. A maximum of 18 frames, including the L55 frame, can be connected, as shown in Figure 1-2 on page 5.

> **Note:** The combined number of D55 or D25 drive frames that can be installed in a TS4500 library is limited to seven.

The number of additional LTO cartridge storage slots per D55 frame ranges from 500 to 970. With the minimum configuration, only 500 slots are available for use. More slots can be enabled by installing a capacity on demand (CoD) license key.

The base capacity on a D55 frame gives the maximum capacity of 500 cartridge slots. FC 1644 must be installed on the L55 frame, with either FC 9002 or FC 9003, and the corresponding prerequisite feature code, to attach a D55 expansion frame, as described in 1.4, "Feature codes for the TS4500" on page 50. The HD CoD for D55 (FC 1650) gives the maximum capacity of 730 - 970 slots, depending on the frame position.

Depending on the frame position, the maximum number of LTO drives that can be installed is 16. As with the L55 frame, four generations of HD2-compatible LTO drives can be installed in the D55 frame:

- ► The LTO Ultrium 8 tape drive (Model 3588 F8C)
- ► The LTO Ultrium 7 tape drive (Model 3588 F7C)

- ► The LTO Ultrium 6 tape drive (Model 3588 F6C)
- ► The LTO Ultrium 5 tape drive (Model 3588 F5C)

Drive slots are fixed. Adding drives to the D55 frame does not affect the number of available storage slots.

Figure 1-5 shows the D55 frame with drive and HD slots.

Two additional I/O stations can be installed in any Dx5 expansion frame by ordering FC 1652. This feature installs two I/O stations in a drive expansion frame. Each additional pair of I/O stations increases the maximum insert/eject throughput for the library. The maximum cartridge capacity for expansion frames with two I/O stations is reduced by 88 cartridges for the Model D55.

Figure 1-5   TS4500 model D55/L55

The position and configuration of the frame, the number of I/O slots, and the installation of capacity on demand (CoD) features all affect the total available storage capacity of the D55.

Table 1-4 shows the available storage capacity, which is based on possible frame positions and configurations.

Table 1-4   Quantity of storage slots in the D55 frame

Licensed features	Frame position	Quantity of drives	Quantity of I/O slots	Quantity of storage slots
Base	1	0 - 12	0 - 36	500
Base	2+	0 - 16	0 - 36	500
HD CoD	1	0 - 12	36	730
HD CoD	1	0 - 16	0	774
HD CoD	2+	0 - 16	36	882
HD CoD	2+	0 - 16	0	970

1.2.2 TS4500 tape library frames for IBM 3592 Fibre Channel drives

The TS4500 tape library models L25 and D25 integrate the TS1155, TS1150, and TS1140 tape drives. The TS4500 Model S25 is a high-capacity, storage-only frame for 3592 slots.

The Model L25 frame includes the Frame Control Assembly (FCA) with two power supplies (for redundancy), an optimized dual-gripper cartridge accessor, on-demand storage slot capacity, and two I/O stations with two 16-slot magazines.

TS4500 tape library Model L25

The L25 can be installed on its own as a complete library enclosure, as shown in Figure 1-3 on page 8, or it can have up to 17 expansion frames that are attached to it. This frame provides the major library components for the whole library, whether it has single or multiple frames. It also provides cartridge storage capacity for 3592 media, and it can be equipped with TS1155, TS1150, and TS1140 (3592 models 55F, EH8, and EH7) dual-ported drives that facilitate 8 Gbps Fibre Channel connectivity. On the TS1155 (3592 model 55E), dual 10 Gb Ethernet host attachment interface, optimized for cloud-based and large, open-compute environments, is provided.

The HD2 expansion frame can be added to either the left or right of the L25 frame. HD1 frames can be added only to the right side of the L25 frame.

The Intermediate Capacity feature (FC 1643) gives a maximum total number of usable cartridge slots of 200. This feature is a prerequisite for the Base Capacity on Demand feature (FC 1644), which gives the maximum capacity of 400 cartridge slots. FC 1644 is required to attach an optional expansion frame. FC 1644 is a prerequisite to install the HD CoD for L25 (FC 1647), which offers the maximum capacity of 550 to 660 slots.

Depending on the frame position, the maximum number of 3592 drives that can be installed is 16. Three generations of HD2-compatible 3592 drives, the TS1155 (3592 55F and 55E), TS1150 (3592 E08), and TS1140 (3592 E07) tape drives, are supported in the L25 frame. Drive slots are fixed. Adding drives to the L25 frame does not affect the number of available storage slots.

Figure 1-6 shows an L25 frame drive and HD slots.

Figure 1-6   TS4500 model D25/L25

The position and configuration of the frame and the installation of capacity on demand (CoD) features affect the total available capacity of the L25. Table 1-5 shows the available storage capacity, which is based on possible frame positions and configurations.

Table 1-5   Quantity of storage slots in L25 frame

Licensed features	Frame position	Quantity of drives	Quantity of I/O slots	Quantity of storage slots
Entry	1	1 - 12	32	100
Intermediate	1	1 - 12	32	200
Base	1	0 - 12	32	400
Base	2+	0 - 16	32	400
HD CoD	1	0 - 12	32	550
HD CoD	2+	0 - 16	32	660

The L25 frame comes standard with two I/O stations. Each I/O station houses a cartridge magazine that allows importing or exporting cartridges from the library without requiring reinventory or an interruption of library operations. The cartridge magazine for each I/O station on 3592 frames can hold up to 16 cartridges, providing a total of 32 I/O slots.

The lockable library door can be opened for bulk-loading IBM LTO Ultrium tape cartridges. Reinventory of the cartridges in tier 0 and tier 1 is performed in less than 60 seconds per frame, each time that the library door is closed. A bar code reader that is mounted on the gripper is used to scan the cartridge bar code labels during inventory.

> **Important:** If a bulk load is performed, the top two rows on tier 1 must remain empty to allow for the initial inventory.

On an HD frame, the inventory checks tier 0 and tier 1 bar code labels only, and the inventory checks the other tier labels only if tier 1 changed.

A door lock is included to restrict physical access to cartridges in the library, and a door open sensor is equipped to prevent accessor movement while the door is open.

Included in the L25 frame is the integrated management console (IMC), which is a built-in platform for tools that are used to manage the TS4500 tape library. The IMC, which includes an LCD panel and a keyboard with a touchpad, can be mounted on either end of your TS4500 tape library. Details of the IMC and other components are described in Chapter 4, "TS4500 management graphical user interface (GUI)" on page 159.

TS4500 tape library Model D25

The D25 frame, as shown in Figure 1-5 on page 11, has the same footprint as the Model L25. The D25 frame cannot be installed on its own. It must be connected to a library with a base frame. A maximum of 18 frames, including the L25 frame, can be connected, as shown in Figure 1-2 on page 5.

> **Important:** The combined number of allowed D55 or D25 frames in a TS4500 library is limited to seven.

The number of additional 3592 cartridge storage slots per D25 frame ranges from 500 to 740. With the minimum configuration, only 500 slots are available for use.

More slots can be enabled by installing a capacity on demand (CoD) license key.

The base capacity on a D25 frame gives the maximum capacity of 500 cartridge slots. FC 1644 must be installed on the L55 frame with either FC 9002 or FC 9003 and the corresponding prerequisite FC to attach a D25 expansion frame, as described in 1.4, "Feature codes for the TS4500" on page 50.

The HD CoD for D25 (FC 1649) gives the maximum capacity of between 660 to 740 slots, depending on the frame position.

Depending on the frame position, the maximum number of 3592 drives that can be installed is 16. Three generations of HD2-compatible 3592 drives, the TS1155 (3592 55E and 55F), TS1150 (3592 E08), and TS1140 (3592 E07) tape drives, are supported in the D25 frame. Drive slots are fixed. Adding drives to the D25 frame does not affect the number of available storage slots.

Figure 1-6 on page 13 shows the drive slots and HD slots.

Two extra I/O stations can be installed in any Dx5 expansion frame by ordering FC 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 maximum cartridge capacity for expansion frames with two I/O stations is reduced by 80 cartridges for the Model D25 frame.

The position and configuration of the frame, the number of I/O slots, and the installation of capacity on demand (CoD) features all affect the total available storage capacity of the D55. Table 1-6 shows the available storage capacity based on possible frame positions and configurations.

Table 1-6   Quantity of storage slots in the D25 frame

Licensed features	Frame position	Quantity of drives	Quantity of I/O slots	Quantity of storage slots
Base	1	0 - 12	0 or 32	500
Base	2+	0 - 16	0 or 32	500
HD CoD	1	0 - 12	32	550
HD CoD	1	0 - 12	0	590
HD CoD	2+	0 - 16	32	660
HD CoD	2+	0 - 16	0	740

1.2.3 TS4500 tape library storage-only HD frames

The TS4500 tape library offers the following storage-only HD frames.

Model S55 and S25

The IBM TS4500 includes the Model S25 frame and the Model S55 frame, which are high density (HD) version 2 storage-only expansion frames, as shown in Figure 1-7.

These frames are designed to increase storage capacity greatly without increasing the frame size or required floor space.

Figure 1-7   Sx5/Sx4 frame

The HD slots contain tape cartridges in a tiered architecture. The cartridge, which is immediately accessible in the HD slot, is a tier 1 cartridge. Behind that tier is tier 2, and so on. 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 1-8 shows the inside of an HD frame from the side. On the right, Figure 1-8 shows a top-down view of one row of an HD frame with cartridges in tiers 0 (door side), 1, 2, and 3.
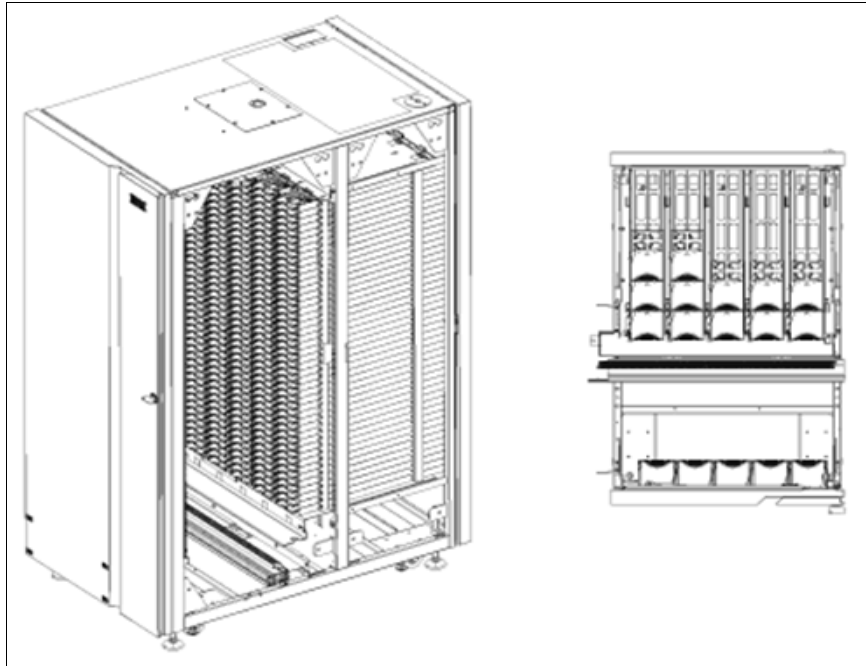
Figure 1-8   The HD frame (left) and top-down view of a row in an HD frame (right)

Models S24 and S54

The IBM TS3500 storage-only frame, HD1 models S24 and S54, can be attached to the TS4500 with the correct FC 1742 ordered.

These generation 1 HD frames can be redeployed into a TS4500 as long as they are installed to the right of the Lx5 frame. You must install FC 1742 before the frames can be added to a TS4500 library string. This feature code replaces the TS3500 cards to be supported on the TS4500, as shown in Figure 1-9.

S24/S54 for TS3500   S24/S54 for TS4500 with FC 1742
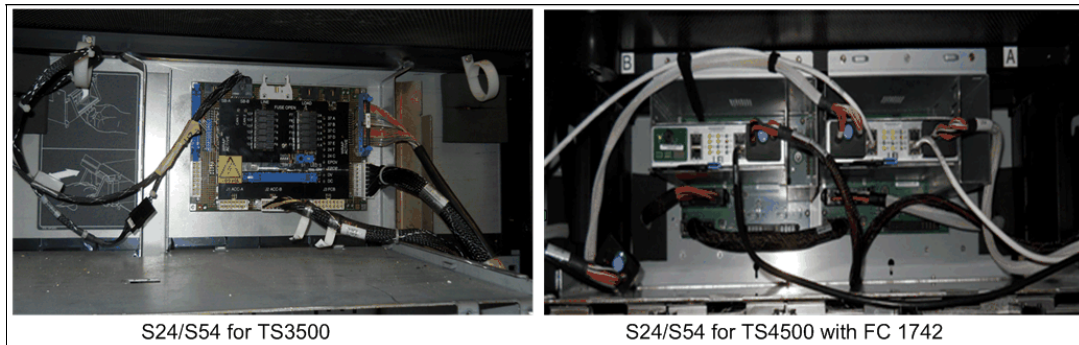
Figure 1-9   Changes to S24/S54 for TS4500 attachment

The TS3500 tape library models S24 and S54 frames are high-density (HD) version 1 storage-only expansion frames, which were attached to existing TS3500 tape libraries and frames.

The Model S24 expansion frame is for 3592 data cartridges. Up to 17 Model S24 expansion frames can be added to the right of the Lx5 frame of the TS4500 Model L25 base frame to increase 3592 cartridge storage. Each Model S24 frame supports up to 1,000 IBM 3592 cartridge slots.

The Model S54 expansion frame is for LTO data cartridges. Up to 17 Model S54 expansion frames can be added to the right of the Lx5 frame of the TS4500 tape library Model L55 base frame to increase LTO cartridge storage. Each Model S54 frame supports up to 1,320 LTO cartridge slots.

The HD1 models S24 and S54 can be added to any TS4500 expansion frame, as long as the expansion frame is added to the right of the Lx5 frame, up to a total of 18 expansion frames, including the Lx5 frame.

HD1 and HD2 frames

All HD slots are black. However, 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, as shown in Figure 1-10.
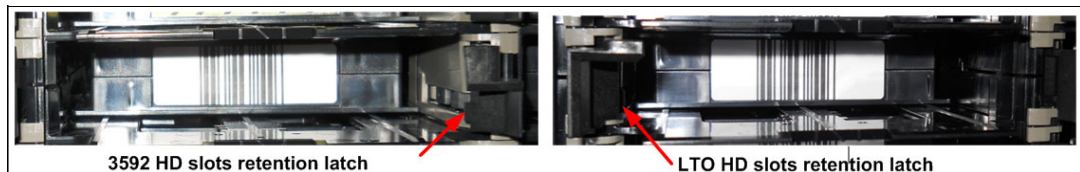
Figure 1-10   HD slot

> **Attention:** The HD slots use a constant force spring to maintain forward pressure on the tape cartridges. Use caution when you insert or remove cartridges from the HD slots.

In an HD library, 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 within an HD slot to scan each bar code. For all inventory operations, tier 2 and higher tiers in an HD slot are only scanned when one of the following changes occurs:

► A tier 1 cartridge bar code label was changed.

► Enough tier 1 bar code labels were changed in a column to warrant an inventory of the entire column of HD slots.

► Inventory of all tiers is selected when you initiate a manual inventory from the TS4500 management GUI.

In HD frames, the cartridge accessor performs 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. Therefore, all HD slots are filled to a minimum tier level until that tier is full across the library.

For the initial bulk load on a newly installed frame, insert cartridges into the deep slots, but leave the top two rows empty. The slots in the top two rows must be empty for the initial audit of the frame to start, and to enable the initial shuffle operation to proceed. The initial audit fills these slots, and then these slots are used like any other HD slot in subsequent library operations.

First-generation HD (HD1) frames can be installed to the right side of an Lx5 frame only.

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

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

The position and configuration of the frame, and the installation of capacity on demand (CoD) features, all affect the total available storage capacity of the S25 and S55 frames. Table 1-7 shows the available storage capacity based on possible frame positions and configurations.

Table 1-7   Quantity of storage slots in S25/S55 frames

Model	Licensed features	Frame position	Quantity of storage slots
S25	S25 Base	Any	600
S55	S55 Base	Any	660
S25	S25 HD CoD	1	798
S55	S55 HD CoD	1	1,054
S25	S25 HD CoD	2+	1,000
S55	S55 HD CoD	2+	1,320
S24	S24 HD CoD	2+	1,000
S54	S54 HD CoD	2+	1,320

1.2.4 TS4500 High Availability (HA) option

The TS4500 High Availability (HA) option provides a second accessor for redundancy and performance. This feature allows dual accessors in a dual active mode, and it has an integrated service bay to reduce service space.

The integrated service bays replace the existing HA frame and Service Bay B frames that are used on the TS3500. The integrated service bays allows a section of a frame to be used for servicing an accessor while the remaining portion of the frame is still available for active storage and drives. Accessor service must be performed through the side, by opening the side doors of integrated service bays. Any HD2 frame can be an integrated service bay.

The second accessor, accessor B, is provided when you order a new Dx5 or Sx5 frame with FC 1442. The new Dx5 or Sx5 frame can be installed in any position, and it will be shipped with the new B accessor. The accessor can be removed from the new frame and installed on the right side of the TS4500 if the new frame is installed on the left side.

Figure 1-11 shows the HA feature that shipped in a new D25 frame.

Figure 1-11   D25 frame that was ordered with FC 1442

The left or A side integrated service bay allows cartridges to be populated in storage columns 9 and 10, while drives can be populated in drive column 4.

The right or B side integrated service bay allows cartridges to be populated in storage columns 1, 2, 3, and 4, while drives can be populated in drive columns 1 and 2. The I/O stations are accessible in the right integrated service bay. Integrated service bays allow a minimum dual accessor system of only two frames.

The available storage for HA is shown in Figure 1-12.

TS4500 High Availability Option with Dual Active Accessors

Frame 1   Frame N

Top View

A   B

| Red, not available for any accessor | Yellow, available for accessor A only | Green, available for accessor A and B | Blue, Available for accessor B only |
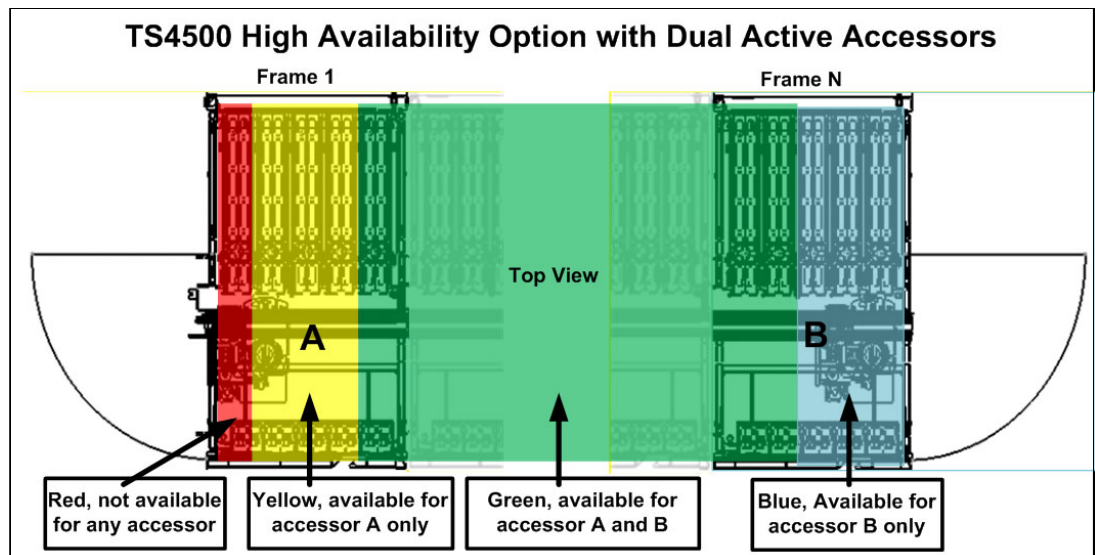
Figure 1-12   Available storage with an HA option

Note: I/O stations are not accessible in the left integrated service bay, so an L25 or L55 frame cannot be used as a left integrated service bay. The frame that ships with the HA option can be installed on the left side if required because no dedicated service bays are on that side. The new accessor must be installed in the frame on the right side.

Elastic Capacity option

The TS4500 provides the Elastic Capacity option to completely eliminate inactive service space. The Elastic Capacity option can provide temporary relief for overflow conditions. These slots are referred to as Tiers T10 - T15 slots. Standard storage slots are Tiers 0 - 5.

With dual active accessors, certain storage slots are only available to a single accessor, and they are unavailable during accessor service. The ability to use these slots is optional, and they can be enabled or disabled on the management interface. Three modes are available for the Elastic Capacity option:

► Do not use
► Use for temporary overflow
► Use for maximum capacity

Do not use

In this mode, the TS4500 does not use the Elastic Capacity slots for media storage, so all media is usable when only one accessor is available. Tier T10 - T15 slots are not used.

Use for temporary overflow

In this mode, cartridges are moved to elastic storage only if the library is 100% full, and if new inserts have no other destination choice. In this case, T10 - T15 is used as temporary storage to handle the library overfill. Cartridges will be returned to HA space after space becomes available either manually by a user, or when the application mounts and demounts the cartridges in the elastic capacity slots (T10 - T15).

Use for maximum capacity

Use this setting to store media cartridges in the limited access (Elastic Capacity) columns as normal storage. The use of these slots can be managed by using different methods:

► Manually: A user can select a cartridge to destage to elastic storage by using the command-line interface (CLI). If the cartridge is already in elastic storage, no action will be taken.

► Small Computer System Interface (SCSI): An application can use the HD Control field of the SCSI Move Medium command to specify that the move is an elastic storage destage.

► Periodic: 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 moved into the Elastic Capacity area. The default usage threshold is 98%.

> **Note:** "Use for maximum capacity" is the default setting if the setting is not changed.

TS4500 capacity tool

The IBM Tape Library Slot Calculator helps calculate capacity and slot numbers for all IBM tape libraries, including TS3100, TS3200, TS3310, TS3500, and the TS4500. This calculation includes capacity with the different elastic capacity options.

This tool can be obtained from this website:

http://www.ibm.com/support/techdocs/atsmastr.nsf/WebIndex/PRS5322

1.2.5 Mainframe-ready

From FW release 3 the TS4500 is supported on IBM z/OS systems with an attached TS7700. The TS7700 requires FW release 4 and higher to attach to a TS4500.

To provide this support, the TS4500 must have two integrated 16 Gb Fibre Channel (FC) switches, which are installed in the bottom of a L25 or D25 frame, as shown in Figure 1-13. The TS4500 management graphical user interface (GUI) supports the preset TS7700 logical library, and supports the use of an external TSSC/IMC.
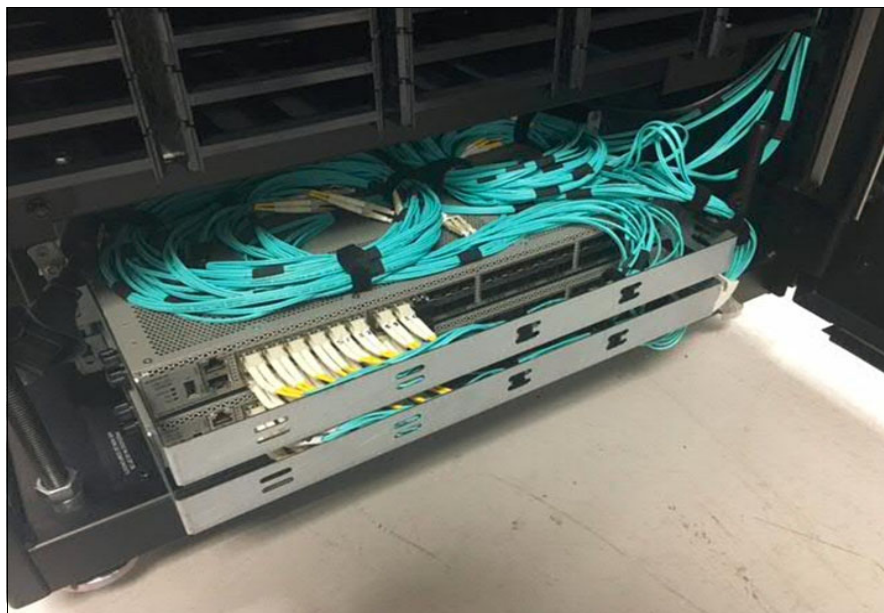
Figure 1-13   Integrated TS7700 back-end switches

Note: The integrated FC switches do not require additional power feeds to the TS4500. The integrated FC switches use bifurcated power cords that are provided with the mounting kit hardware for the switches. These power cords connect internally to the existing TS4500 Power Distribution Units.

1.2.6 External TSSC/IMC

The TS4500 now supports the use of an external TSSC/IMC so that a single TSSC provides the Call Home capability for several TS7700, TS4500, or TS3500 devices on the same site, as shown in Figure 1-14.
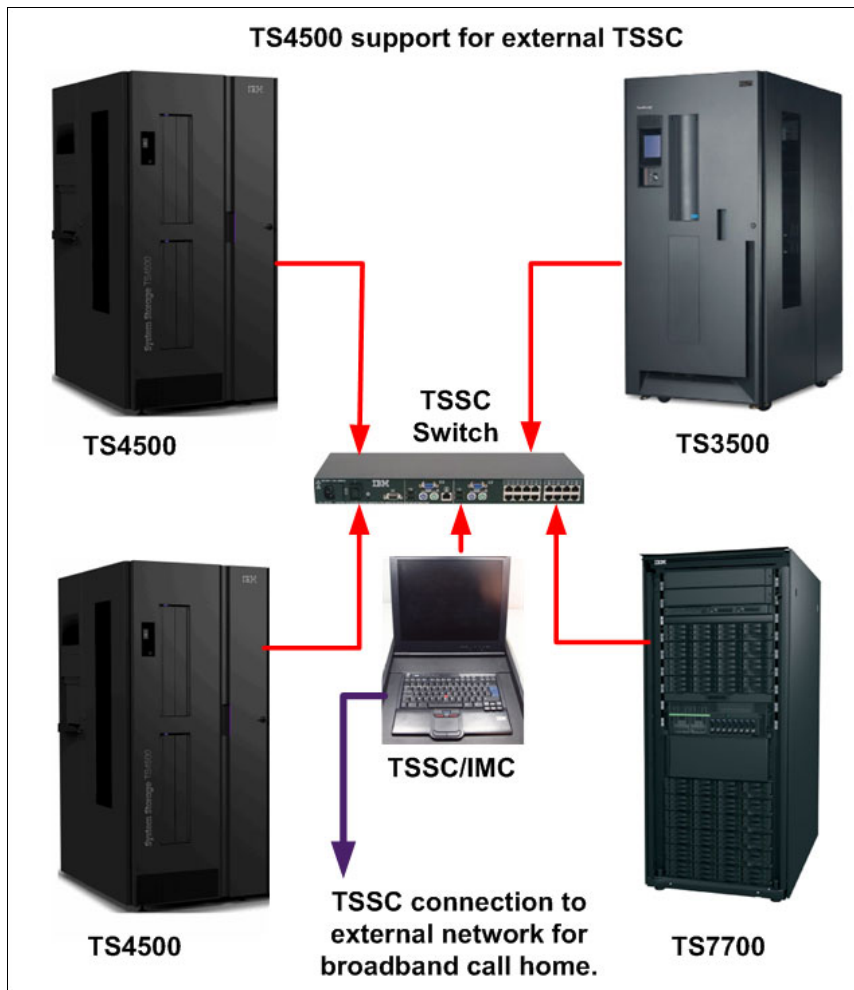
Figure 1-14   External TSSC server

Note: The external TSSC can also be a TSSC/IMC inside another TS4500. This configuration requires that you install FC 2704 on the Lx5 frame. FC 2704 provides a 26-port switch to allow connection to up to 24 additional devices to share the TSSC/IMC.

1.2.7 TS4500 tape library top rack frame TR1

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, which is shown in Figure 1-15, reduces the storage footprint and simplifies cabling by providing extra rack space above the library for power distribution units (PDUs), Fibre Channel (FC) switches, tape data movers, or IBM Spectrum Archive™ nodes.

Figure 1-15   Tape library with an installed top rack

A top rack is installed in the field by an IBM service support representative (SSR) 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 (FC) 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. FC 1751, Power Distribution Unit (PDU), can be ordered optionally 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, FC 9954, through FC 9959 or FC 9966, is required for each PDU that is ordered.

Figure 1-16 shows the top rack without installed covers and devices.
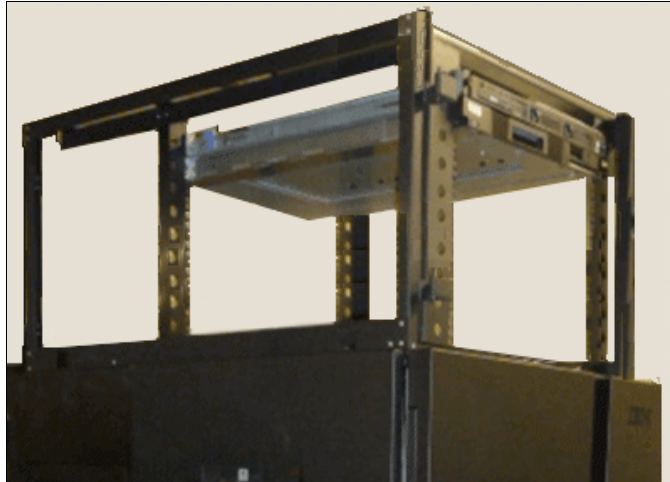
Figure 1-16   Top rack without covers and devices

Important: The top rack is treated as an independent rack space, and it is not tied to the service or support of the tape library.

1.3 TS4500 tape library components

The TS4500 tape library consists of one or more frames, which contain additional components that supply power to the library, installed tape drives, and components for handling and storing tape cartridges.

To view the location of each available component in the front and side of the frame, see Figure 1-17.
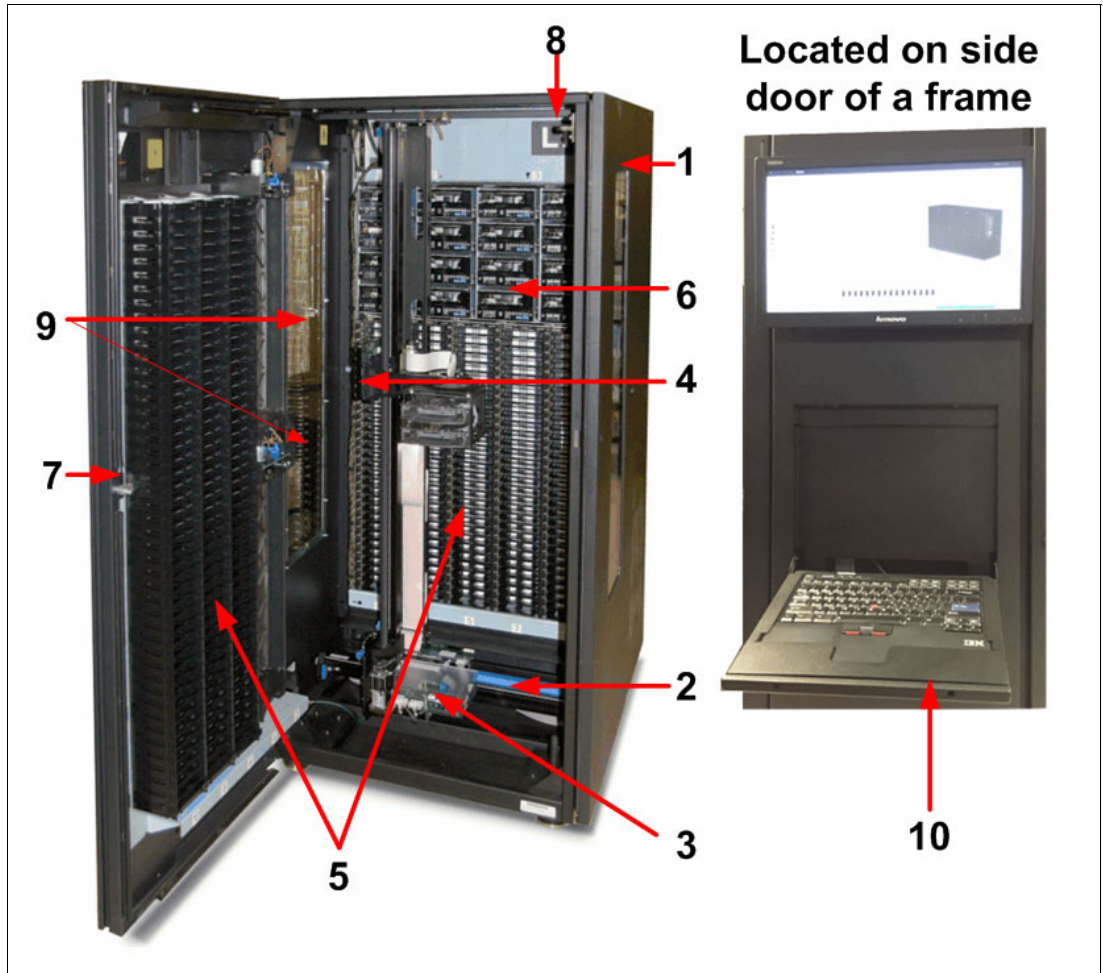
Figure 1-17   TS4500 components that are available from the front of the frame

See Table 1-8 for a description of the components.

Table 1-8   Inside the front of the TS4500

Number	Component
1	Library frames
2	Rail system
3	Cartridge accessor
4	Accessor controller
5	Cartridge storage slots
6	IBM LTO or 3592 tape drives
7	Front door
8	Door safety switch
9	I/O stations
10	Integrated management console

Accessor B will be located in the right side frame. Accessor B is functionally the same as accessor A, which is shown in Figure 1-18.
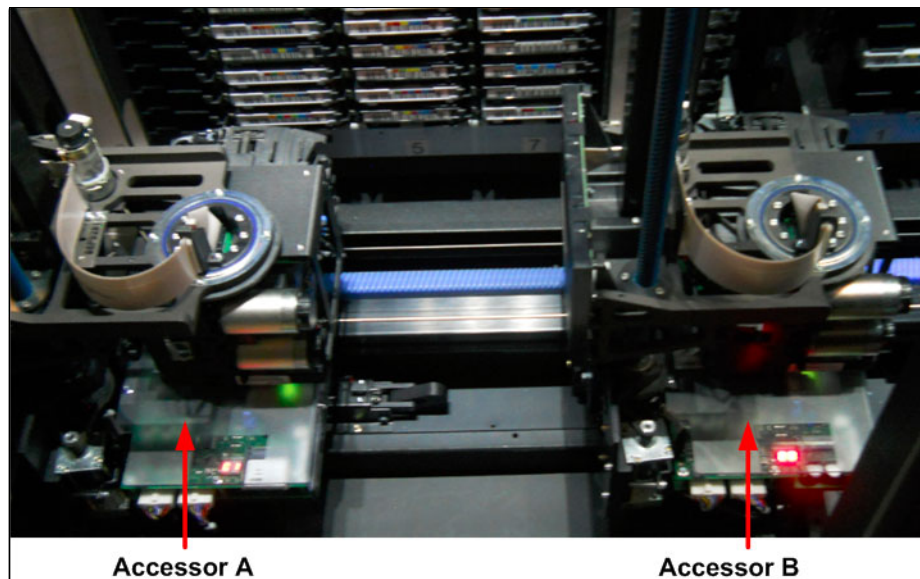
Figure 1-18   Dual accessor

To view the location of each component that is available in the top and rear of the frame, see Figure 1-19.
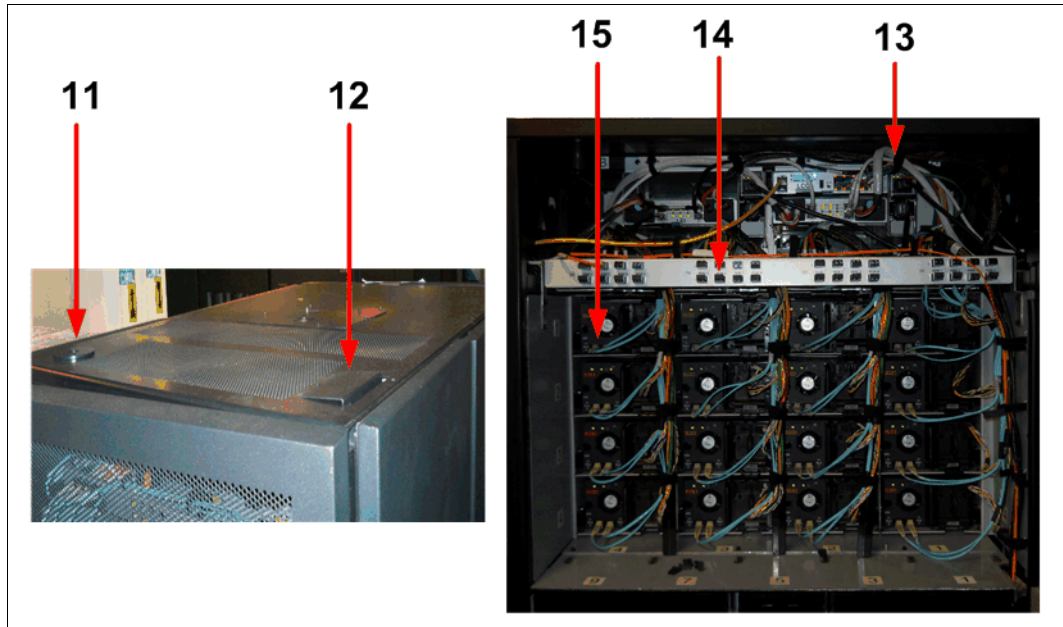
Figure 1-19   Top and rear of the TS4500

See Table 1-9 for a description of these components.

Table 1-9   Top and rear components of the TS4500

Number	Component
11	Power cable hole
12	Fibre Channel cable hole
13	Frame control assembly
14	Patch panel
15	Rear of IBM LTO or 3592 tape drives

To view the location of each component that is available on the front door, see Figure 1-20.
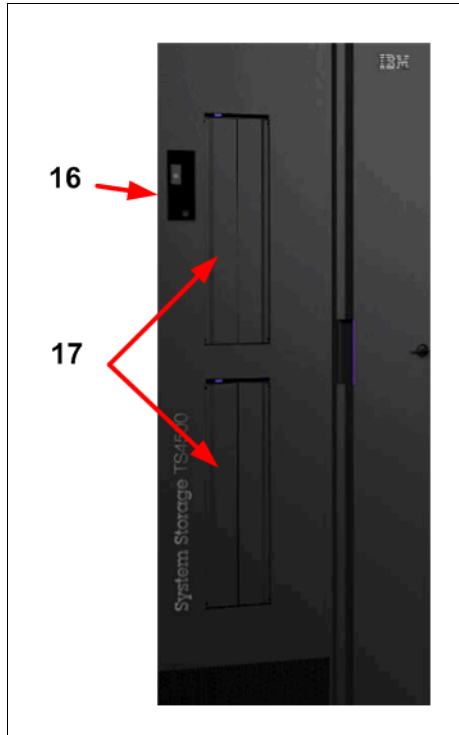
Figure 1-20   Front door

See Table 1-10 for a description of these components.

Table 1-10   Front door components of the TS4500

Number	Component
16	Display panel
17	I/O stations

Library frames

The base frame (Lx5 models) and the expansion frames (Dx5, Sx5, 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.

Rail system and track cable

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.

TS4500 has a newly designed flex track cable and guide. This new flex track cable and guide was designed to reduce cost and outage time when you add a frame, as shown in Figure 1-21.
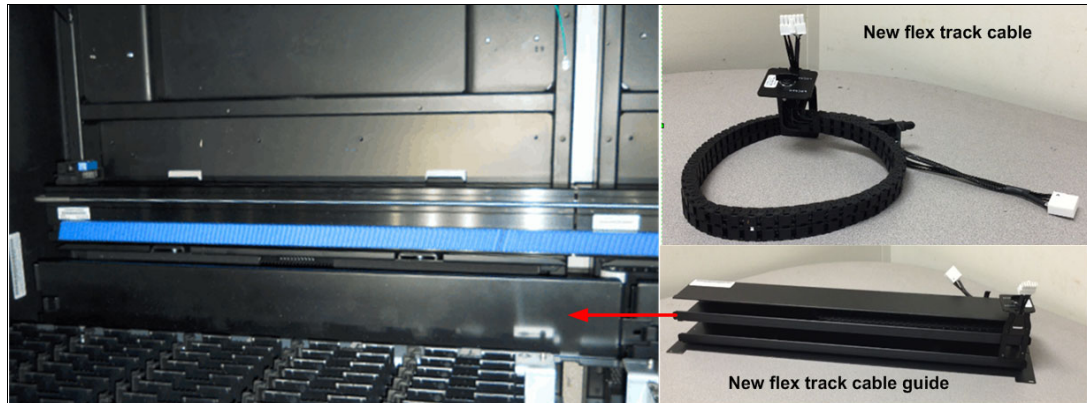
Figure 1-21   Rail system and track cable

The new style of cable requires no tools to install or replace. It is stacked in a new guide that is designed with two-chambers, which separate signal and power wires. Accessor A uses the top guide and accessor B uses the bottom guide, as shown in Figure 1-22.
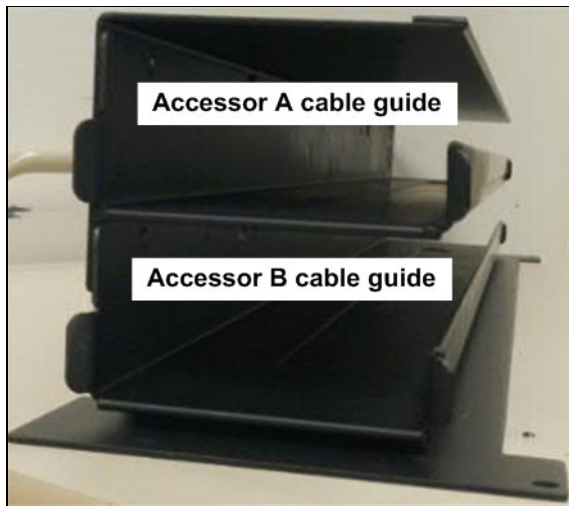
Figure 1-22   Track cable guide

These cables plug into the same frame. You are required to move them only if you add frames to the left.

> **Important:** When you add the new HA feature to an existing TS4500, in addition to ordering the correct length flex track cable, you are required to order FC 2071 or FC 2072 for each existing frame.

Cartridge accessor

The *cartridge accessor* moves cartridges between the storage slots, tape drives, and the I/O station of the TS4500 tape library. If the HA option is installed, two accessors exist, accessor A and accessor B. Functionally, accessor A and accessor B are identical. They have the same hardware components, except for a bottom bumper and the location of the X home sensor moving to the right side of accessor B.

The accessors consist of the following components.

X-axis and Y-axis motion assemblies

This group of parts 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*, as shown in Figure 1-23.
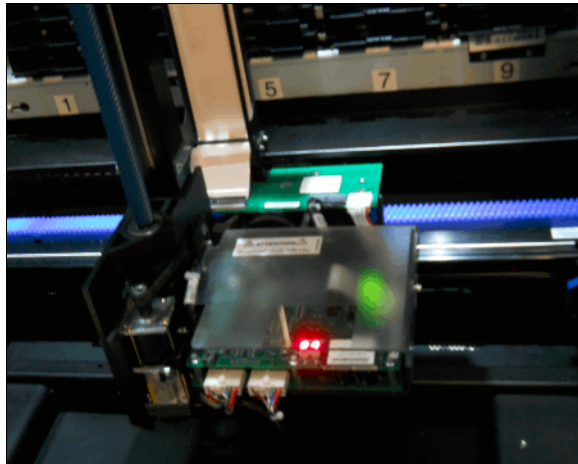
Figure 1-23   Motion assembly

Pivot assembly

This group of parts provides a mounting platform for the gripper mechanism and the bar code reader. This assembly can rotate 180° around the vertical axis, as shown in Figure 1-24.
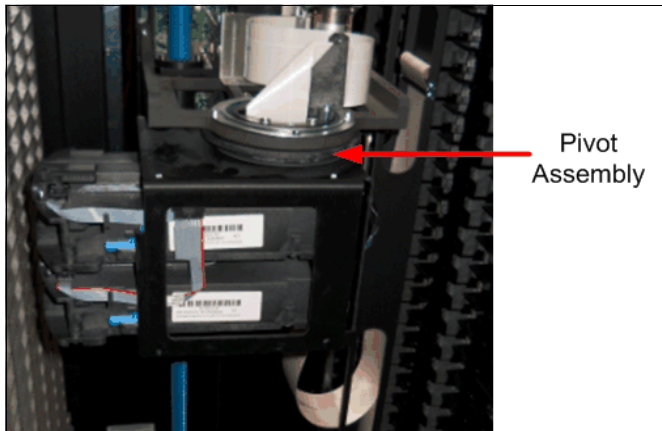
Figure 1-24   Pivot assembly

Optimized dual gripper

This electromechanical device (which is mounted on the pivot assembly) gets or puts cartridges from or to a storage slot, tape drive, or I/O station. The gripper is independently controlled, and it can grip a single cartridge. Two grippers are on the pivot assembly (Gripper 1 and Gripper 2). The grippers are in the dual-gripper transport mechanism, as shown in Figure 1-25.
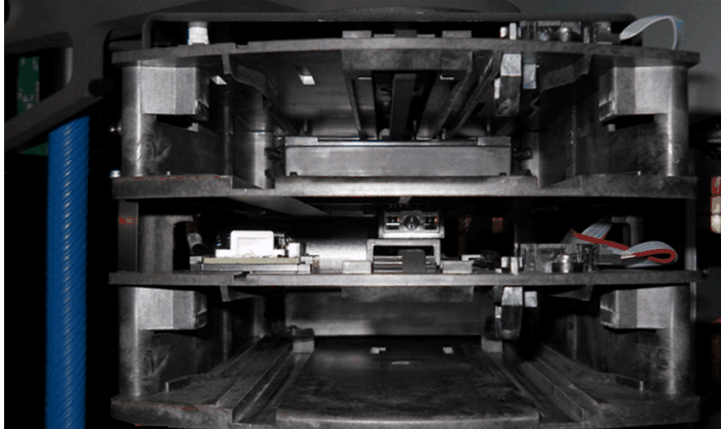
Figure 1-25   Dual gripper

Bar code reader and calibration assembly

This assembly has a dual purpose. It reads the bar code on a label that is affixed to a cartridge or to the rear of empty storage slots, and calibrates the frame after the installation or hardware change. The bar code reader/calibration sensor is mounted on the bottom of the top gripper, and it can be seen between the two grippers, when it is viewed from the front. It is used for frame calibration during inventories, audits, insertions, and inventory updates (a process that is invoked each time that you open a door).

An Auxiliary Lighting Element (ALE) assists the bar code reader. The ALE provides light to assist the bar code reader to scan labels correctly. The ALE connects to the top of the bottom gripper.

The inventory update determines whether cartridges are added to or removed from the library, or moved within the library. The bar code assembly, calibration assembly reader, and ALE are shown in Figure 1-26.
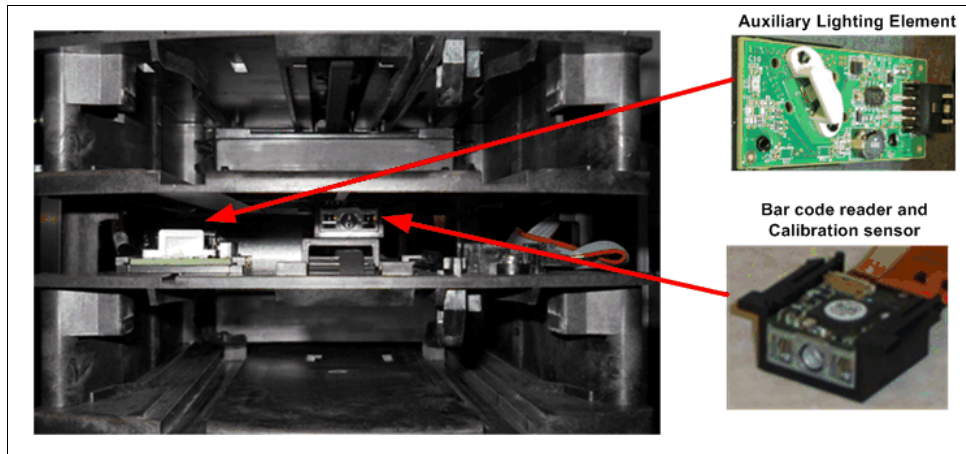
Figure 1-26   Bar code reader, calibration sensor, and ALE

A temperature/humidity sensor is installed on the standard flex cable (SFC) card in the scanner assembly. This sensor tracks temperature and humidity throughout the library, noting the accessor position and the time of the recorded temperature and humidity.

Accessor controller

This controller is a circuit board that facilitates all accessor motion requests, such as calibrations, moves, and inventory updates. This controller is on the side of the accessor assembly, as shown in Figure 1-27.

Figure 1-27   Accessor controller

Cartridge storage slots

All frames contain single-deep cells that are mounted on the door of the frame. Each cell stores one tape cartridge. High-density cells are mounted on the inside wall of each frame. These high-density cells each store four (3592) or five (LTO) tape cartridges. Individual frames do not support mixed media (a combination of 3592 and LTO tape cartridges). However, mixed media is supported within the TS4500 tape library.

Release 2 introduces new single-deep cells for both LTO and 3592 cartridges that are on the door side of HD2 frames. A chevron fiducial, which is similar to the chevron fiducial that is on the deep cells for individual cell calibration, is included in the new single-deep cells. Ribs are included to reduce cell wear, and they are a new feature of the single-deep cells, as shown in Figure 1-28.
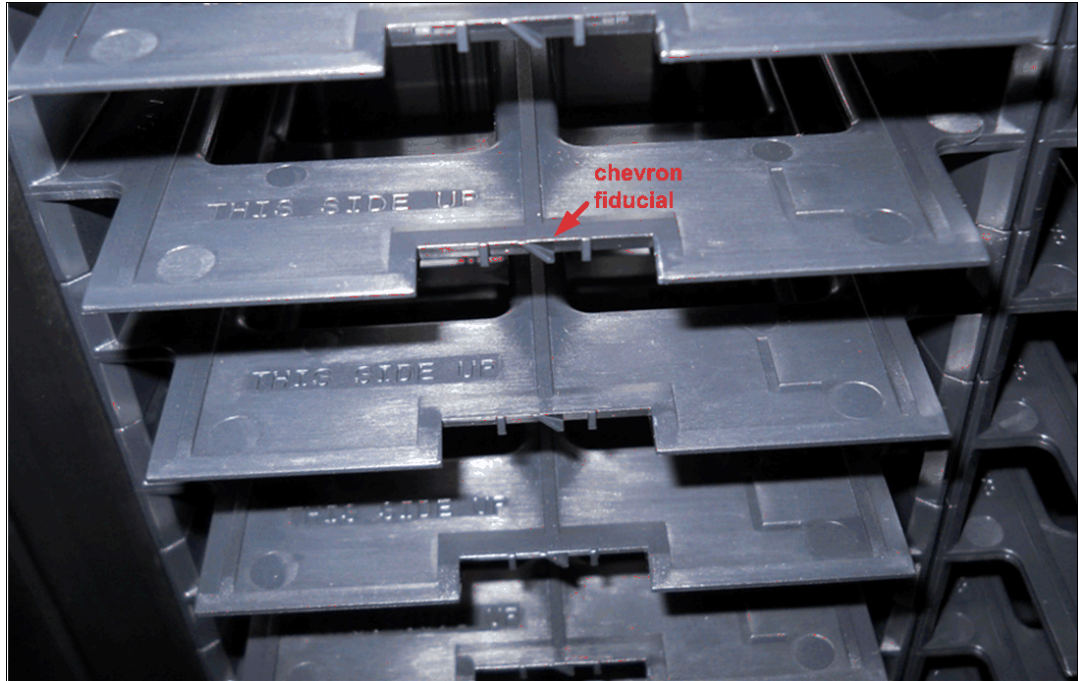
Figure 1-28   New door side single-deep cell slots

IBM LTO or 3592 tape drives

Drive frames can contain one or more units that are mounted in the frame. The TS4500 tape library supports LTO and 3592 tape drives. The HD2 frames of the TS4500 tape library support HD2-compatible models of the TS1155, TS1150, TS1140, LTO-8, 7, 6, and 5 tape drives.

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. Up to 16 drives can be installed in each Lx5 or Dx5 frame that is in frame position 2 or higher. LTO and 3592 tape drives cannot be mixed in the same frame, but the LTO and 3592 frames can be mixed in the same library. 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. These drives are described in more detail in Chapter 2, "TS4500 Ultrium Linear Tape-Open and 3592 tape drives" on page 63.

Note: No drives are installed in the storage-only frames (models S25, S24, S55, and S54).

Table 1-11 provides an overview of the supported tape drives.

Table 1-11   Tape drives that are supported by the TS4500 tape library

Type of drive	Speed of connection	Native data rate	Native capacity	Other information
IBM LTO Ultrium 8	8 Gbps Fibre	360 MBps	12 TB (10.91 TiB)	Known as the LTO-8 tape drive, Model 3588 F8C, TS1080
IBM LTO Ultrium 7	8 Gbps Fibre	300 MBps	6 TB (5.46 TiB)	Known as the LTO-7 tape drive, Model 3588 F7C, TS1070
IBM LTO Ultrium 6	8 Gbps Fibre	160 MBps	2.5 TB (2.27 TiB)	Known as the LTO-6 tape drive, Model 3588 F6C, TS1060
IBM LTO Ultrium 5	8 Gbps Fibre	140 MBps	1.5 TB (1.36 TiB)	Known as the LTO-5 tape drive, Model 3588 F5C, TS1050
IBM TS1155	8 Gbps Fibre for model 55F 10 Gbps Optical Ethernet for model 55E	360 MBps	900 GB (.82 TiB) with JK cartridge 3 TB (2.73 TiB) with JL cartridge 7 TB (6.37 TiB) with JC/JY cartridge 15 TB (13.64 TiB) with JD/JZ cartridge	Known as the 3592 55E or 3592 55F tape drive
IBM TS1150	8 Gbps Fibre	360 MBps	900 GB (.82 TiB) with JK cartridge 2 TB (1.82 TiB) with JL cartridge 7 TB (6.37 TiB) with JC/JY cartridge 10 TB (9.1 TiB) with JD/JZ cartridge	Known as the 3592 EH8 tape drive
IBM TS1140	8 Gbps Fibre	250 MBps	500 GB (.48 TiB) with JK cartridge 1.6 TB (1.46 TiB) with JB/JX cartridge 4 TB (3.6 TiB) with JC/JY cartridge	Known as the 3592 EH7 tape drive

Figure 1-29 shows the TS4500 drive bay.

Figure 1-29   TS4500 drive bay

Front door

The front door contains single cartridge storage slots on the inside of the door that are referred to as *tier 0 slots*. Two I/O stations are installed on the front door of the base frame. Optionally, two extra I/O stations can 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. The front door is shown in Figure 1-20 on page 29.

> **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.

Door safety switch

This switch ensures that power to the cartridge accessor is switched off whenever the front door or side door is opened. This safety component ensures that accessor movement is stopped while the front door is open. Figure 1-30 shows the front door safety switch.
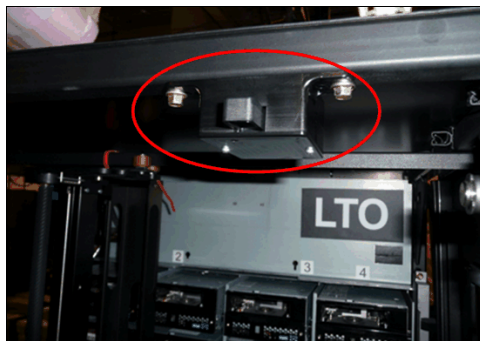
Figure 1-30   Front door safety switch

Side door and accessor service access

To service a single accessor concurrently, the accessor that requires service needs to be placed into service mode from the management GUI. After the accessor parks, and the side door is open, the service bay switch (SBS) will activate. This sequence will put the SBS into the up position. Figure 1-31 shows the SBS mechanism.
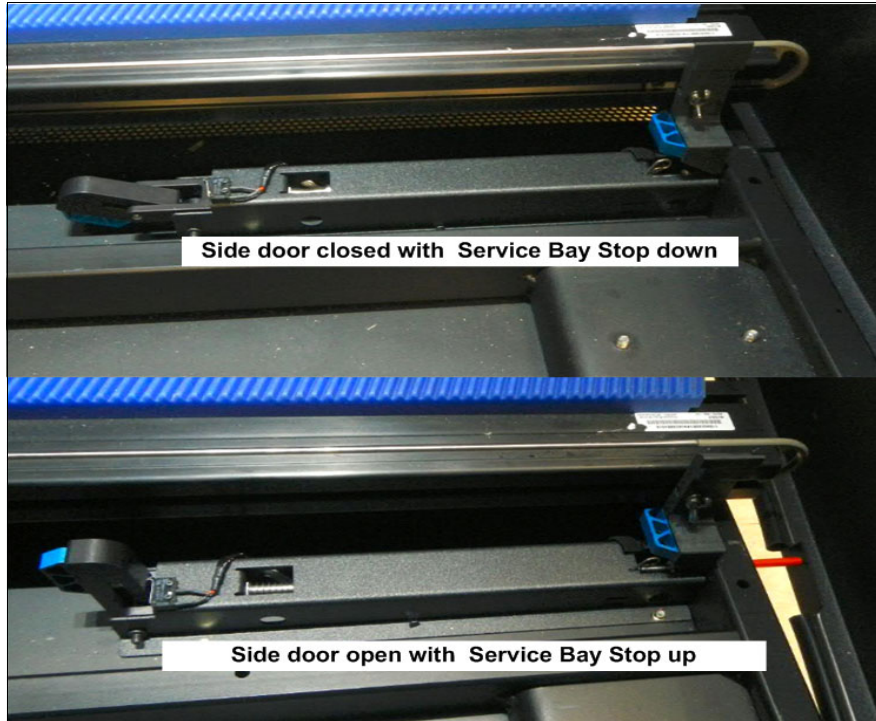
Figure 1-31   Service bay switch mechanism

Figure 1-32 shows an accessor in service with side door open and end stop up. The second accessor is working and it is prevented from moving into the service area by the end stop.

Accessor in service with side door open and Service Bay Stop in place
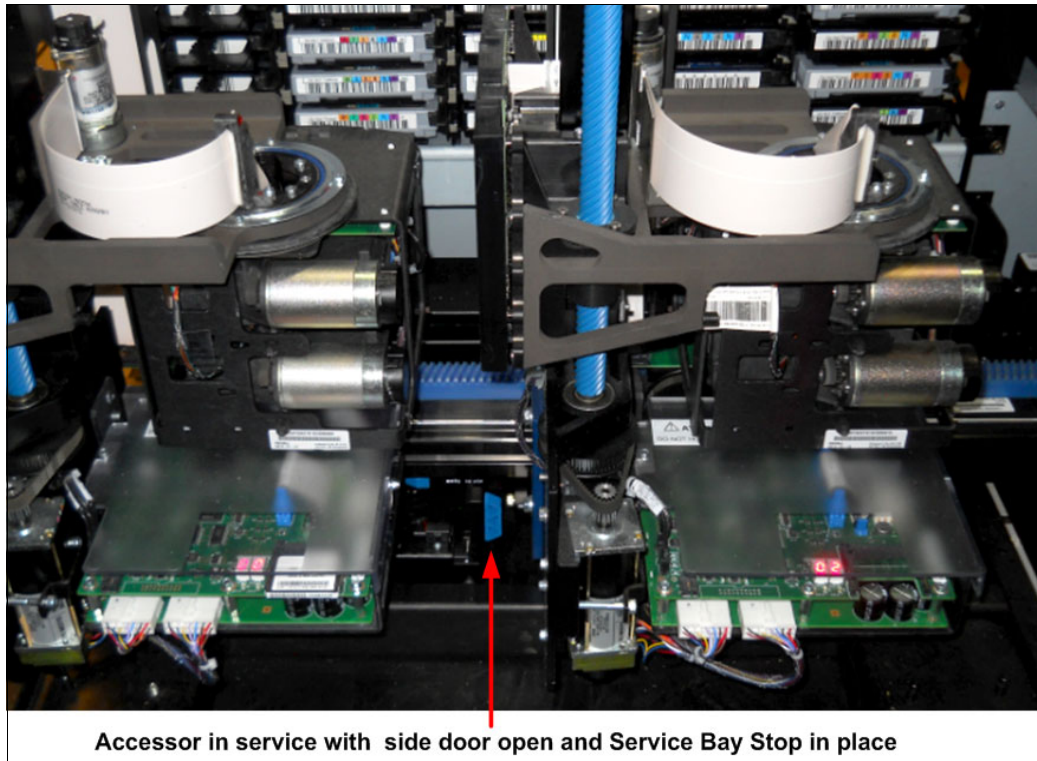
Figure 1-32   Accessor in service

To service the accessor, it must be removed from the TS4500 by using the side door. This action is a concurrent action with the second accessor that is used for move commands. This process is simple because the end stops and track cable can be removed without any tools.

I/O stations

Two I/O stations on the front door of the base frame enable the insertion or removal of tape cartridges without requiring the library to reinventory the frame. Optionally, two additional I/O stations can be installed on any Dx5 expansion frame. The I/O station is universal, and either LTO or 3592 magazines can be installed in it.

Insertion or removal of cartridges can be performed by using the I/O stations while the TS4500 tape library performs other operations, without requiring an inventory.

The TS4500 tape library base frames (models L25 and L55) come with two I/O stations. Each I/O station houses a cartridge magazine so that individual cartridges can be handled independently of the tape library:

► A cartridge magazine for LTO frames can hold up to 18 cartridges.
► A cartridge magazine for 3592 frames can hold up to 16 cartridges.

On libraries with LTO and 3592 frames, the first Dx5 frame (different from the Lx5) can have I/O stations that ship with magazines for the different drive type. The LTO and 3592 magazines can be installed on any I/O station.

Magazines for different media types can also be ordered by using FC 1628 for LTO and FC 1629 for 3592.

The handles on the cartridge magazine are used to insert and remove the magazine, or to carry it during transport. The magazine safety lock, as shown in Figure 1-33, retains cartridges in their slots and prevents them from falling out while the magazine is transported.

Figure 1-33   Tape cartridge magazine safety lock

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. The I/O doors will not close correctly if the magazine is not unlocked.

Figure 1-34 shows a full 3592, a full LTO magazine, and an empty 3592 magazine.

Figure 1-34   I/O magazines

Two additional I/O stations can be installed in any Dx5 expansion frame by ordering FC 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 maximum 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, which is 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 (which is numbered 1 in Figure 1-35 on page 41) 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 that is next to the eject button (numbered 2 in Figure 1-35 on page 41) indicates that the I/O station is locked because the accessor can insert or remove cartridges. Do not attempt to open the I/O station when the lock status indicator is illuminated.

Figure 1-35 shows the top I/O station and panels, which control and show the state of the I/O station.
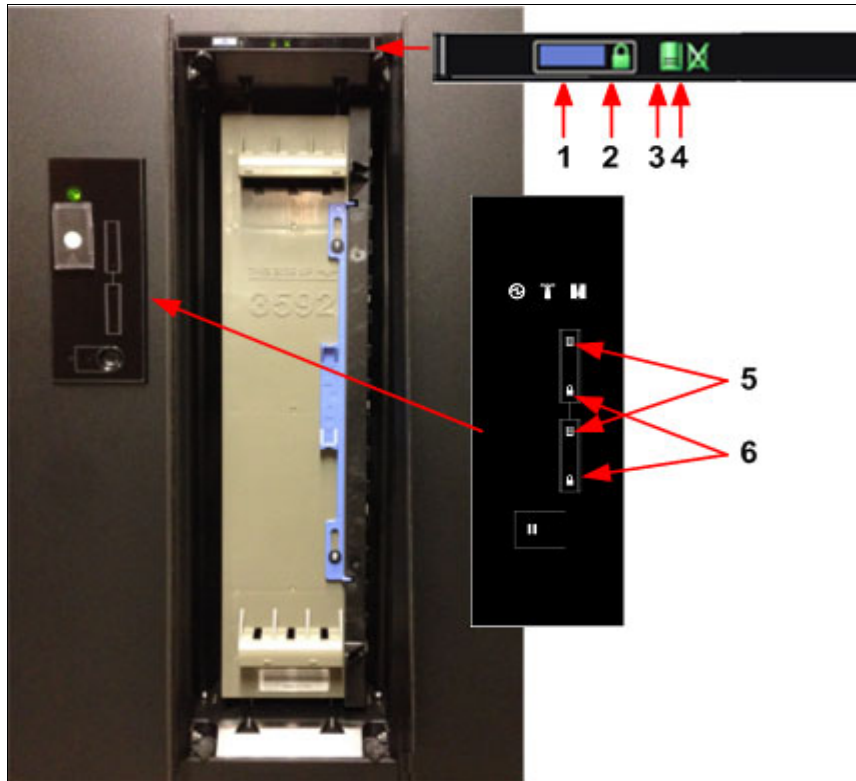
Figure 1-35   I/O station LEDs and controls

Table 1-12 describes all of the I/O station controls and LEDs.

Important: Use only the eject button (which is numbered 1 in Figure 1-35 on page 41) or the management GUI to open and close the I/O station doors. Do not attempt to open or close the doors manually.

Table 1-12   I/O station (numbers correspond to Figure 1-35 on page 41)

Number	Function
1	Eject button.
2	Open/close state. Off: Normal state. Blinking: Transitional state. Whenever the button is pushed, it blinks and goes off when the doors open, and it blinks and comes back on as a solid light if it is locked by a "code". On solid: Locked.
3	Unload is required, or cartridges are present. Off: No cartridges are present. Blinking: The I/O station is full so an intervention is required. On: Several cartridges are present.
4	No magazine is present. On solid: No magazine is present.
5	I/O capacity indicator.
6	I/O lock status indicator.

If the I/O station is obstructed, the doors automatically reopen.

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.

TS4500 integrated management console (IMC)

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 panel and a keyboard with a touchpad, can be mounted on either end of your TS4500 tape library. A library controller card (LCC) and a power source are required within that end frame or within the adjacent frame. Alternatively, with Feature Code 2737, 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 are 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.

Figure 1-36 shows the IMC.

The IMC is described in more detail in Chapter 4, "TS4500 management graphical user interface (GUI)" on page 159.

Figure 1-36   The integrated management console (IMC)

IMC power distribution unit (PDU)

The TS4500 IMC power distribution unit (IMC PDU) provides power to the card cage power supply and to the TS4500 integrated management console (IMC).

The IMC PDU, as shown in Figure 1-37, is typically installed in the end frame of the library with the IMC.

Figure 1-37   IMC PDU

A new Model Sx5 feature (FC 2737) provides a separate IMC power source, which enables the IMC to be installed on an Sx5 frame where the power cable is not long enough to reach a Dx5 or Lx5 frame. The feature includes instructions for moving the IMC PDU from the Lx5 frame to the Sx5 frame with the IMC, and for attaching a separately ordered power cord to a client outlet at that Sx5 frame. The feature also includes two extremely long Ethernet cables to connect the IMC to the Lx5 frame LCC at any frame position.

Power cable hole

It is possible to route power cables through the top of a frame in the TS4500 tape library. This routing method is an alternative to routing the power cables through the bulkhead at the bottom rear of the TS4500 tape library. This routing method might be necessary if the equipment is installed on a non-raised (solid) floor or if a top rack is installed.

Fibre Channel cable hole

It is possible to route Fibre Channel cables from servers through the top of a frame in the TS4500 tape library. This routing method is an alternative to routing the Fibre Channel cables through the bulkhead at the bottom rear of the TS4500 tape library. This routing method might be necessary if the equipment is installed on a non-raised (solid) floor.

TS4500 frame control assembly (FCA)

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), up to two library frame interconnect (LFI) cards, and two power supplies, both of which can provide power to the library and all drives in a frame. All of these components are connected by using two back plane cards (BPCs).

Figure 1-38 shows the frame control assembly in the TS4500.
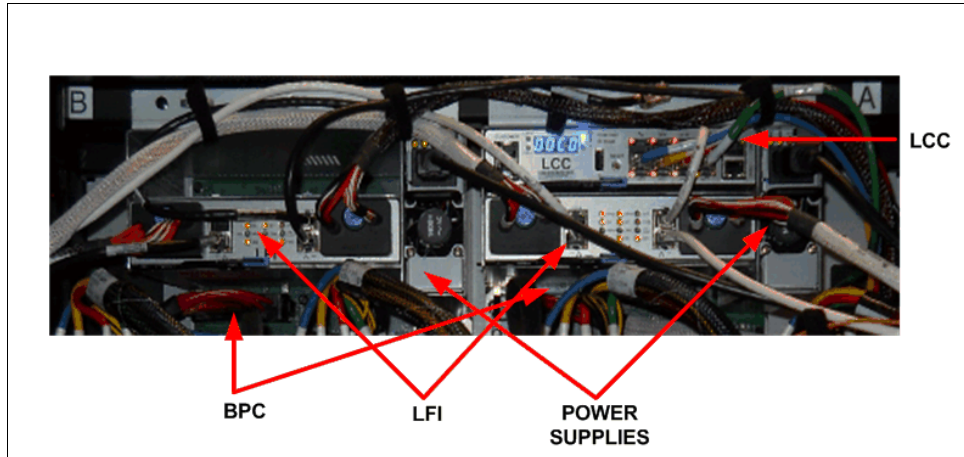
Figure 1-38   Frame control assembly

The library control card (LCC)

The *library control card* (LCC) is the management node card for the TS4500 tape library. This card is used for the Ethernet connection to all components in the library, including the user interface and IMC. See Figure 1-39.
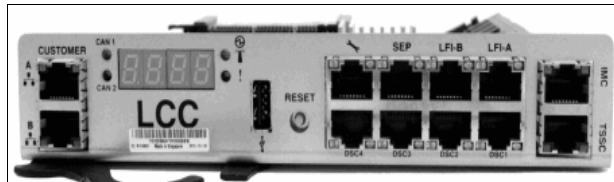
Figure 1-39   Library control card

The LCC has redundancy capability. In multiple drive frame configurations, the library negotiates the primary LCC, which controls the management functions.

During the power-up process, a selection process occurs to select the primary LCC. The selection process considers the LCC with the best database capabilities and the best hardware capabilities. The hardware capabilities relate to I/O station control and frame types.

Each LCC knows how many LCCs are in the system. If only one LCC is in the system, this LCC becomes the primary LCC. If any primary LCC fails, any LCC card can resume operations as the primary LCC.

The library frame interconnect (LFI) cards

The *library frame interconnect* (LFI) cards provide communication between the frames of the TS4500 tape library through cable connections. Each Lxx frame comes with one LFI card. A second LFI is required if expansion frames are added. When you face the back of the frame, the LFI on the right is LFI-A and the LFI on the left is LFI-B. Both cards are identical, but connections differ, depending on whether the card is LFI-A or LFI-B.

Figure 1-40 shows the LFI card.

Figure 1-40   Library frame interconnect (LFI)

> **Note:** Do not use tools to tighten the screws on the LFI card connectors, or this can result in cables not being correctly plugged or damage to the connectors.

Power supplies

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 of the Lx5 and Dx5 frames comes with two power supplies. Model Sx5 frames do not have their own power supply. They share power with either an Lx5 or Dx5 frame, as shown in Figure 1-41.
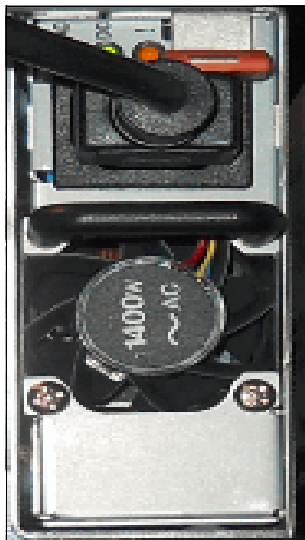
Figure 1-41   Power supply

Back plane cards (BPCs)

Each of the Lx5 and Dx5 frames comes with two *back plane cards* (BPCs). With a single frame configuration (or a configuration with no FCA control system), redundant power is provided for each BPC. If one BPC fails, the other BPC in the frame picks up the load for the failed BPC.

Patch panel

The patch panel that houses the cable connections to connect hosts to the tape drive is in the rear of the frame above the drives, as shown in Figure 1-42.
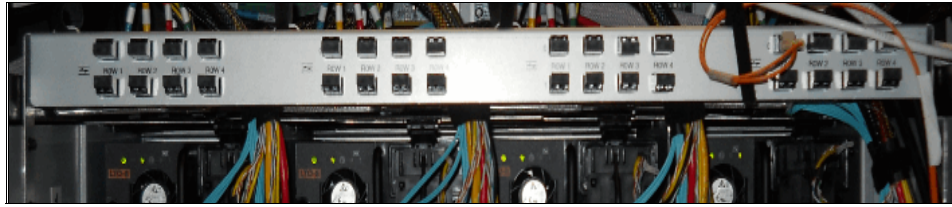
Figure 1-42   Fiber patch panel

Display panel

The display panel on the base frame of the TS4500 tape library houses the library power and pause buttons. It displays library and I/O status indicators, as shown in Figure 1-43.
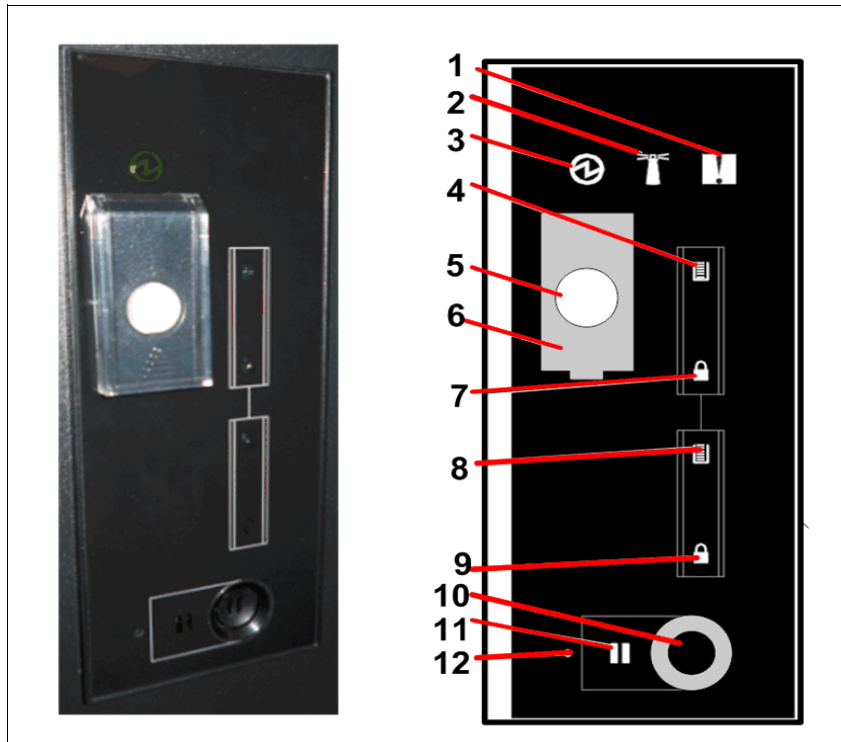
Figure 1-43   Display panel

Table 1-13 describes the indicators and buttons that are available on the display panel.

Table 1-13   Display panel component descriptions

Number	Component
1	Warning indicator (yellow)
2	Library beacon (blue)
3	Power indicator (green)
4	Upper I/O fullness indicator (green)
5	Power switch

Number	Component
6	Power switch cover
7	Upper I/O lock indicator (green)
8	Lower I/O fullness indicator (green)
9	Lower I/O lock indicator (green)
10	Pause button
11	Library pause indicator (yellow)
12	Access recovery button

Expansion frames with optional installed I/O stations also have a display panel. However, the panel on expansion frames does not include the library power button, as shown in Figure 1-44.

Figure 1-44   Expansion frame with I/O station

Pause button

You pause the library by pressing the pause button on the display panel (number 10 on Figure 1-43 on page 47) on the base frame of your TS4500 tape library. This pause button causes the library to move the cartridge accessor to the base frame and pause operations for 30 seconds or while a frame door is open. The pause light next to the pause button stops blinking, and it illuminates solid to indicate that the library is paused (number 11 on Figure 1-43 on page 47).

Power button

The power button procedures are described.

Power on

This procedure powers on the TS4500 tape library to begin the library initialization sequence and bring the library to a ready state:

► From the display panel on the base frame of the library, slide the plastic cover that protects the power button up to expose the button (number 6 on Figure 1-43 on page 47).

► Press the power button (number 5 on Figure 1-43 on page 47) and wait to see that the green power indicator turns on and stays on.

► The power button executes a power-on initialization sequence for about 2 minutes. During that time, the menus on the TS4500 management GUI are not available for use. After the power-on initialization sequence completes, the library performs an inventory of the tape cartridges.

Power off

This procedure powers off the TS4500 tape library after normal operation, but *not* during an emergency:

► Ensure that the host application removed cartridges from all drives and that the library is varied offline from the host (if the host is attached).

► Pause the library by pressing the pause button on the display panel (number 10 on Figure 1-43 on page 47) on the base frame of your TS4500 tape library. This pause button causes the library to move the cartridge accessor to the base frame and pause operations for 30 seconds or while a frame door is open. The pause light next to the pause button stops blinking, and it illuminates solid to indicate that the library is paused (number 11 on Figure 1-43 on page 47).

► The health status pod on the System page of the management GUI also shows when the library is paused.

► From the display panel on the base frame of the library, slide the plastic cover that protects the power button up to expose the button (number 6 on Figure 1-43 on page 47).

► Press the power button (number 5 on Figure 1-43 on page 47) and wait until the green power indicator light turns off.

Note: Always pause the library before you power it off. If you power off the library before you pause the library, the library might take longer to come online after the next power-on.

Access Recovery

This button can be used to unlock the administrator password and can only be done from the front panel.

When you press the Access Recovery button, you have 15 minutes to log into the library and reset the administrator password with a temporary password. You must enter a new administrator password when you log out and back in again.

Press the Access Recovery button, See Figure 1-43 on page 47.

► Log into the GUI by using **admin** for the user name and password
► Go to **Access** → **Roles** and then highlight the admin role
► Go to **Actions** → **Reset Password**

Media verification

The TS4500 supports media verification, which is fully controlled by the TS4500 at a logical library level. Media verification is transparent to any software application that controls the library.

This feature can be used to verify any media for the ability to read all of the data on the selected media within a logical library. Media verification is set up to run automatically on a set date.

You can set a recurring schedule for verification by days, months, or years. After you set up media verification, you can verify a single medium before the set date, if required. For more information, see "Media verification" on page 229.

Web camera

After the mounting hardware feature is installed by an IBM service support representative (SSR), you can mount a web camera in any frame of a TS4500 tape library. Certain clearances are necessary to accommodate the mounting hardware and the camera.

The camera is client-supplied and it can be installed in any frame to visually monitor the location of the library's robotics. Feature Code (FC) 1530, Web Camera Mounting Hardware, is required to install a web camera. The maximum camera dimensions can vary. However, no part of the camera can extend more than 60 mm (2.36 in.) from the center of the tripod mount to ensure sufficient clearance so that the accessor movement is not obstructed.

The camera mount (FC 1530) can be mounted on the front or rear frame support.

Fire suppression

Each Dx5, Lx5, Sx5, and Sx4 frame in the TS4500 tape library has an area on the top where an opening can be cut to allow the entrance of pipes, conduits, or other parts to use for fire suppression. The installation of a fire-suppression system is the responsibility of the client.

The TS4500 tape library is constructed to allow the third-party installation of fire-suppression equipment. When you are deciding whether to implement fire-suppression equipment, see the local and national standards and regulations.

> **Important:** 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 suggestions about fire-suppression systems.

1.4 Feature codes for the TS4500

You can order feature codes (FCs) to install components in library frames or to enhance the capacity or capabilities of the library.

A client-setup unit (CSU) is a feature that you, as the client, 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 when you order and receive these features. Table 1-14 shows the available feature codes.

Table 1-14   Feature codes for the frame models of the TS4500 tape library

Feature code	Model	CSU	Description
1404	L25, L55	No	TS1140 and TS1150 tape drive support. This FC triggers the shipment of a JK diagnostic cartridge. When Model L25 is ordered, FC 1404 is required. When FC 9080 (Mixed Media) is ordered for the Model L55, FC 1404 is required.
1405	L25, L55	Both	LTO-6 and 5 tape drive support. This FC triggers the shipment of an L5 diagnostic cartridge. When Model L55 is ordered, a minimum of one of FC 1408, 1405 or 1407 is required but more than one can be selected. When FC 9080 (Mixed Media) is ordered for Model L25, a minimum of one of FC 1408, 1405 or 1407 is required but more than one can be selected.
1406	L25, L55	No	TS1150 and TS1155 tape drive support. This triggers the shipment of a JL CE 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	LTO-7 and 6 tape drive support. This FC triggers the shipment of an L6 CE cartridge. When Model L55 is ordered, a minimum of one of FC 1408, 1405 or 1407 is required but more than one can be selected. When FC 9080 (Mixed Media) is ordered for Model L25, a minimum of one of FC 1408, 1405 or 1407 is required but more than one can be selected.
1408	L25, L55	No	LTO-8 and 7 tape drive support. This FC triggers the shipment of an L7 CE cartridge. When Model L55 is ordered, a minimum of one of FC 1408, 1405 or 1407 is required but more than one can be selected. When FC 9080 (Mixed Media) is ordered for Model L25, a minimum of one of FC 1408, 1405 or 1407 is required but more than one can be selected.
1442	D25, D55, L25, L55	No	Dual accessors. This FC triggers the shipment of four CE/diagnostic cartridges (two cartridges of the latest generation for both LTO and 3592). Service Bay Stop-A related parts and Service Bay Stop-B related parts. TS4500 Accessor B, including scanner, enhanced grippers, and enhanced node cards. A maximum of one HA kit (1442) per library can be ordered.
1450	D25, D55	No	TS4500 frame control assembly (FCA).
1460	L25, L55	No	Redundant Accessor Power/Network, which provides power and internal network redundancy for the L25/L55 frame. This is a prerequisite to FC 9002.
1521	D25, D55, L25, L55	No	First TS4500 quad drive mounting kit. Prerequisite: FC 1450 (for Dx5 frame models only).
1522	D25, D55, L25, L55	No	Second TS4500 quad drive mounting kit. Prerequisite: FC 1521. This feature is not supported if the frame is used as an integrated service bay (ISB).

Feature code	Model	CSU	Description
1523	D25, D55, L25, L55	No	Third TS4500 quad drive mounting kit. Prerequisite: FC 1522. This feature is not supported if the frame is used as an integrated service bay (ISB).
1524	D25, D55, L25, L55	No	Fourth TS4500 quad drive mounting kit. Prerequisite: FC 1523. This feature is not supported if the frame is used as an integrated service bay (ISB).
1530	D25, D55, L25, L55, S25, S55	No	Web camera mounting hardware. Provides mounting hardware only.
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 (CoD) provides a license key to increase storage from entry capacity to intermediate capacity.
1644	L25, L55	Yes	Base capacity on demand provides a 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. One 3592 tape drive install feature or one 3588 tape drive install feature should be removed from the library frame when a tape drive is removed.
1682	L25, L55	Yes	Path failover.
1742	S24, S54	No	TS4500 Control upgrade. This FC 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 that is ordered (if multiple top racks are installed on adjacent frames).

Feature code	Model	CSU	Description
1751	TR1	No	Power distribution unit FC 1751 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. A maximum of two FC 1750s can be ordered. Prerequisite: For each FC 1751 ordered, one power cord (FC 9954 through FC 9959 or FC 9966) must also be ordered.
1802	L25, L55	No	Non-HA 1 - 2 frame X-track cable.
1806	L25, L55	No	Non-HA 3 - 6 frame X-track cable.
1814	L25, L55	No	Non-HA 7 - 14 frame X-track cable. Not supported by FC 2071 or FC 9071.
1818	L25, L55	No	Non-HA 9 - 18 frame X-track cable. Not supported by FC 2071 or FC 9071.
1909	L25, L55, D25, D55	No	Single power source bifurcated cable. This feature allows attachment of a powered frame to a single outlet while it also maintains drive redundant power.
1951	D25, D55, L25, L55, S25, S55	No	Power distribution units. This feature provides two PDUs, mounting hardware, including rack brackets, and internal power cables. FC 1951 supports any combination of up to three pairs of power cords for FC 4875 on the same frame and FC 9989 on adjacent frames. Corequisite: One power cord feature (FC 9954 through FC 9959 or FC 9966).
2002	L25, L55	No	1 - 2 Frame Flex Track Cable A.
2006	L25, L55	No	3 - 6 Frame Flex Track Cable A.
2014	L25, L55	No	7 - 14 Frame Flex Track Cable A.
2018	L25, L55	No	9 - 18 Frame Flex Track Cable A.
2071	L25, L55	No	Flex track guide. This FC includes AXY, AXY plate, ASC to Flex track cable and new end stops.
2072	D25, D55, S25, S55, S24, S54	No	Flex track guide for expansion frame.
2309	D25, D55, L25, L55	No	TS4500 Accessor Refresh. This FC provides complete accessor assembly with HD grippers to Lxx models or models with FC 1442. Prerequisite: FC 2071, FC 2072, or FC 9071, FC 9072.
2402	L25, L55	No	1 - 2 Frame Flex Track Cable B.
2406	L25, L55	No	3 - 6 Frame Flex Track Cable B.
2414	L25, L55	No	7 - 14 Frame Flex Track Cable B.
2418	L25, L55	No	9 - 18 Frame Flex Track Cable B.
2704	D25, D55, S25, S55, S24, S54	No	Console expansion. 26-port Ethernet switch, rack mount. This feature provides a 26-Port Ethernet switch and an attachment cable for connection to a TS3000 System Console or Master Console for Service. Up to 24 additional connections are provided by this feature. Mutually exclusive with FC 1951 and FC 4879.

Feature code	Model	CSU	Description
2715	L25, L55	No	TSSC Console attachment. This FC is a cable to attach a unit to the Ethernet switch provided by the TSSC. A maximum of 43 of the FC 2715 can be included in a single TSSC facility. FC 2704 is supported on Lx5 models if you are connecting the frame to an existing TSSC.
2735	L25, L55	No	USB Optical Drive. This feature provides a USB optical drive for use with the integrated management console (IMC). The optical drive is required for IMC code and service Knowledge Center updates.
2737	S25, S55	No	IMC Separate Power Source. This feature will allow longer distances between the IMC end panel and an FCA by supplying 2x longer Ethernet cables. For both plant and field, instructions will also be provided for moving the IMC PDU from another frame into this frame. One of the FC 9970-9985, 9989 power cords is a prerequisite to FC 2737.
4879	L25, D25	Yes	TS7700 BE Switch Mounting Hardware. This feature provides 2x Fibre Channel switch mounting hardware, including rack brackets and power cords. The prerequisite is FC 4880. PDUs are not required with TS7700 back-end switches in a TS4500.
4880	L25, D25	Yes	TS7700 BE 16 Gb Switch. This feature provides one 16 Gb Fibre Channel switch with 24 LC Shortwave ports. The 16 Gb switch supports attachment of up to sixteen 3592 tape drives to a TS7700 (2 switches are required by the TS7700 for redundancy). Patch-panel-to-switch Fibre Channel cables are ordered against the frame that contains the tape drives by using feature codes AGK1 (if tape drives are 2 or 3 frames away from the switch) or AGKQ (if tape drives are fewer than 2 frames away from the switch).
6013	D25, D55, L25, L55	Yes	LC to LC Fibre Channel cable - 13 m (43 ft.).
6025	D25, D55, L25, L55	Yes	LC to LC Fibre Channel cable - 25 m (82 ft.).
6061	D25, D55, L25, L55	Yes	LC to LC Fibre Channel cable - 61 m (200 ft.).
8750	D55, L55	No	LTO cleaning cartridge (FC 8750). This FC is a 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. This feature is used as a part of the process to add any Dxx or Sxx frame. Prerequisites: FC 1460 and FC 1644.
9003	L25, L55	No	Additional expansion frame attachment. This feature is used as a part of the process to add any Dxx or Sxx frame. Prerequisites: The first expansion frame attachment (FC 9002) is required.
9040	L25, L55	No	High availability library. The prerequisite is FC 9071 or FC 2071, flex track A cable FC 2002 or FC 2006 or FC 2014 or 2019, and flex track B cable FC 2402 or FC 2406 or FC 2414 or FC 2418.
9071	L25, L55	No	Flex Track Guide Base. This feature includes AXY, AXY plate, ASC to Flex track cable and new end stops. The prerequisite is FC 2002 or FC 2006 or FC 2014 or FC 2018.
9072	D25, D55, S25, S55, S54, D54	No	Flex Track Guide for expansion frame.

Feature code	Model	CSU	Description

9080	L25, L55	No	Mixed Media Library. Library contains a mix of LTO and 3592 frames. Prerequisite:
			    For Model L25, prerequisite of FC 1628 (LTO Magazine) and a minimum of one of FC 1405 or FC 1407 (LTO CE cartridge).
			    For Model L55, prerequisite of FC 1629 (3592 Magazine) and FC 1404 (3592 CE cartridge).
			Mixed media is 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 Microsoft Windows system.
9213	L25, L55	No	Attached to another system that is not an IBM system.
9215	L25, L55	No	Attached to Linux system.
9217	L25, L55	No	Attached to z/OS, TS7700.
9218	L25, L55	No	Attached to High Performance Storage System (HPSS).
9400	L25, L55	No	Attached to IBM i5/OS or IBM OS/400® system.
9600	L25, L55	No	Attached to IBM AIX® system.
9607	D25, D55, L25, L55	No	3588 F7C plant install.
9608	D25, D55, L25, L55	No	3588 F7C field install.
9609	D25, D55, L25, L55	No	3588 F8C plant install.
9610	D25, D55, L25, L55	No	3588 F8C field install.
9690	D25, D55, L25, L55	No	3588/3592 drive. Field install. FC 9690 is a counting feature code. Prerequisite: FC 152x (drive mounting kit). Each FC 152x supports up to four of FC 969x.
9692	L25, L55	No	3592 E07/EH7 tape drive. Plant install. FC 9692 is a manufacturing routing code. Prerequisite: FC 152x (drive mounting kit).
9695	L55, D55	No	3588 F5A/F5C tape drive. Plant install. FC 9695 is a manufacturing routing code. Prerequisite: FC 152x (drive mounting kit).
9697	L55, D55	No	3588 F6A/F6C tape drive. Plant install. FC 9697 is a manufacturing routing code. Prerequisite: FC 152x (drive mounting kit).
9699	L25, D25	No	3592 EH8 tape drive - plant install FC 9699 is a manufacturing routing code. Prerequisite: FC 152x (drive mounting kit).
9700	D25, D55, L25, L55	No	No host attach cables - from plant.
9704	L55, D25	No	3592 55E tape drive. Plant install. FC 9704 is a manufacturing routing code. Prerequisite: FC 152x (drive mounting kit).
9705	L55, D25	No	3592 55F tape drive. Plant install. FC 9705 is a manufacturing routing code. Prerequisite: FC 152x (drive mounting kit).
9735	L25, L55	No	IMC broadband Call Home. This feature indicates that you allow broadband Call Home, so no additional remote service tools are required.

Feature code	Model	CSU	Description
9954	D25, D55, L25, L55, S25, S55	No	NEMA L6-30 Power Cord. FC 9954 is used with PDU FCs 1751 or 1951. FC 9954 provides 1x power cord for FC 1751 and 2x power cords for FC 195x.
9955	D25, D55, L25, L55, S25, S55	No	RS 3750DP power cord. FC 9955 is used with PDU FCs 1751 or 1951. FC 9955 provides 1x power cord for FC 1751 and 2x power cords for FC 195x.
9956	D25, D55, L25, L55, S25, S55	No	IEC 309 power cord. FC 9956 is used with PDU FCs 1751 or 1951. FC 9956 provides 1x power cord for FC 1751 and 2x power cords for FC 195x.
9957	D25, D55, L25, L55, S25, S55	No	4.3 m power cord (Australia/NZ). FC 9957 is used with PDU FCs 1751 or 1951. FC 9957 provides 1x power cord for FC 1751 and 2x power cords for FC 195x.
9958	D25, D55, L25, L55, S25, S55	No	4.3 m power cord (Korean). FC 9958 is used with PDU FCs 1751 or 1951. FC 9958 provides 1x power cord for FC 1751 and 2x power cords for FC 195x.
9959	D25, D55, L25, L55, S25, S55	No	Unterminated power cord. FC 9959 is used with PDU FCs 1751 or 1951. FC 9959 provides 1x power cord for FC 1751 and 2x power cords for FC 195x.
9966	D25, D55, L25, L55, S25, S55	No	Unterminated power cords (China CCC cert). FC 9966 is used with PDU FCs 1751 or 1951. FC 9966 provides 1x power cord for FC 1751 and 2x power cords for FC 195x.
9970	D25, D55, L25, L55, S25, S55	No	Dual 4.3 m 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 power cord is the default power cord for all countries other than those countries that are specified for FC 9972 and FCs 9976 through 9983. This power cord can be used for all countries, except the following countries: ► Argentina ► Australia ► Brazil ► Canada ► China ► Japan ► Korea ► New Zealand ► Philippines ► South Africa ► Taiwan FC 9970 must be ordered with FC 1901. Only 1 power cord is shipped for an S25 and S55 to be used in conjunction with FC2737
9972	D25, D55, L25, L55	No	Dual 4.3 m 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. Corequisite: FC 9972 must be ordered with FC 1901. Only 1 power cord is shipped for an S25 and S55 to be used in conjunction with FC2737.

Feature code	Model	CSU	Description
9976	D25, D55, L25, L55	No	Dual 4.3 m power cords with 10 Amp/250 Vac, non-watertight IRAM 2073 plug. FC 9976 is for Argentina.
9977	D25, D55, L25, L55	No	Dual 4.3 m power cords with 15 Amp/250 Vac with earth pin InMetro NBR 14136 plug. FC 9977 is for Brazil. Only 1 power cord is shipped for an S25 and S55 to be used in conjunction with FC2737.
9978	D25, D55, L25, L55	No	Dual 4.3 m power cords with 10 Amp/250 Vac AZ/NZS 3112/2000 plug. FC 9978 is for Australia and New Zealand. Only 1 power cord is shipped for an S25 and S55 to be used in conjunction with FC2737.
9979	D25, D55, L25, L55	No	Dual 4.3 m power cords with 15 Amp/250 Vac JIS C8303, C8306 plug. FC 9979 is for Japan. Only 1 power cord is shipped for an S25 and S55 to be used in conjunction with FC2737.
9980	D25, D55, L25, L55	No	Dual 4.3 m power cords with 10 Amp/250 Vac, GB 2099.1, 1002 plug. FC 9980 is for China. Only 1 power cord is shipped for an S25 and S55 to be used in conjunction with FC2737.
9981	D25, D55, L25, L55	No	Dual 4.3 m power cords with 15 Amp/250 Vac with earth pin KS C8305, K60884-1 plug. FC 9981 is for Korea. Only 1 power cord is shipped for an S25 and S55 to be used in conjunction with FC2737.
9982	D25, D55, L25, L55	No	Dual 4.3 m power cords with 10 Amp/250 Vac CNS 10917-3 plug. FC 9982 is for Taiwan. Only 1 power cord is shipped for an S25 and S55 to be used in conjunction with FC2737.
9983	D25, D55, L25, L55	No	Dual 4.3 m power cords with 10 Amp/250 Vac SANS 164-1 plug. FC 9983 is for South Africa. Only 1 power cord is shipped for an S25 and S55 to be used in conjunction with FC2737.
9984	D25, D55, L25, L55	No	Dual 4.3 m 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 client-supplied NEMA L6-20R receptacles. Only 1 power cord is shipped for an S25 and S55 to be used in conjunction with FC2737.
9985	D25, D55, L25, L55	No	Dual 4.3 m 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 client-supplied Russellstoll 3743U2 or 9R23U2W receptacles. Only 1 power cord is shipped for an S25 and S55 to be used in conjunction with FC2737.
9989	D25, D55, L25, L55	No	Dual 4.3 m power cords with 10Amp/250V with IEC 309 C14 plug. FC 9989 is for use with adjacent frame PDUs (FC 1951) or external (client-supplied) PDUs. Only 1 power cord is shipped for an S25 and S55 to be used in conjunction with FC2737.

Feature code	Model	CSU	Description
AGKQ	L25, D25	No	3-meter OM3 quad cables. This FC requires FC 1521 or FC 1522 or FC 1523 or FC 1524.
AGK1	D25, D55, L25, L55	No	10-meter OM3 fiber Cable (LC). This feature provides a 10-meter 50.0/125 micrometer fiber optic cable that is terminated with LC Duplex connectors.
AGK2	D25, D55, L25, L55	No	25-meter OM3 fiber Cable (LC). This feature provides a 25-meter 50.0/125 micrometer fiber optic cable that is terminated with LC Duplex connectors.
AGK3	D25, D55, L25, L55	No	80-meter OM3 fiber Cable (LC). This feature provides an 80-meter 50.0/125 micrometer fiber optic cable that is terminated with LC Duplex connectors.

To order media, see *Ordering additional LTO cartridges and media supplies* in the *IBM TS4500 Introduction and Planning Guide*, SC27-5990:

http://www.ibm.com/support/docview.wss?uid=ssg1S7005016

1.5 Host platforms and device drivers

The TS4500 tape library is supported on many operating systems. For a current list of host software versions and release levels that support the TS4500 tape library, see the IBM System Storage Interoperation Center (SSIC) web page to confirm support and to check for all required firmware and drivers:

http://www.ibm.com/systems/support/storage/ssic/interoperability.wss

To download the required drivers, go to IBM Fix Central:

http://www.ibm.com/support/fixcentral

Feature codes for operating systems

The following no-charge specify feature codes indicate the server platform to which the TS4500 tape library is attached. These features are used by IBM for device driver distribution:

► FC 9210: Attached to HP-UX
► FC 9211: Attached to Sun system
► FC 9212: Attached to Windows system
► FC 9213: Attached to another system that is not an IBM system
► FC 9215: Attached to Linux system
► FC 9217 Attached to IBM System z®, TS7700
► FC 9218: Attached to High Performance Storage System (HPSS)
► FC 9400: Attached to IBM System i®
► FC 9600: Attached to IBM System p

More than one platform-attached feature can be chosen because the library can be attached to more than one of these platforms. Only one of each feature is added. That is, if two or more Windows servers use the TS4500, only one FC 9212 is required.

Tip: The device driver is available for each operating system from IBM Fix Central:

http://www.ibm.com/support/fixcentral/

1.6 Specifications

The TS4500 tape library is a stand-alone tape subsystem that consists of one or more frames. It can expand in a modular manner to provide large capacities. The frames join side to side, and they can be added on the left side or right side of the installed frames.

1.6.1 Physical specifications

Table 1-15 lists the physical dimensions of the TS4500 tape library frames.

Table 1-15   Physical dimensions

Model	Width[a]	Depth	Height
L25, L55, D25, D55, S25, S55, S24, and S54 (on casters)	782 mm (30.8 in.)	1,212 mm (47.72 in.)	1,800 mm (70.9 in.)
L25, L55, D25, D55, S25, S55, S24, and S54 frames with top rack	782 mm (30.8 in.)	1,212 mm (47.72 in.)	2,320 mm (91.34 in.)
L25, L55, D25, D55, S25, S55, S24, and S54 frame with covers	782 mm (30.8 in.)	1,212 mm (47.72 in.)	1,800 mm (70.9 in.)
L25, L55, D25, D55, S25, S55, S24, and S54 frame without covers	725 mm (28.5 in.)	1,212 mm (47.72 in.)	1,800 mm (70.9 in.)

a. Frame width only. Additional interframe spacing of 30 mm (1.2 in.) is required.

Table 1-16 lists the weights of the frames according to the number of installed drives, robotics, and tape cartridges.

Table 1-16   TS4500 tape library weight

Model and position	Minimum weight of frame (with no tape drives or cartridges)[a]	Maximum weight of frame (with maximum tape drives and cartridges) [b]
L25 Position 1 (leftmost frame)	407.8 kg (899 lb.)	586.5 kg (1,293 lb.)
L25 Position 2+	407.8 kg (899 lb.)	630.5 kg (1,390 lb.)
D25 Position 1 (leftmost frame)	310.7 kg (685 lb.)	500 kg (1,103 lb.)
D25 Position 2+	310.7 kg (685 lb.)	552.5 kg (1,218 lb.)
L55 Position 1 (leftmost frame)	410 kg (904 lb.)	592 kg (1,305 lb.)
L55 Position 2+	410 kg (904 lb.)	637 kg (1,404 lb.)
D55 Position 1 (leftmost frame)	316 kg (697 lb.)	503.5 kg (1,110 lb.)
D55 Position 2+	316 kg (697 lb.)	557 kg (1,228 lb.)
S25 Position 1 (leftmost frame)	299 kg (660 lb.)	491.2 kg (1,083 lb.)
S25 Position 2+	299 kg (660 lb.)	540.2 kg (1,191 lb.)
S55 Position 1 (leftmost frame)	304 kg (670 lb.)	509.4 kg (1,123 lb.)
S55 Position 2+	304 kg (670 lb.)	564 kg (1,244 lb.)
S24 Position 2+	285.8 kg (630 lb.)	526.2 kg (1160 lb.)

Model and position	Minimum weight of frame (with no tape drives or cartridges)[a]	Maximum weight of frame (with maximum tape drives and cartridges) [b]
S54 Position 2+	290.3 kg (640 lb.)	562.5 kg (1240 lb.)
TR1 Weight of top rack (empty)[c]	24.5 kg (54 lb.)	24.5 kg (54 lb.)
Weights that are 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 to shift part of the weight to other frames.		

a. Frames in position 1 (the leftmost frame in a library string) can have a maximum of 12 tape drives.
b. Drive frames in positions 2+ can accommodate 16 tape drives.
c. A top rack can be installed optionally on any HD 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.).

When you plan for the installation, the space implications in the computer room must be considered for the possibility of adding more frames in the future.

1.6.2 Floor requirements

The library must be installed on a raised or solid floor. The floor must have a smooth surface and, if raised, the floor must not have ventilation panels beneath the leveling jackscrews. If carpeted, it must be confirmed that the carpet is approved for computer-room applications. To accommodate unevenness in the floor, the leveling jackscrews can be raised or lowered to the following specifications:

► The maximum allowable variance must not exceed 7 mm (0.27 in.) per 76 mm (3 in.).
► The maximum out-of-level condition must not exceed 40 mm (1.6 in.) over the entire length and width of the library.

The floor on which the library is installed must support the following weight specifications:

► Up to 4.8 kilograms per square cm (68.6 lbs. per square inch) of point loads that are exerted by the leveling jackscrews
► Up to 211 kilograms per square meter (43.4 lbs. per square foot) of overall floor loading

The number of point loads that is exerted depends on the number of frames that makes up the library. Four point loads are on each frame (at the corners of each frame).

For more information, see the *IBM TS4500 Introduction and Planning Guide*, SC27-5990.

1.6.3 Operating environment

See the *IBM TS4500 Knowledge Center* for detailed environmental specifications:

https://www.ibm.com/support/knowledgecenter/STQRQ9/com.ibm.storage.ts4500.doc/ts4500_planning.html

1.6.4 Power and cooling specifications

Power for the components of the TS4500 tape library is provided by a power supply within the Lx5 or Dx5 frame. The Lx5 power supply provides power to the components that are housed in the Lx5 frame. The Dx5 power supply provides power to the components in the Dx5 frame. The Sx5 models receive their power supply from an adjacent frame (either an Lx5 or Dx5, depending on the configuration).

Models Lx5 and Dx5 of the TS4500 tape library with installed PDUs (FC 1951) can power up to two adjacent frames by specifying a power cord (FC 9989) on each of the adjacent frames and plugging the cords into the spare outlets on the (FC 1951) PDUs, which are on the adjacent Lx5 or Dx5 frame.

Figure 1-45 shows the first adjacent frame cord that is plugged into the PDU receptacles and the second adjacent frame power cord that is plugged into the consecutive PDU receptacles. The adjacent frames that receive power through FC 9989 can be up to three frames away from the frame with FC 1951. By using adjacent frame power cords, clients can power up to three frames from only two facility outlets.
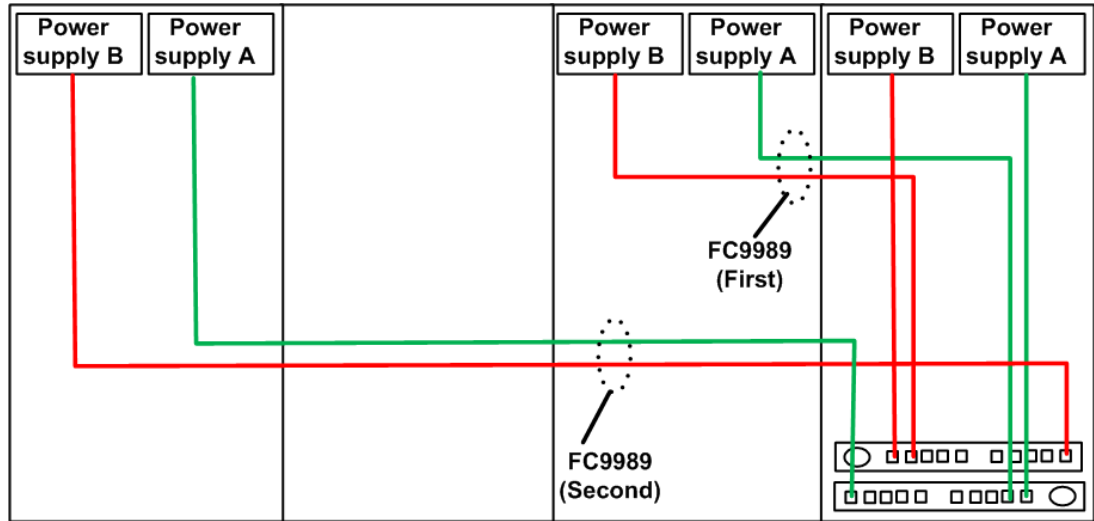
Figure 1-45   FC 9989 cable positions with FC 1951

Table 1-17 lists the power requirements for the Lx5 and Dx5 frames.

Table 1-17   Power requirements for the TS4500 tape library

Power requirements	Rating	Rating with FC 1951 installed
AC line voltage	200 - 240 V AC (nominal)	200 - 240 V AC (nominal)
AC line frequency	50 - 60 Hz	50 - 60 Hz
Nominal power	1.4 kW	1.4 kW
Line current	8.0 A	24.0 A
kVA	1.6 kVA	4.8 kVA
Recommended Customer Circuit minimum	10 A	20 A
Recommended Customer Circuit maximum	20 A	32 A

Table 1-18 shows the environmental specifications for the TS4500 which refers to the hardware of the TS4500 tape library, and might lead to temperatures greater than allowable for the cartridges and media stored in the library.

Table 1-18   Equipment environment specifications for the TS4500 tape library

Product operation							Product power off	
Dry-bulb temperature[a]		Relative Humidity (Non-condensing)		Maximum Wet-bulb temp.	Maximum elevation	Dry-bulb temp.	Relative humidity (% RH)	Maximum Wet-bulb temp.
Allowable	Recommended	Allowable (% RH)	Recommended (% RH)					
16 to 32°C	16 to 25°C	20 to 80%	20 to 50%	26°C	3050 m	5 to 45°C	5 to 80%	28°C

a. Derate maximum dry-bulb temperature 1°C/300 m (1.8°F/984 ft.) above 900 m (2 953 ft.).

For frames that contain LTO tape cartridges or IBM 3592 Enterprise Tape Cartridges, refer to their environmental and shipping specifications for these products and adjust the operating environment for the library accordingly:

https://www.ibm.com/support/knowledgecenter/en/STCMML8/com.ibm.storage.ts3500.doc/ipg_3584_meesij.html

For more information about planning the installation of the TS4500, see the IBM TS4500 Knowledge Center under Planning:

https://www.ibm.com/support/knowledgecenter/STQRQ9/com.ibm.storage.ts4500.doc/ts4500_planning.html

2

TS4500 Ultrium Linear Tape-Open and 3592 tape drives

The IBM TS4500 tape library supports Ultrium Linear Tape-Open (LTO) and IBM TS1100 (3592) tape drives.

The high-density 2 (HD2) frames of the TS4500 tape library support HD2-compatible models of the IBM TS1155 (3592 55E and 3592 55F), IBM TS1150 (3592 EH8), IBM TS1140 (3592 EH7), LTO-8 (3588 F8C), LTO-7 (3588 F7C), LTO-6 (3588 F6C), and LTO-5 (3588 F5C) tape drives.

This chapter includes the following topics:

- ► IBM TS1100 tape drives for the TS4500 tape library
- ► IBM TS1155 and TS1150 tape drive
- ► IBM TS1140 tape drive (Model 3592 EH7)
- ► IBM LTO Ultrium tape drives for the TS4500 tape library
- ► IBM LTO Ultrium 8 tape drive (Model 3588 F8C)
- ► IBM LTO Ultrium 7 tape drive (Model 3588 F7C)
- ► IBM LTO Ultrium 6 tape drive (Model 3588 F6C)
- ► IBM LTO Ultrium 5 tape drive (Model 3588 F5C)
- ► IBM Spectrum Archive

2.1 IBM TS1100 tape drives for the TS4500 tape library

The TS1100 family of drives for the TS4500 include the IBM TS1155 tape drives (machine types 3592-55E and 3592-55F), IBM TS1150 tape drives (machine type 3592-EH8), and TS1140 tape drives (machine type 3592-EH7). These drives offer a design that is focused on high capacity, performance, and high reliability for storing mission-critical data.

The 3592 family was enlarged and improved with the addition of the IBM TS1155, 3592 Model 55E, and Model 55F tape drives. The TS1155 is an enhancement of the fifth generation of the 3592 model EH8 and E08 tape drive family. It provides the unprecedented capacity of 15 TB of uncompressed data on a single tape and new physical host connection options.

> **Note:** This chapter only describes the 3592 models the attach to the TS4500. For other 3592 models, see the *IBM Tape Library Guide for Open Systems*, SG24-5946.

The 3592 tape drive family has the following common characteristics, which are described in this section:

► Technology enhancements
► Reliability and availability
► Performance or capacity scaling
► Features that are designed for capacity and performance
► Physical attachment
► Media
► 3592 media cartridge
► WORM functions
► Tape encryption for TS1155, TS1150, and TS1140

2.1.1 Technology enhancements

The 3592 tape drive family includes the following key features:

► Virtual backhitch, which is the optimum adaptive format and algorithm for improved start-and-stop write performance. For more information, see "Virtual backhitch (nonvolatile caching)" on page 69.

► High performance and robust dual microprocessor architecture. One microprocessor operates the host attachment interface (which is running proven 3590 host attach microcode). The other microprocessor focuses strictly on writing data and reading data from tape. Each microprocessor resets the other microprocessor to act as a fail-safe.

► Statistical Analysis Recording System (SARS) algorithm with extended mount count.

► Fast random access performance when the tape drive operates on any of the Short Length Cartridge (SLC) types.

► Support of an enhanced capacity scaling and segmentation format when the tape drive operates on the full-length, read/write cartridge types JA, JB, JC, and JD, which enable fast locate and read times.

► Streaming lossless data compression (SLDC) algorithm, which is an enhancement of the Lempel-Ziv class 1 (LZ-1) data compression algorithm.

► The JD, JZ, and JL media types contain 16 KB cartridge memory, increased from the 8 KB cartridge memory that is contained in JC and JB media types and 4 KB cartridge memory that is contained in JA, JW, JR, and JJ media types.

Recording format

The IBM 3592 tape drive uses an advanced interleaved bidirectional serpentine recording technique that writes 8, 16, or 32 (depending on the drive) data tracks at a time on a 3592 cartridge. The 3592 cartridge is a half-inch, advanced metal particle, dual-layer tape.

The tape layout consists of five servo bands (prerecorded on the tape) and four data bands where the data is written, as shown in Figure 2-1. The servo bands provide location information to control the positioning of the head as it writes and reads data within the data band. For more information about this design, see "Servo tracks" on page 65.

As shown in Figure 2-1, the area between adjacent servo bands is a *data band*. The 3592 media has four data bands, each with a number of data tracks (128 - 288, which is different for each model).
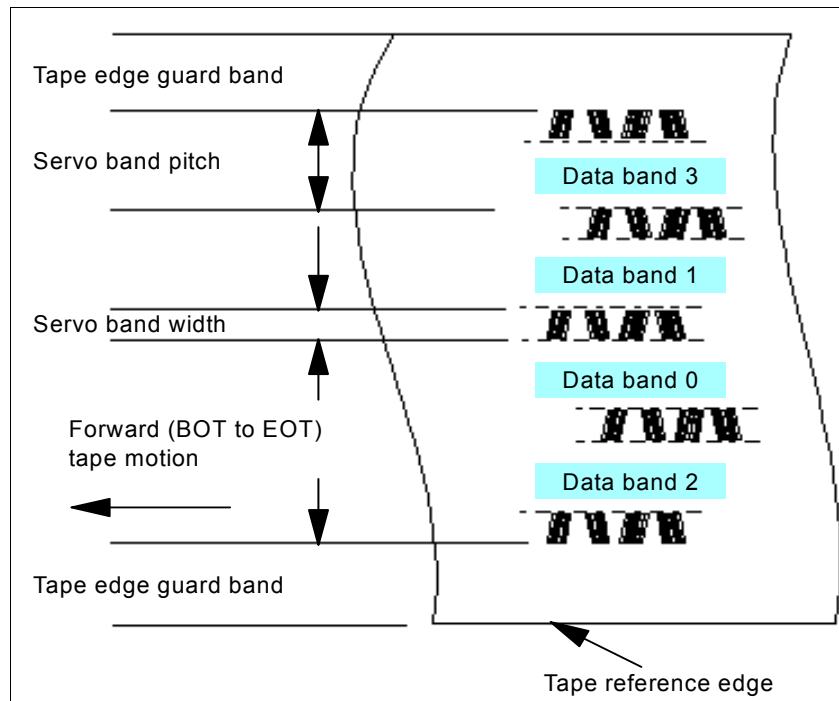

Figure 2-1   Layout of the servo and data bands on the 3592 media

Servo tracks

Servo tracks or bands help to ensure accurate positioning of the tape drive head over the data track so that the head does not stray onto an adjacent track. Servo tracks are necessary to support high-data densities on the tape where the tracks are extremely close together. The servo tracks are written at the time of cartridge manufacture before the cartridge is usable for data storage and retrieval. Each tape write head has two *servo heads*, one servo head for each of the two *servo bands* that it spans.

Two servo bands are used simultaneously to provide two sources of servo information for increased accuracy. Control positions within the servo band are used to reposition the head to write forward and reverse wraps, within each of the four data bands. This timing-based servo technology can be finely tuned. This technology supports extremely high track densities for future 3592 generations because more than eight positions can be defined within the same servo band, expanding the potential track densities.

In addition, significant advances occurred in the tape coating process, which uses high-quality metal particle media.

2.1.2 Reliability and availability

The 3592 tape drive incorporates and expands on the high reliability and function of previous IBM drives that were developed over many years of experience. It builds on proven technologies to enhance and apply new techniques to ensure high reliability and availability.

Improved availability

Improved availability includes the following characteristics:

► Single field-replaceable unit (FRU)

When a service call is placed, the IBM service support representative (SSR) does not replace any parts or subassemblies inside the canister. The new smaller drive unit means that for any failure within the drive, the IBM SSR exchanges the entire unit rather than performing lengthy diagnostics or component replacement in the field.

► Redundant, hot-pluggable power supplies

In all configurations, the drives are seated in *cradles* that contain two power supplies. Each pair of power supplies can be used by one or two drives. One power supply is sufficient to run both drives, and the second power supply is provided for redundancy.

► Retention of the Fibre Channel (FC) worldwide name ID during service action

When a failed drive is exchanged, you do not need to reconfigure the attached hosts or the storage area network (SAN) to recognize a replacement drive. This function also eliminates any issues with SAN hosts finding incorrect addresses during a system reboot.

► Retention of the IP configuration for the Ethernet ports during service action

When a failed drive is exchanged, you do not need to reconfigure the attached Ethernet hosts to recognize a replacement drive. Ethernet port configuration data is maintained during replacement.

Advanced technology

Advanced technology includes the following characteristics:

► Robust loader mechanism

The loader mechanism is suitable for the heavy-duty cycle usage in mainframe systems. The leader block on the tape cartridge is replaced by a metal pin, which is enhanced over previous drive implementations for increased robustness.

► Elimination of drive pneumatics and mechanical adjustments

The aerodynamic movement of the tape over the flat-lap head pulls the tape close to the head while the tape is moving, and provides maximum efficiency in reading and writing. Because of the shape of the head, particles do not accumulate on the tape, which eliminates the possibility of debris contamination of the tape surface. Air-bearing heads effectively cushion the tape that is moving across the head.

However, whenever the tape stops, it relaxes toward the head surface. The head has a two-stage actuator: one mechanism for moving to the required tape wrap, and another finer actuator for adjustments to the track-following servo.

► Straighter and shorter tape path for better tape tracking

Tape tracking is improved by using grooved rollers to provide surface-controlled guiding. This enhancement decreases potential wear or damage on the edges of the tape and decreases lateral movement with the shorter tape path.

- ► Speed matching to reduce backhitching (See 2.1.3, "Features that are designed for capacity and performance" on page 68)

  Buffering, speed matching, and virtual backhitch algorithms all serve to eliminate physical backhitching. They improve performance and reduce the wear that is caused by continually braking and reversing direction on the drive mechanics.

- ► Channel calibration to optimize performance and data integrity

  The drive uses individual read/write data channel calibration, which uses sophisticated techniques that were originally implemented in disk technology.

Enhanced service functions

The following service functions were enhanced:

- ► Enhanced SARS recording

  The tape drive uses Statistical Analysis Recording System (SARS) to help to isolate the failures between media and hardware. SARS uses the cartridge performance history that is saved in the cartridge memory module and the drive performance history that is kept in the drive flash. The cartridge memory is a serial Electronically Erasable Programmable Read-Only Memory (EEPROM), with read-only and rewritable areas, to determine the more likely cause of failure.

  SARS can cause the drive to request a cleaner cartridge (based on usage) to mark the media as degraded, and to indicate that the hardware is degraded. SARS information is reported through the TapeAlert flags and through media information messages (MIMs) and service information messages (SIMs).

- ► Diagnostic information

  The drive maintains logs to assist engineering or service personnel. The logs are included in drive memory dumps, and they are accessible to service personnel in several ways, including through the new hot-pluggable service panel. Memory dumps are maintained over Power On Reset (POR).

- ► More temperature and voltage sensors to improve error isolation

  The drive contains sensors and circuits to detect errors. A temperature sensor monitors the temperature of the drive electronics. Voltage sensors detect when the power supply is out of tolerance. Other error checks, such as tape velocity checks, read/write data integrity checks, and servo checks are performed by using circuitry and sensors. The drive microcode checks for logic errors to handle hardware-detected errors and to detect and report microcode-related errors.

- ► Drive status indicators and reliability, availability, and serviceability (RAS) functions on the library drive interface

  The drive provides indicators for FC status, whether the power is good, and faults. However, the drive hot-pluggable service panel is the key service tool to perform test procedures and interpret results.

- ► Concurrent microcode update, with options to switch the new or old copy of drive code

- ► Backup drive vital product data (VPD card) that is stored from the drive

  When a drive is replaced, the VPD can be downloaded quickly to the drive by using the backup, which reduces the time that is taken for repair or configuration.

- ► Preventive maintenance

  The 3592 tape drive requires no preventive maintenance beyond the use of the cleaning cartridge. The 3592 media cartridges require proper care and appropriate handling and shipping procedures.

2.1.3 Features that are designed for capacity and performance

The unique features and specifications of the 3592 make it a true enterprise tape drive in terms of performance and reliability. The following sections describe these industry-leading features in greater detail.

> **Important:** These features are generic for all 3592 tape drives. The TS1155, TS1150 and TS1140 offer other advanced features that are described in 2.2, "IBM TS1155 and TS1150 tape drive" on page 81 and 2.3, "IBM TS1140 tape drive (Model 3592 EH7)" on page 99.

Data buffer

The drive has a large data buffer with read-ahead buffer management that addresses the lowest band of data rates. It effectively collects more blocks of data in the buffer before it writes to the drive at a higher speed. As a result of this data buffer, the drive stops and starts less often, which generally improves the overall performance and reliability of the drive and tape.

Speed matching

For medium data rates, when the drive is operating from a host that cannot sustain the maximum 3592 data rate, the drive performs dynamic *speed matching*. The drive adjusts the native data rate of the drive as closely as possible to the net host data rate (after it factors out data compressibility). The 3592 drive operates at various speeds (between six and 13 speeds, depending on the drive that is used) when the 3592 format is read or written to in an attempt to match the effective host data rates.

If the net host data rate is between two of the speed matching native data rates, the drive calculates at which of the two data rates to operate. Speed matching reduces the number of required backhitches. In certain environments, the backhitch of the drive is masked by the data buffer of the drive. Therefore, the system throughput is not improved or reduced by speed matching.

Cartridge memory

The *cartridge memory* (CM), which is a passive, contactless silicon storage device that is physically a part of the cartridge, is contained within the cartridge. The CM is used to hold information about that specific cartridge, the media in the cartridge, and the data on the media.

The 3592 uses the same CM module as LTO media, with a capacity of 4 KiB, which is extended to 8 KiB on JB or JX media (and JC, JY, or JK media), and enhanced to 16 KiB for JD or JZ media. The CM was designed for 3592 to support the high-resolution tape directory feature. The CM differs from the LTO specification because it supports the high-resolution tape directory feature. See "High-resolution tape directory" on page 68.

Communication between the drive and the CM occurs through a noncontact, passive radio frequency interface (RFI), which eliminates the need for physical connections to the cartridge for power or signals.

High-resolution tape directory

The 3592 drive maintains a tape directory structure with a higher granularity of information about the physical position of data blocks and file marks on the media. This feature gives the 3592 drive improved nominal and average access times for locate operations. Locate times are uniform.

They are based on the position of the block or file mark on the tape, independently of the uniformity of the block size or file mark distribution along the length of the tape. Therefore, the 3592 locate and space performance is targeted to be completely and individually dependent on the longitudinal position on tape of the target block or file mark.

Virtual backhitch (nonvolatile caching)

The 3592 stages write-data through an intermediate dynamic random access memory (DRAM) buffer on its way to tape. This buffer is volatile because it does not retain what is stored if power is lost. For streamed writes (or reads), this buffer yields considerably improved performance.

When the streaming writes cease, a typical pre-3592 tape drive halts the tape and repositions it directly upstream of where the writing ended. From this action, data that is received later can be written immediately after the previously written data. This method eliminates the waste of the considerable length of tape. Substantial lengths of unwritten tape can significantly reduce capacity. Here, a backhitch (reverse) by typical tape drives is used to eliminate this loss of capacity loss after a write to tape.

Nonvolatile caching (NVC) is a 3592 feature that can help greatly improve write performance through backhitch reduction. This system temporarily reserves portions of physical tape for cache areas. Data that is received from the host is written to the volatile buffer as usual, and to nonvolatile tape cache areas, with the exception that no backhitch is necessary when temporary copies are written to cache areas of tape. This temporary capacity loss is easily recouped.

The data is written to temporary cache areas and it is not released in the volatile buffer, but instead it accumulates. This accumulation continues until the buffer is nearly full. At this time, the accumulated data in the buffer is rewritten through a streamed write to the standard area of tape.

When the rewrite is complete, the temporary cache areas of tape are released so that they can be overwritten. To significantly improve the average write throughput to tape, temporary copies can be written to the cache areas of tape without backhitching until the buffer is nearly full. Then, a rewrite of the data can be streamed to the standard area of tape.

Aside from the improved write throughput performance, the second effect of NVC writing is to recover the capacity that is lost by the standard writing technique. Data that is received between synchronization events fills containers of data to be written to tape that are called *device blocks* or *data sets*. The standard writing technique calls for padding the last partially filled data set. This padding on average amounts to half the size of the last data set. With the large data set sizes of modern tape drives, this loss can be substantial.

The streaming rewrite of the data that is accumulated in a buffer causes nearly all data sets that are written to a standard area of tape to be written in full, which is known as *data set packing*.

Writing in NVC mode is automatically started by the drive when host writing behaviors are detected that can perform better when in NVC writing mode. Similarly, NVC writing is discontinued when host commands are received that do not benefit from NVC writing, or when commands, such as `Rewind`, are received. When NVC writing is exited, the drive writes any packed data sets that are accumulated in its buffer before it runs the command that stops NVC mode.

Because NVC writing is automatically started and stopped, it is not apparent to host applications. The only indication that NVC writing occurs is the improved capacity and performance that can result from this new mode of writing.

The two components of NVC, backhitch reduction and data set packing, provide major performance and capacity improvements over standard tape drives, such as the 3590, or the Linear Tape-Open (LTO) writing of synchronized data. Data set packing improves overall tape capacity. Backhitch reduction decreases the frequency of mechanical repositions. NVC provides an innovative approach to increasing capacity and write performance in a way that is not apparent to host applications.

2.1.4 Performance or capacity scaling

The 3592 tape drives support scaling and segmentation modes on the read/write (JA, JB, JC, or JD) cartridges so that clients can trade off capacity for improved access times.

> **Note:** The TS 1155 drive models supports capacity scaling only on the JD full length R/W media. Capacity scaling is not supported for economy (JJ, JK, and JL) or Write Once Read Many (WORM) tapes (JW, JX, JY, JR, and JZ).

Although 256 settings of capacity are supported on the 3592 drive, the following settings are often used:

► Full capacity default mode
► A 20% scaled fast access mode (capacity scaled, front of tape through an x'35' setting)
► Performance scaling for 87% capacity (segmented format, capacity scaling setting x'E0')

Performance scaling, which is also known as *capacity scaling*, is a function through which data can be contained in a specified fraction of the tape, which yields faster locate and read times. This function is possible through the action of modifying internal formatting indicators in the medium and in the cartridge memory chip.

The normal serpentine track format is altered in such a way as to limit the recorded portion of the tape to a specified fraction of the length of the tape, as shown in Figure 2-2. In the 3592, an application can issue a `Mode Select` command to scale an individual cartridge. It pertains only to the cartridge that is loaded and it is not persistent.
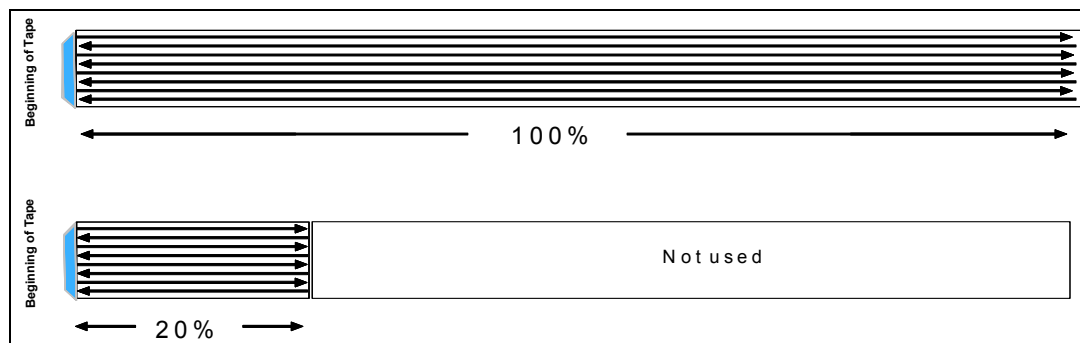

Figure 2-2   Examples for a 100% tape and scaled tape to 20%

The result of performance scaling a tape to a percentage value (for example, 20%) is that the maximum number of recordable gigabytes is reduced to 20% of the normal value. Also, the average time to locate a random record on a full tape that starts from load point is (roughly) 20% of the time to locate a random record from load point for a full, unscaled tape.

The cartridge can be rescaled from any current value to any supported new value. Tape is logically erased by this rescaling. (The end of the data mark is written at the beginning of the tape.) However, tape is 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 scaled or rescaled.

When a scaling operation is requested on a JD type cartridge using the TS1155 drive, the media will be up-formatted to the J5A logical format at the same time the scaling operation is performed unless the format is controlled through explicit means.

Performance segmentation

Performance segmentation provides fast access and capacity by allowing the tape to be divided into two segments. One segment is a fast access segment to be filled first, and the other segment is more capacity to be filled after the first segment. Therefore, it is high performance in two ways. It has segmentation and high-performance random access in the first segment, as though it was a scaled cartridge, while it provides other larger capacity, as shown in Figure 2-3.
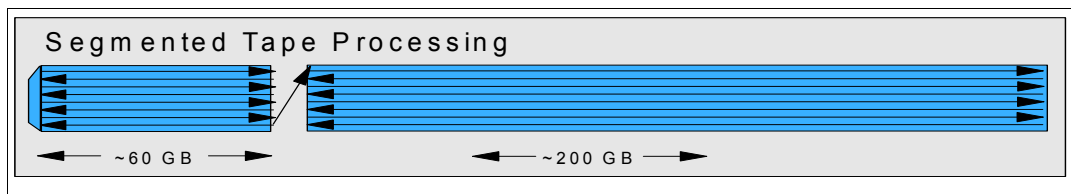

Figure 2-3   Segmented tape on 3592

Performance capacity scaling and segmentation have the following implications:

► If host systems provide a means to limit the amount of data that a client places on the media, for example, with a percent usage construct, the user achieves a much faster average access time to the first data. Also, more locates on the same volume improve significantly.

► With segmentation, a less than 1% degradation occurs in the data rate because of the increased number of wrap changes. Segmentation also reduces the nominal cartridge capacity by approximately 10%.

2.1.5 Physical attachment

The 3592 (model EH7, EH8, 55F) tape drives are supported on the following environments:

► IBM System i
► IBM iSeries
► IBM OS/400
► IBM Power Systems™ (p6 and newer)
► IBM System p (p5 and older)
► IBM RS/6000®
► IBM pSeries
► IBM System x
► IBM xSeries
► Sun servers
► Hewlett-Packard servers
► All Intel technology-compatible servers that run Microsoft Windows and Linux

The 3592 (model 55E model) tape drives are supported on open systems servers running Microsoft Windows only. Approval of i-RPQ 8B3685 will be required for ordering a TS1155 Tape Drive Model 55E.

Fibre Channel drives

The TS4500 3592 Fibre Channel (FC) tape drives come with dual-ported 8 Gbps, switched FC attachments, Providing attachment to multiple servers or a single server with redundancy. This feature offers attachment flexibility in an open systems environment. The drive can be attached to open systems servers directly with Fibre Channel host bus adapters (HBAs).

The TS1155, TS1150, and TS1140 tape drives attempt to connect at 8 Gbps. However, they autonegotiate down to 4 Gbps, 2 Gbps, or 1 Gbps if the system or switch that they are connected to cannot support higher bandwidth.

The 3592 Fibre Channel (FC) attach tape drives can operate as a node loop port (NL_port) (Fibre Channel Arbitrated Loop [FC-AL] support) or as a node (N_port) (supporting direct connection to a SAN switch, which is also known as *point-to-point* or fabric mode). The 3592 tape drives autonegotiate to the N_port or NL_port, depending on whether a loop or a point-to-point connection is detected when the drive boots.

The drives do not autonegotiate if the drive was set to force an explicit setting of these configurations. Regardless of whether the 3592 tape drives connect as an NL_port or an N_port, they autonegotiate to be a public device (attached to a switch) or a private device (attached to another N_port, that is, directly to a host).

If a library drive is replaced, an IBM SSR will select the replacement unit to automatically inherit the configuration attributes of the failed unit. This way, a user can avoid reconfiguring the zoning in the switches. Alternatively, the Management Interface (MI) can be used to change these fields directly at any time.

For more information about FC attachment planning, see *IBM TotalStorage Enterprise Tape System 3592 Introduction and Planning Guide,* GA32-0555.

For the latest information about applications and their levels that support 3592 tape drives, see the ISV matrix, which is available to download as a PDF file from the "Independent Software Vendor Matrix (ISV) for IBM TotalStorage 3592 tape drives and LTO" from the TS4500 product web page from the Resources tab:

http://www.ibm.com/systems/storage/tape/ts4500/index.html

Multiple Fibre Channel ports

All FC 3592 models have two independent FC interfaces or ports. Both ports run the Small Computer System Interface (SCSI) protocol with FC tape support. Through two ports, concurrent attachment of two independent FC configurations can be made to each drive. One or both ports can be attached to various open systems servers, SAN switches, and directors.

The 3592 tape drives support industry-standard shortwave LC-Duplex fibre optic cables, with cable lengths of up to 500 m (1,640 ft.) and 50 microns of core fibre, depending on the required attachment speed.

The following maximum distances are supported by the shortwave adapters with the LC-Duplex fibre optic cables:

► One Gbps shortwave adapters have a maximum distance of 500 meters (1,640 ft.).
► Two Gbps shortwave adapters have a maximum distance of 300 meters (984 ft.).
► Four Gbps shortwave adapters have a maximum distance of 150 meters (492 ft.).
► Eight Gbps shortwave adapters have a maximum distance of 50 meters (164 ft.).

Supported topologies

The 3592 tape drives support switched fabric and point-to-point loop topologies.

Switched fabric

Two or more FC endpoints connect through a switch. The FC architecture supports up to 256 ports through each switch. Switches include a function that is called *zoning*. By using this function, you can partition the switch ports into port groups and then assign group access to other groups. This function prevents group interference. With switched fabrics, all of their ports have simultaneous use of the full FC architecture bandwidth.

Point-to-point loop

A point-to-point loop is similar to a point-to-point topology. Both have two connected FC endpoints. The difference is in the protocol. Therefore, when only two FC endpoints are connected, either protocol is usable. However, both endpoints must use the same protocol. The 3592 model supports a point-to-point loop. Most FC adapters default to the loop protocol when they are not directly connected to a fabric.

> **Important:** SAN switches normally default the switch port to loop mode. If the port is set to automatic mode, loop mode is the first mode that is attempted during the port login process. The 3592 accepts loop mode and logs in to the port. To get the 3592 to log in to the SAN switch port in fabric mode, the port on the switch must be set to fixed fabric mode by the switch administrator or at the drive by using the management interface.

Address assignments

The 3592 tape drives must have an FC address to communicate over the FC interface. The tape drives support hard and soft addressing. Most FC hosts (initiators) support hard addressing and do not support soft addressing. For more information, see the device driver documentation.

Fibre Channel worldwide name ID

Each Fibre Channel card on the 3592 tape drive has four names (Node 0, Node 1, Port 0, and Port 1) that are hardcoded into the electronics of the card by IBM manufacturing. These names are similar to a serial number and are unique throughout the world.

More details about SAN best practice and IBM SAN switches can be found in the *IBM Tape Library Guide for Open Systems*, SG24-5946.

Ethernet drives

IBM TS1155 Tape Drive, Model 55E, delivers 10 Gb Ethernet host attachment interface optimized for cloud-based and hyperscale environments.

This drive provides dual 10 Gb optical Ethernet host attachment ports using Remote Direct Memory Access (RDMA) over Converged Ethernet for cloud-based and open-compute environments.

The dual 10 Gb ports uses short wave multi-mode optical SFP transceivers and the allowable cable lengths are shown in Table 2-1.

Table 2-1   Ethernet optical cable limits

Fiber cable type	Connector Type	Minimum modal bandwidth at 850 nm (MHz x km)	Operating range in meters
62.5 µm MMF	LC	160	2-26
62.5 µm MMF	LC	200	2-33
50 µm MMF	LC	400	2-66
50 µm MMF	LC	500	2-82
50 µm MMF	LC	2000	2-300

The TS1155 Ethernet drive currently will support iSCSI Extension for RDMA (iSER) on Converged Ethernet (RoCEv2). This specific protocol utilizes a UDP transport layer and required Data Center Bridging (DCB) switches and lossless networks.

Extensions for RDMA (iSER) is a standard that enables iSCSI hosts and targets to take advantage of RDMA capabilities. iSER runs on top of a RDMA capable Network Interface Card (rNIC) regardless of the protocol.

The TS1155 55E is supported through Microsoft Windows device driver and requires approval of i-RPQ 8B3685.

2.1.6 Media

Users must cost-effectively store more digital information than ever before, often to meet growing regulatory and legal requirements. The 3592 tape drives help meet these needs with the IBM Tape Cartridge 3592. The TS1155, TS1150, TS1140, TS1130, TS1120, and 3592-J1A all use the 3592 tape cartridge. This tape cartridge offers various capacity options, depending on the drive and the recording format that are used or the cartridge model that was ordered: Data, WORM, or Economy.

These capabilities expand the range of client data workloads that can be addressed with the 3592 tape drives. The economy cartridge can help lower the cartridge cost for users with smaller capacity needs and provide faster access to data. The WORM cartridges provide nonerasable, nonrewritable storage media. Users with regulatory or legal requirements to store electronic records for long periods might be able to use the 3592 tape drives to provide cost-effective storage.

The 3592 cartridges have a form factor that is similar to the 3590 tape cartridge. They are supported in the following IBM cartridge library environments:

► IBM TS3500 tape library
► IBM TS4500 tape library

The IBM 3592 ½-inch tape cartridge contains an advanced fourth-generation metal particle formulation in a dual-layer coating on a half-inch-wide tape. The IBM tape uses an advanced magnetic coating and process that provides a high output and signal quality to support the current 3592 tape drives.

The tape features an ultra-smooth and uniform magnetic layer that is less than 0.2 microns thick and a specially refined coating formulation that is designed to help improve media reliability and performance and minimize the wear of the tape heads and components. A precision timing-based servo with enhanced features helps enable high track densities, high data rates, data access performance, high reliability, and stop-start performance.

The following media are used for the different media types:

► Dual-coat, MP nanocubic particle, and Polyethylene naphthalate (PEN) substrate 8.9 μm nominal thickness (JA types)

► Dual-coat, MP nanocubic particle, and PEN substrate 6.6 μm nominal thickness (JB types)

► Dual-coat, Barium Ferrite (BaFe) particle, PEN substrate, and 6.1 μm nominal thickness (JC types)

► Dual-coat, BaFe particle, Aramid substrate, and 5.0 μm nominal thickness (JD types)

Modifications to the cartridge design and construction help improve pin retention, hub and clutch engagement, spool alignment, and tape stacking within the cartridge. These enhancements help improve reliability and durability of the media and the tape drive. Enhanced assembly strengthens the cartridge at critical locations and helps make the 3592 cartridge less susceptible to damage, such as damage from being dropped.

The tape is pulled from the cartridge with a leader pin rather than a leader block as in the 3590 cartridge. A sliding door covers the area that was formerly occupied by the leader block in a 3590 cartridge. A locking mechanism prevents the media from unwinding when the cartridge is not in a drive. A special mechanical design provision prevents the 3592 cartridge types from being loaded into 3590 or 3490 drives. If a 3592 cartridge is inadvertently loaded into a 3590, the cartridge present sensor does not change state and the drive does not attempt to load.

2.1.7 3592 media cartridge

This section provides more detail about the 3592 cartridge media that are supported by the TS4500 tape library.

Media types and compatibility

Multiple media types are in the 3592 range. The capacity of the 3592 tape cartridge depends on the format that is used when the tape is written from the beginning-of-tape (BOT). Two basic formats are used: Enterprise Format (EFMT) and Enterprise Encrypted Format (EEFMT). Each tape drive model has different formatting capabilities for the TS4500 compatible drives, as shown in Table 2-2. The TS1155 is not supported for z/OS attachment.

Table 2-2   Read and write SMS z/OS media types that are supported

Drive type	EFMT1	EFMT2 EEFMT2	EFMT3 EEFMT3	EFMT4 EEFMT4	EFMT5 EEFMT5
TS1150	No	No	No	Read/write	Read/write
TS1140	Read only	Read only	Read/write	Read/write	No

All 3592 tape drives support cartridge reuse. The 3592 tape cartridges can be reformatted to any tape format that is supported by the tape drive when the tape is written from BOT. When the tape is reformatted, all existing data on the cartridge is erased.

By using their supported densities, 3592 tape drives can use different media. Table 2-3 shows the capability of each drive to use media inside a TS4500.

Table 2-3   Drive and cartridge compatibility

Tape unit	JD, JL, or JZ cartridge	JC, JK, or JY cartridge	JB or JX cartridge
TS1150, TS1155	Read/write	Read/write	No
TS1140	No	Read/write	Read/write

Table 2-4 shows the media types, native capacity options, and compatibility options that are available with 3592 tape drives that are supported by the TS4500 tape library.

Table 2-4   IBM Enterprise 3592 media types

Media description	Media type	3592 55E, 55F format J5A native capacity	3592 EH8 format J5 native capacity	3592 EH7 format J4 native capacity	Case color	Label, door, and write-protect switch color
Extended data	JB	Not supported	Not supported	1.6 TB (1.46 TiB) / 1 TB (.9 TiB) E06 format	Black	Dark green
Advanced data	JC	7 TB (6.37 TiB)	7 TB (6.37 TiB)	4 TB (3.6 TiB)	Black	Dark purple
Advanced data	JD	15 TB (13.64 TiB)	10 TB (9.1 TiB)	Not supported	Black	Burnt orange
Advanced economy	JK	900 GB (.82 TiB)	900 GB (.82 TiB)	500 GB (.45 TiB)	Black	Light purple
Advanced economy	JL	3 TB (2.73 TiB)	2 TB (1.82 TiB)	Not supported	Black	Apricot
Extended WORM	JX	Not supported	Not supported	1.6 TB (1.46 TiB) / 1 TB (.9 TiB) E06 format	Platinum (silver-gray)	Dark green
Advanced WORM	JY	7 TB (6.37 TiB)	7 TB (6.37 TiB)	4 TB (3.6 TiB)	Platinum (silver-gray)	Dark purple
Advanced WORM	JZ	15 TB (13.64 TiB)	10 TB (9.1 TiB)	Not supported	Platinum (silver-gray)	Burnt orange

Figure 2-4 shows an example of the media types: a full length read/write tape on the left, WORM cartridges in the middle, and economy read/write cartridges on the right. The WORM cartridges have a platinum-colored shell, and the read/write cartridges have a black shell.

Figure 2-4   IBM Enterprise 3592 WORM and read/write cartridges

Labels

The 3592 cartridges use a media label to describe the cartridge type. Figure 2-5 shows a 3592 JD cartridge label. In tape libraries, the library vision system identifies the types of cartridges during an inventory operation. The vision system reads a *volume serial number* (VOLSER), which is on the label on the edge of the cartridge. The VOLSER contains 1 - 6 characters, which are left-aligned on the label. If fewer than 6 characters are used, spaces are added. The media type is indicated by the seventh and eighth characters.
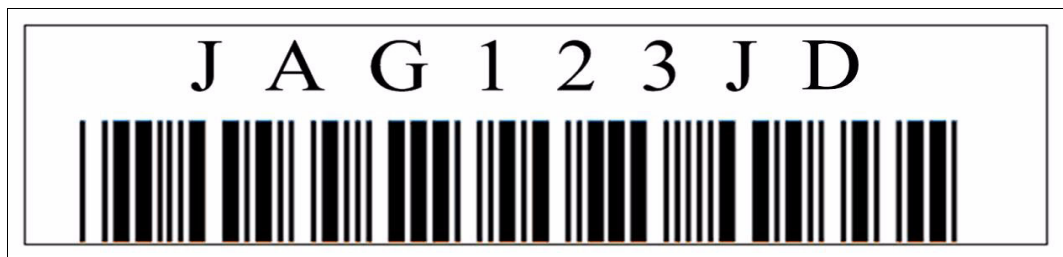

Figure 2-5   View of the 3592 cartridge label

Note: Client-printed bar code labels are not currently supported on the TS4500. Certain bar code labels that were previously scanned by the TS3500 successfully are not readable by the TS4500 at general availability (GA). Issues with reading media labels are most often issues with those labels that were printed by the client.

Cleaning cartridges

One cleaning cartridge is designed specifically for the 3592 tape drives. As with the data cartridges, the 3592 cleaning cartridges are not interchangeable with any other model cleaning cartridges (for example, LTO cleaning cartridges). Therefore, both types of cleaning cartridges must be inserted into the library if both types of drives are in the environment.

The cleaning cartridge also contains a cartridge memory device, which automatically tracks the number of times that it was used. Cleaning cartridges must be replaced after 50 cleaning cycles.

The physical characteristics of the 3592 cleaning cartridge can be used to distinguish it from the 3592 data cartridges. The product label on the top of the cartridge is white with the word "cleaning" printed on it. Instead of the write-protect switch, a non-moveable light gray block exists, which is shown as number 1 in Figure 2-6. The cartridge door is also light gray. If you order cleaning cartridges with pre-attached labels, the first three characters of the VOLSER are CLN, as identified by number 2 in Figure 2-6.
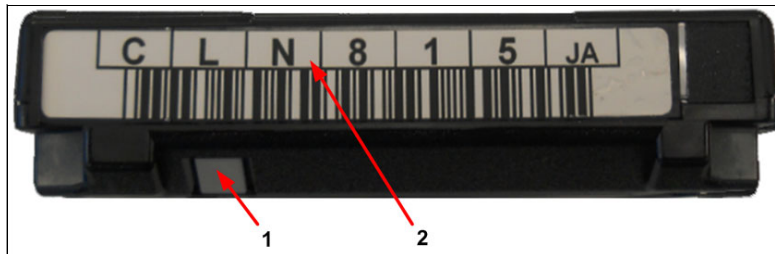

Figure 2-6   Cleaning cartridge

> **Note:** The IBM Enterprise Tape Cartridge is universal. It can be used on any model 3592 tape drive.

2.1.8 WORM functions

All 3592 tape drives with the appropriate installed microcode version can read and write WORM cartridges. The WORM data cartridges for the IBM 3592 tape drive provide nonalterable, nonrewritable tape media for long-term records retention. The WORM cartridges include the following characteristics:

- ► WORM cartridges are available in the following formats for the TS4500:
    - – JX (extended), which is supported by 3592 EH7, with 1.6 TB in EH7 format, and no support on the 3592 EH8, 3592 55E, and 3592 55F
    - – JY (advanced), which is supported by the 3592 EH7 and E0H tape drives only, 4 TB in EH7 format, and 7 TB in E08, 55E, and 55F formats
    - – JZ (advanced), which is supported by the 3592 EH8, E55, and F55, at 15 TB in 55E and 55F format, and 10 TB in E08 format
- ► Nonreversible screws are used to secure the media housing.
- ► WORM and read/write cartridges can be intermixed in the same IBM TS4500 tape library.
- ► When the drive senses that a cartridge is a WORM cartridge, the microcode prohibits changing or altering user data that is already written on the tape. The microcode tracks the last point on the tape to which data can be appended with an overwrite-protection pointer that is stored in the cartridge memory.
- ► Each WORM cartridge is identified by using a Worldwide Cartridge Identifier (WWCID), which is permanent and locked. The WWCID provides another level of security for data that must be maintained.
- ► A WORM cartridge can never be changed to non-WORM, and a non-WORM cartridge cannot be changed to WORM.
- ► User data that is written on WORM never can be modified or erased.

WORM basics

The 3592 tape drives support 3592 read/write cartridges and 3592 WORM cartridges. The WORM cartridge is geometrically identical to a read/write cartridge. It uses the same rewritable media formulation. However, the servo format, which is mastered onto the tape at manufacturing, is different for WORM cartridge types.

The WORM function does not come from any inherent non-reversible media characteristic (such as permanent WORM on optical CD-R media or optical WORM). Instead, the WORM function is enabled by the method by which the microcode of the 3592 drive handles a WORM cartridge.

The microcode of the drive does not support the overwrite or erasure of previously written user data, such as records or file marks. However, the microcode of the drive supports appending new data after the existing data.

Unique cartridge identifier

Each IBM 3592 tape WORM cartridge is identifiable through a unique cartridge identifier (UCID). The intent of the UCID is that it is constructed to ensure that it is unique worldwide. This identifier is derived from the 4-byte unique cartridge memory serial number of the cartridge memory chip in the 3592 WORM cartridge.

This serial number is concatenated with the 8-byte unique tape serial number that was created from information that was mastered into the timing-based servo at the time that the cartridge was manufactured.

The parts of UCID that come from this combined serial number are written to a locked part of the cartridge memory. This other level of security supports legal audit requirements. Furthermore, the UCID supports unique cartridge tracking, and it can be the differentiator to using other WORM tape providers.

Drive operation to prevent overwriting

A WORM drive handles a WORM cartridge differently than a read/write cartridge. In general, a WORM drive responds to a subset of the Small Computer System Interface (SCSI) commands that work on a read/write cartridge. For example, an `Erase` command is rejected with the correct error posted.

Additionally, a WORM drive rejects certain command sequences of otherwise valid commands. For example, if a cartridge is not empty, a `Rewind` command that is followed by a `Write` command is rejected with the correct error posted.

The microcode tracks the last point that can be appended on the tape by using an overwrite-protection pointer that is stored in the CM. The SARS data can be written and updated on WORM tapes because the SARS data is not in the user area of the tape.

The 3592 tape drives allow append operations to data that is already on WORM cartridges, and allow overwriting of file marks and other non-data attributes to provide application transparency. However, they do not allow overwriting data under any circumstances. After they are full of data, WORM cartridges cannot be reused or erased by the drive, and they must be physically destroyed or bulk-degaussed to delete data. For full tape application use, certain trailer and label record overwrites are allowed.

> **Important:** WORM cartridges cannot be reused after they are written to, so WORM cartridges must be physically destroyed when they are no longer of use. If the WORM cartridge has sensitive data, it must be bulk-erased before it is discarded. This erases everything on the tape, including the mastered servo pattern, rendering the tape useless.

2.1.9 Tape encryption for TS1155, TS1150, and TS1140

The TS1155, TS1150, and TS1140 tape drives use an Advanced Encryption Standard (AES) encryption key, which is a random string of bits that are generated specifically to scramble and unscramble data. Encryption keys are created by using algorithms that ensure that each key is unique and unpredictable. The longer the key string is, the harder it is to break the encryption code. These drives use 256-bit AES algorithm keys to encrypt data.

The following types of encryption algorithms are used for encryption:

► Symmetric algorithms

Symmetric (or *secret key*) encryption uses a single key for encryption and decryption. Symmetric key encryption generally is used for encrypting large amounts of data efficiently.

► Asymmetric algorithms

Asymmetric encryption uses a pair of keys. Data that is encrypted by using one key can be decrypted only by using the other key in the asymmetric key pair.

When an asymmetric or public/private key pair is generated, the public key is used for encryption, and the private key is used for decryption.

TS1155, TS1150, and TS1140 tape drives use both types of encryption algorithm. Symmetric encryption is used for high-speed encryption of user or host data. Asymmetric encryption (which is slower) is used for protecting the symmetric key that is used to encrypt the data (key wrapping).

The TS1155 and TS1150 support the capability to record both encrypted and plain data on a given volume, under certain circumstances. as follows:

► The drive must be in Application Managed Encryption (AME) (T10 method).

► In the T10 mode, encryption is controlled on a block-by-block basis by the application. New key associated data will be stored within J5A and J5 format datasets as required to support this feature. Labels are not recorded using the zero-key method in this mode.

► The reported Format Identifiers in Medium Sense will report non-encrypted J5A and J5 format identifier, unless all blocks on the medium are encrypted. Encryption format for a volume will be determined at first write from BOT, and will be enforced for all subsequent appended blocks. Labels will be encrypted with zero key in this mode.

The TS1155, TS1150, and TS1140 tape drives support a number of encryption management techniques for open systems:

► Application-managed encryption (AME)
► Library-managed encryption (LME)
► System-managed encryption (SME) (for z/OS only)

> **Note:** System-managed encryption (SME) is supported on the TS4500 for TS1140 and TS1150 drives only. This is provided for TS7700 IBM z Systems® attachment only.

For more information about encryption, see Chapter 3, "Encryption" on page 149.

IBM Security Key Lifecycle Manager

IBM Security Key Lifecycle Manager (SKLM) is the IBM strategic platform for the storage and delivery of encryption keys to encrypt storage endpoint devices. IBM SKLM can be used with the TS1155, TS1150, and TS1140 tape drives. Similar to the previous product, IBM Encryption Key Manager (EKM), SKLM serves data keys to the tape drive.

It focuses on ease of use and provides a graphical user interface (GUI) to help with the installation and configuration of the key manager. It also allows for the creation and management of the key encrypting keys (certificates).

For more information about IBM Security Key Lifecycle Manager, see the IBM Security Key Lifecycle Manager V2.5 documentation in IBM Knowledge Center:

http://www.ibm.com/support/knowledgecenter/SSWPVP_2.5.0/com.ibm.sklm.doc_2.5/welcome.htm

2.2 IBM TS1155 and TS1150 tape drive

The IBM TS1155 tape drive (which is also referred to as the *3592 Model 55G, 55E or 55F)* is an enhanced fifth-generation tape drive of the IBM 3592 tape family. The TS1155 tape drive provides higher levels of cartridge capacity than the TS1150 Model E08 (EH8). It is designed to provide an increased capacity of 50% on JD media types compared with its predecessors.

> **Note:** The TS1155 model 55G and TS1150 E08 are drives designed for installation in the TS3500.

The primary difference of the TS1155 (55E, 55F) from the base TS1150 drive (EH8) is that the capacity is increased 50% on JD media types, and for the TS1155 model 55E the replacement of FC host attachment by 10 GB Ethernet (RoCE v2) ports.

The TS1155 model 55F tape drive has a dual-port, 8-Gbps Fibre Channel interface for Fibre Channel attachment to host systems, or a switched fabric environment.

The TS155 model 55E tape drive has a dual-ported 10 Gb Ethernet port for host attachment, which is optimized for cloud-based and large, open-compute environments.

The TS1155 Tape drive is capable of reading and writing 15 TB capacity on existing JD media types (JD/JZ/JL) compared to 10 TB for TS1150. The TS1155 tape drive supports JC 4 TB format (read-only) and JC 7 TB format (R/W). Media written in TS1155 format is not readable by TS1150, but is back-portable for reformatting to TS1150 format of 10 TB.

The TS1155 Tape drive is not compatible with IBM TS7700 or Enterprise Tape Control Unit environments.

The IBM TS1150 tape drive (which is also referred to as the *3592 Model EH8)* is the fifth tape drive generation of the IBM 3592 tape family. The TS1150 tape drive provides higher levels of performance, reliability, and cartridge capacity than the TS1140 Model EH7 tape drive.

The TS1155 and TS1150 utilize new Tunnel Magneto Resistive TMR head technology, and initial generations of the TS1150 utilize a Giant Magneto Resistive (GMR) head design. Both are high-technology, 3-module, 32-channel head technology for higher native data rate performance.

The TS1155 and TS1150 provide a native data rate performance of up to 360 MBps versus the 250 MBps data rate of the TS1140 tape drive Model EH7.

The TS1150 EH8 and TS1155 55F tape drives have dual-port 8-Gbps Fibre Channel interface for Fibre Channel attachment to host systems, or a switched fabric environment.

The TS1155 and TS 1150 record in two native recording formats, supporting encryption and nonencryption:

► J5A logical format is used to represent the non-encrypted recording format for TS1155, and J5A-E is used to denote the encrypted recording format for TS1155.

► J5 logical format is used to represent the non-encrypted recording format for TS1150, and J5-E is used to denote the encrypted recording format for TS1150.

The TS1155 is downward read-only compatible to TS1140 format (J4 and J4-E) on supported cartridges, and the TS1150 is downward read/write compatible to the TS1140 formats.

Note: The TS1150 and TS1155 cannot read or write any format from J3, J3-E (TS1130), or earlier.

The host interfaces to open systems platforms are maintained as with previous 3592 models.

The TS1155 and TS1150 support integration with the TS4500 tape library. Figure 2-7 shows the IBM TS1150 (3592 EH8) tape drive and the TS 1155 (3592 55E and 55F) will be physically the same format as the TS1150.

Figure 2-7   TS1150 tape drive

The TS1155 and TS1150 drive maintains the same features and technology enhancements that were introduced with the TS1120 and extended by the TS1130 and the TS1140. In addition.The TS1155 and TS 1150 offers several enhancements over the predecessor models, which are described next.

When replacing a TS1155 55E drive, the TS4500 will maintain all iSCSI configuration for the new drive by copying the iSCSI configuration to the new dive, such as the IP address information and iSCSI names.

The port MAC address might change depending on which level of LCC card is installed. On the original version of LCC card, the MAC address might have to be changed manually by using the CLI if you want to maintain the same MAC address of each port.

With the latest level of LCC card, the MAC address to be maintained as the same as the replaced drive, so no setting of MAC address is needed. This card will overwrite the MAC address with a TS4500-assigned address. This card is identified by the label on the LCC card, show in a Version 4.4 or higher, as shown in Figure 2-8.
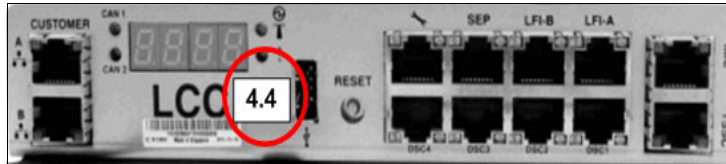

Figure 2-8   New model LCC card

The TS1155 and TS1150 have the following key features, including those features that were introduced with the 3592-J1A, 3592-E05, 3592-E06, and 3592-E07 (EH7):

► Digital speed matching
► Channel calibration
► High-resolution tape directory
► Recursive accumulating backhitch-less flush or nonvolatile caching (NVC)
► Backhitch-less backspace
► Virtual backhitch
► Read ahead
► Synchronous Data Link Control (SDLC) compression
► Capacity scaling
► Single FRU
► Error detection and reporting
► SARS
► Revised encryption support
► Dual-stage 32-head actuator
► Offboard data string searching
► Enhanced logic to report logical end of tape
► Added partitioning support
► Data Safe mode
► Enhanced Ethernet support
► New enhanced Barium Ferrite (BaFe) particle media types
► Dual-port, 8 Gb FC attachment with failover support for FC drives
► Dual port, 10 Gb Ethernet ports for TS1155 55E
► Max Capacity mode logical end-of-tape (LEOT) support for up to 4% more capacity
► Partitioning that is supported by Spectrum Archive and IBM Linear Tape File System™ (LTFS)

2.2.1 Physical attachment

The TS1155 and TS1150 are supported for attachment in the IBM TS4500 and communicates with the TS4500 tape library through an internal Ethernet interface, and uses Statistical Analysis and Reporting System (SARS) to isolate failures between the media and the hardware.

The TS1155 Model 55F and TS1150 Model EH8 offers a dual-port 8 Gbps Fibre Channel host attachment interface. This feature provides flexibility in open systems environments, because the drives can attach to open systems servers directly with Fibre Channel attachments.

The TS155 model 55E tape drive has a dual-ported 10 Gb optical Ethernet ports for host attachment. This drive has been optimized for cloud-based and large, open-compute environments

These drives have similar back panels, which is shown in Figure 2-9 for the TS1155 model 55F and TS1150 model EH8.
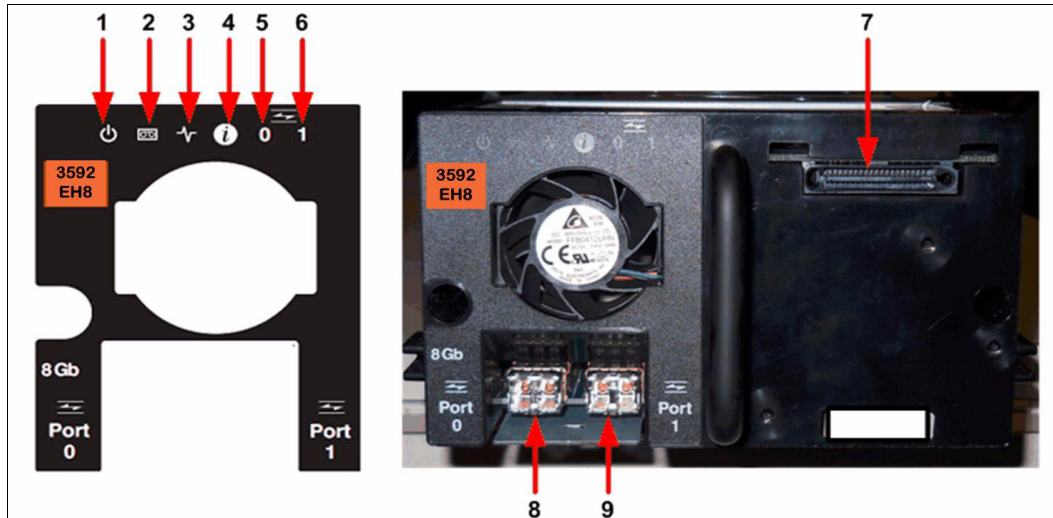

Figure 2-9   TS1155 model 55F and TS1150 rear panel

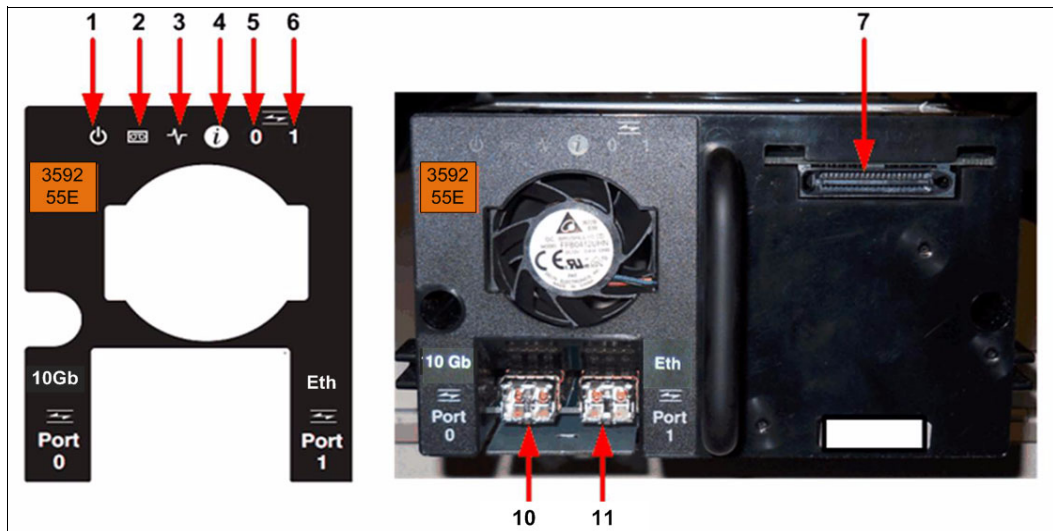Figure 2-10 shows the rear panel for the TS1150 and TS1155 model 55E.

Figure 2-10   TS1155 model 55E rear panel

Table 2-5 describes all of the components on the rear panel and shows the normal status of the light-emitting diodes (LEDs). The numbers in Table 2-5 relate to the numbers in Figure 2-9 on page 84 and Figure 2-10 on page 84.

Table 2-5   Rear panel

Number	Description	LED color or description
1	Power status	Green
2	Drive status	Yellow or green
3	Library connection	Green
4	Information	Blue
5	Host port 0 activity	Green or yellow
6	Host port 1 activity	Green or yellow
7	TS4500 interface connector	TS4500 communication and power
8	Port 0, 8 Gbps fiber connection	Supports N_ports and NL ports, which can autoconfigure between using the FC-AL protocol and the Direct Fabric attach protocol
9	Port 1, 8 Gbps fiber connection	Supports N_ports and NL_ports, which can autoconfigure between using the FC-AL protocol and the Direct Fabric attach protocol
10	Port 0, 10 Gbps Ethernet connection	RoCE v2 protocol. Short wave multimode optical SFP transceiver
11	Port 1, 10 Gbps Ethernet connection	RoCE v2 protocol. Short wave multimode optical SFP transceiver

The TS1155 and TS1150 have the same front bezel with a chevron fiducial as the TS1140. The buttons and display are the same buttons and display on all of the previous models of 3592 drives.

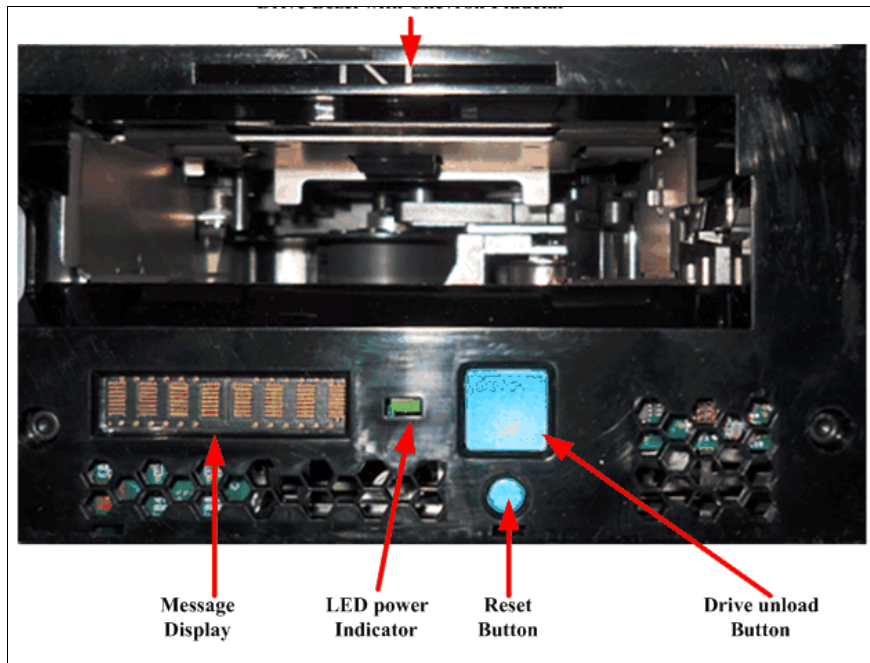Figure 2-11 shows the front of the 3592 EH8 tape drive.

Figure 2-11   TS1155 and TS1150 front panel

2.2.2 TS1155 and TS1150 physical characteristics

The TS1155 and TS1150 drives have an identical form factor, and it is plug-compatible with existing 3592 models. It maintains low power and improves power management. The maximum continuous operating power was decreased by 5 watts from the TS1140. The drive power usage is 46 watts maximum operating power, as compared to 51 watts for the TS1140. Standby power is fewer than 23 watts.

They have a standby cooling management feature, which reduces the fan speed when the drive is idle to further reduce power and reduce airborne debris contaminants. The fan operating mode is controlled by a single input signal that is called *full-speed mode* or *variable-speed mode*. In full-speed mode, the fan or blower runs at full speed. In variable-speed mode, the blower adjusts its speed based on the ambient temperature down to a minimum of about 50% of its full speed.

The speed of the fan is based on the following conditions:

► The drive code enables variable-speed mode under the following conditions:

– The drive is unloaded and idle for 5 minutes.
– The internal temperature is at least 3 degrees below the full speed required temperature limit.

► The drive code reverts to full-speed mode as soon as the following conditions are met:

– A cartridge is placed in the loader or loaded.
– The internal temperature of the drive rises above the full speed required temperature limit.

The internal temperature sensor is sampled at 5-minute intervals.

Internal hardware enhancements

These drives feature the following significant hardware enhancements over the previous models:

► Thirty-two channel-enhanced error correction code (ECC) recording format.

► Enhanced JD-type media servo pattern.

► Flangeless rollers, which are designed to minimize tape edge damage and debris buildup by the elimination of the roller flanges.

► Tunnel Magneto Resistive (TMR head) on the TS1155 and on new version of the TS1150 whereas older generation of TS1150 use a Giant Magneto Resistive Heads (GMR head). These advanced heads are designed to reduce friction with advanced head coating to prevent corrosion and to extend head and tape cartridge life.

► Skew Actuator, which allows dynamic skew adjustment of the head to keep the head perpendicular to the tape.

The data-dependent, noise-predictive, maximum-likelihood (DD-NPML) detection scheme was developed at IBM Research, Zurich, to enable the accurate detection of data errors.

2.2.3 Media

The TS1155 and TS1150 drives use the following enhanced Barium Ferrite (BaFe) second-generation particle media types. The new media can be read/written up to 360 MBps native sustained data rate (up to 700 MBps at 3:1 compression ratio) in the new 32-channel Jag 5, 5E, 5A, and 5AE logical format, as shown in Table 2-6.

Table 2-6   Media type and read/write format compatibility

Media type	TS1155				TS1150				
	Logical Format read/write				Logical Format read/write				z/OS Media Type
JD	J5A	J5A-E	J5	J5-E	J5	J5-E			Media 14
JZ	J5A	J5A-E	J5	J5-E	J5	J5-E			Media 15
JL	J5A	J5A-E	J5	J5-E	J5	J5-E			Media 16
JC	J5A	J5A-E	J5	J5-E	J5	J5-E	J4	J4-E	Media 11
JY	J5A	J5A-E	J5	J5-E	J5	J5-E	J4	J4-E	Media 12
JK	J5A	J5A-E	J5	J5-E	J5	J5-E	J4	J4-E	Media 13

Important: The TS1155 and TS1150 are not compatible with several older 3592 cartridge media types: JA, JB, JW, JJ, JR, and JX media types J3, J2, and J1. (MEDIA5, MEDIA6, MEDIA7, MEDIA8, MEDIA9, and MEDIA10).

► These drives improve capacity and performance by writing and reading J5 and J5A logical format, by using a new 32-channel enhanced ECC recording format with a higher track density and higher linear density on the same media types.

► The appropriate microcode levels that are available for TS1150 and TS1140 and must be installed that enable the recognition of the J5A and J5 format and allow reuse of the media in the older formats. Therefore, a model J5A drive can reformat media that was written in the older format, and write on it in the appropriate format.

> **Important:** This design supports a common scratch pool by media type regardless of the last written format or allocation target drive.

2.2.4 Capacity and performance

Capacity and performance were improved from the TS1155 and TS1150 tape drive for all media types, and for all formats that the drives reads or writes.

Capacity improvement

The use of the 3592-55E and 55F logical format offers the following capacity improvements on existing and new cartridges:

- ► IBM Enterprise Advanced Data media (JZ and JD), which is a capacity of 15 TB
- ► IBM Enterprise Advanced Data media (JC and JY), which is a capacity of 7 TB
- ► IBM Enterprise Economy Data media (JZ), which is a capacity of 3 TB
- ► IBM Enterprise Economy Data media (JK), which is a capacity of 900 GB

The use of the 3592-EH8 logical format offers the following capacity on existing and new cartridges:

- ► IBM Enterprise Advanced Data media (JZ and JD), which is a capacity of 10 TB
- ► IBM Enterprise Advanced Data media (JC and JY), which is a capacity of 7 TB
- ► IBM Enterprise Economy Data media (JZ), which is a capacity of 2 TB
- ► IBM Enterprise Economy Data media (JK), which is a capacity of 900 GB

Performance improvement

The overall performance is increased over the previous model by various improvements:

- ► Improved data rate and capacity
- ► Improved latency by reducing access time to data
- ► Improved data compression
- ► Beginning of partition (BOP) caching
- ► Humidity sensor support
- ► Increased cartridge memory size and related functions
- ► Improved high-resolution tape directory (HRTD)
- ► Larger main data buffer
- ► Extended copy support

Higher data rates and capacity

The following format data rates are available (at 256K and greater block size):

- ► The 55E format data rates go up to 360 MBps maximum native, and to 600 MBps maximum compressed.
- ► The EH8 and 55F format data rates go up to 360 MBps maximum native, and to 700 MBps maximum compressed.
- ► The EH7 format data rates go up to 250 MBps maximum native, and to 700 MBps maximum compressed.

Table 2-7 summarizes the capacity and performance characteristics for uncompressed data.

Table 2-7   Capacity and performance summary

Media	55E or 55F format capacity native data rate (minimum - maximum)	EH8 format capacity data native rate (minimum - maximum)	EH7 format capacity native data rate (minimum - maximum)
JC or JY	7 TB (6.37 TiB) 99 MBps - 303 MBps	7 TB (6.37 TiB) 99 MBps - 303 MBps	4 TB (3.6 TiB) 90 MBps - 251 MBps
JD or JZ	15 TB (13.64 TiB) 112 MBps - 365 MBps	10 TB (9.1 TiB) 112 MBps - 365 MBps	N/A
JK	900 GB (.82 TiB) 99 MBps - 303 MBps	900 GB (.82 TiB) 99 MBps - 303 MBps	500 GB (.48 TiB) 90 MBps - 251 MBps
JL	3 TB (2.73 TiB) 112 MBps - 365 MBps	2 TB (1.82 TiB) 112 MBps - 365 MBps	N/A

Improved latency

These tape drives adds features to improve latency by reducing access time to data:

► Improved locate and rewind speed profile for the new media types by using 12.4 meters (13.5 yards) per second (m/s) end-to-end versus 12.4 m/s profiled (JD, JZ, and JL media only):

 – JD, JZ, and JL media feature a redesigned brake button for higher reliability, longer life, and higher locate speeds.

 – The improved profile represents a 9% speed improvement for a rewind/locate operation from EOT to BOT versus the previous profile, which partially compensates for the longer tape length of the new media types.

► Load and thread times are reduced by approximately 33% from 15 seconds load/ready to 10 seconds load/ready. This reduction applies to both JC and JD media types.

This improvement is possible by operating the motors at a higher operating speed for repeatable read (RR), loader, and threader motors.

Improved data compression

The TS1155 and TS1150 drives feature a larger history buffer usage in the compression core. This change increases the history buffer from 1 KiB to 16 KiB, which enables more efficient compression by increasing the history over which string matches can be applied. The new method can increase the nominal compression ratio for the Calgary Corpus data standard from approximately 2.0 to 3.1.

> **Note:** For the TS1150, the improved compression method is only available when you process the EH8 logical formats on the new JD, JZ, and JL media or on unformatted JC, JY, or JK media. When you process the EH7 format, the historical compression method is used for compatibility. TS1155 cannot write in EH7 format.

As in previous models, the 3592 tape drive uses the data compression that is known as *Streaming Lossless Data Compression Algorithm* (SLDC). This compression method is identical to the method that was used in previous models, except for the larger history buffer. SLDC is an implementation of a Lempel-Ziv class 1 (LZ-1) data compression algorithm. SLDC is an extension to the Adaptive Lossless Data Compression (ALDC) algorithm, which is used in leading industry tape products. Users of SLDC can expect to achieve the same, or better, data compression as users of ALDC.

A key difference between SLDC and previous lossless compression algorithms is that record boundaries and file marks are encoded as control symbols. The encoding of record boundaries and file marks as control symbols allows the compressed data stream to be separated into a serial stream of records and file marks by the decompression logic without requiring additional information, such as information from an attached header.

Beginning of partition caching

These drives implement beginning of partition (BOP) caching. In this implementation, after the initial set of tape blocks in a partition is read, either by the read-ahead function or an explicit command, the initial set of tape blocks remains in a special place in the cache data buffer (until an unmount or a partition change). Subsequent locate operations to BOP or read operations of these blocks complete quickly, without requiring completion of physical motion. BOP caching is supported in all partition modes.

This feature is automatic, cannot be disabled, and uses approximately 6 MB space (one data set) in the main data buffer.

Humidity sensor

The drives contains a humidity sensor and a temperature sensor. The humidity sensor provides the following functions:

► Humidity tracing in drive logs

   The drive logs humidity data in the tape map during read and write.

► Maximum humidity logging in cartridge memory

   The maximum humidity that is sensed during a cartridge mount is loaded in the cartridge memory.

► Humidity data is externalized in log pages and, like temperature data, humidity data can now be read through standardized SCSI Log pages by an initiator. However, there is no capability to set environmental thresholds.

Increased cartridge memory size and related functions

The new JD, JZ, and JL media types contain 16 KB cartridge memory (CM), which increased from the 8 KB that was contained in JC and JB media types. The CM contains a larger medium auxiliary memory (MAM) area, which is available to the application.

Improved high-resolution tape directory

The TS1155 and TS1150 drive provides a higher-granularity directory to improve the accuracy of tape locate operations for the new JD, JZ, and JL media types. The granularity of wrap entries is increased from 64/wrap to 128/wrap for the new media types. High-resolution tape directory (HRTD) resolution for JC media types is unchanged. HRTD directories are maintained separately for partitions.

They maintain a tape directory structure with a high granularity of information about the physical position of data blocks and file marks on the media. The longitudinal position (LPOS) longitudinal location information that is contained in the servo pattern is associated with and recorded with the host block information in the HRTD. This feature allows the 3592 to have fast and consistent nominal and average access times for locate operations.

Therefore, locate times are uniform and based on the position of the block or file mark on the tape independently of the uniformity of the block size or file mark distribution along the length of the tape.

The HRTD feature maintains an overall granularity of 64 directory entries per logical wrap:

► JA media 570 m (623.36 yards) logical wrap results in a granularity of 8.9 meters (29.1 ft.).

► JB media 775 m (847.55 yards) logical wrap results in a granularity of 12.1 meters (39.6 ft.).

► JC media 842 m (920.8 yards) logical wrap results in a granularity of 13.2 meters (43.3 ft.).

► JD media 1032m (1128.6 yards) logical wrap results in a granularity of 8.06 meters (26.4 ft.). For the segmented or scaled formats with shorter logical wraps, granularity is improved.

The 3592 drive has many redundancy and recovery features that prevent the possibility of data loss in the loss of a directory and allow a rebuild of the directory under all circumstances:

► The HRTD table consists of information for each logical wrap. Each wrap area contains up to 64 entries. Each entry contains the LPOS, logical block, and file mark count information with access point and other internal information of interest.

► The entire HRTD table is stored in the housekeeping data set on tape. The entire HRTD structure is also written in the end-of-data (EOD) data set for the tape if the tape has a valid EOD. The HRTD entries are also distributed in accumulating sequential fashion into the Data Set Information Table of all user data sets as they are written on tape. Control structures, which define the validity of the HRTD and EOD information on the tape, are in the cartridge memory.

► If a valid HRTD cannot be recovered from the housekeeping data set, the HRTD might be rebuilt by using the EOD or distributed copies of HRTD information. The HRTD can also be rebuilt by reading the tape. Depending on the mechanism that must be used to rebuild the HRTD, this rebuild can occur quickly (seconds if the EOD copy can be used) or take longer (minutes if a full rebuild is required).

► The drive can read all data from a cartridge without any HRTD information, although locate times might be affected. However, the drive does not allow a write operation without a valid HRTD to guarantee the integrity and validity of the information on tape.

Larger main data buffer

These drives feature a 2 GB main data buffer, which is twice the size of the 1 GB main buffer in the TS1140 drive. The additional buffer is used to improve overall performance, reduce backhitches, improve speed matching performance, and support BOP caching and other improvements.

External copy support

These drives support the *external copy* function, which offers these advantages:

► The capability is similar to serverless copy in that it allows data to be copied from one drive to another drive with no transfer through the host at high data rates.

► Data can be an entire volume or a group of logical blocks.

► The hosting drive (TS1155 or any drive that supports the feature) can pull or push data to a second drive of any type (vendor-neutral and does not require feature support).

► The function works in a SAN environment, and it is supported on true switches (non-hubs).

SkipSync or Same Wrap Backhitchless Flush mode feature

These drives, like previous models, implement a feature that is known as same wrap backhitchless flush mode (SWBF mode), which is also called the *SkipSync* feature. This feature is similar to previous models, plus the following enhancements:

► In default mode, SkipSync is enabled to use up to 1.5% capacity loss and uses spare capacity, so no impact occurs to client capacity in the nominal Constant Capacity LEOT mode.

► SkipSync can be programmed through Mode page 0x30 to allow up to 33% capacity loss, which essentially enables SkipSync for all transactions.

► The performance (throughput) improves for operations or transaction sizes that use SkipSync because of the increased nominal data rates of the TS1150.

How SkipSync operates

When a sync command (`WFM 0`) or a Write File Mark (WFM) non-immediate command is received after a block or series of data blocks (referred to here as a *transaction*), the TS1150 drive does not perform a backhitch immediately after the synchronization or WFM completes. Instead, it continues to stream on the same wrap and write a Data Set Separator (DSS) pattern until enough data is received to record additional data sets. SkipSync results in a significant performance improvement due to backhitch avoidance but a reduction in the overall available capacity on the volume.

In default mode, SWBF mode (SkipSync) is entered after a flush is received under these conditions:

► The received transaction size is greater than 204 MB compressed.
► The drive is not already in Recursive Accumulating Backhitchless Flush (RABF) mode.
► Enough excess capacity remains based on the current LPOS so that the drive predicts that it will still achieve the minimum capacity threshold that is selected. The minimum capacity threshold is 1.5% for the TS1150 default mode.

Dynamic speed matching support

The TS1155 and TS1150 drives continues to perform dynamic speed matching to minimize backhitches when it operates from a host that cannot sustain the maximum data rate. The drive performs dynamic speed matching automatically to adjust the native data rate of the drive as closely as possible to the net host data rate (after data compressibility is factored out).

The following data rate ranges depend on the logical format and the media type that are used:

► Twelve speeds from 112 MBps to 365 MBps for 3592 JD, JZ, and JL cartridges that are initialized in J5 and J5A format

► Twelve speeds from 99 MBps to 303 MBps for 3592 JC, JY, or JK cartridges that are initialized in J5 format

► Twelve speeds from 62 MBps to 252 MBps for 3592 JC or JY cartridges that are initialized in J4 format

Throughput is increased through speed matching as the drive performs the following functions:

► Adjusts tape speed based on host data rate
► Calculates effective host data rate (EHDR)
► Optimizes data rate by selecting optimal EHDR
► Forces speed changes mid-wrap if it is advantageous
► Minimizes time to record data

Virtual backhitch

These drives include the following key feature improvements:

► Virtual backhitch (transaction write with sync)
► Single wrap backhitchless flush (large transaction writes with sync)
► Backhitchless backspacing (American National Standards Institute (ANSI) file writes)

The TS1150 and TS1155 function is improved with Recursive Accumulating Backhitchless Flush (RABF) and the addition of a new same wrap backhitchless flush (SWBF) function that extends virtual backhitch effectiveness for large files.

Fast sync and skip performance for these tape drive are enhanced because of the better data rate performance over the TS1140.

For more information about these features, see "Virtual backhitch (nonvolatile caching)" on page 69.

Read ahead feature

On sequential reads, the tape drive automatically runs *read ahead* and fills the buffer with data sequentially beyond the target block.

These drives support advanced automatic read-ahead and read-space virtualization at improved access performance and 2x data buffer size. When the drive processes a command to locate or read a block, the drive automatically continues to stream down the tape and to 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.

With this unique function, the drive outperforms competitive drives, which stop and wait for the next command.

Performance scaling and segmentation

These drives support for capacity scaling is summarized next. They support capacity scaling only on full-length R/W media type (JD or JC).

Format support

The TS1155 drive models support capacity scaling only on the JD full length R/W media type.

The TS1150 drive writes the EH7 scaled format (JC media only) and the scaled EH8 format (on JC and JD media). Segmented formats are supported.

EH7 scaled format behavior on JC media is unchanged from the TS1140, and full cartridge *accumulating backhitchless flush* (ABF) capability is supported on any scaled cartridge.

When a scaled cartridge is up-formatted, the scaling value is retained, and the scaled capacity is uplifted to the capacity ratio of the new format.

Partitioning support

The following partitioning is supported:

► Scaling is supported only on single partition cartridges.

► Issuing a `Format Medium` command to attempt to partition a scaled cartridge results in the rejection of the command.

► Scaling a partitioned cartridge results in resetting the cartridge to a scaled, single partition format.

The effect of *capacity scaling* is to contain data in a specified fraction of the tape, which yields faster locate and read times. Alternatively, economy tapes (the JK or JL media type) can be purchased.

Performance scaling limits the data that is written to the first 20% of the cartridge. When the performance segmentation option is used, the overall capacity of the cartridge is limited to 86.6% of the total capacity.

The fast access segment occupies the first 20% of the cartridge, followed by the slower access segment. Medium capacity is calculated as a fraction of nominal maximum capacity. Scaled medium capacity is approximately equal to the nominal unscaled medium capacity times this value divided by 256.

Segmentation is available only within a specified range of capacity scaling settings that achieve this faster performance.

> **Note:** On a TS1155 when a scaling operation is requested on a JD type cartridge, the media will be up-formatted to the J5A logical format at the same time the scaling operation is performed unless the format is controlled through explicit means.
>
> On a TS1150 when a scaling operation is requested on a JC type cartridge, the media is reformatted to the J5 logical format at the same time that the scaling operation is performed unless the format is controlled through explicit means.

Cartridges that are performance-scaled or performance-segmented can be reused (reformatted) to their full capacity, to the performance-scaled capacity, or to the performance segmentation format as indicated through the assigned data class.

> **Important:** Capacity scaling is not supported for economy (JK and JL) or WORM tapes (JY and JZ).
>
> **Tip:** Check the *IBM Tape Device Drivers Installation and User's Guide,* GC27-2130, for the capacity scaling limitations and instructions for setup.

2.2.5 Access performance specifications and drive characteristics

Table 2-8 summarizes the access performance and drive characteristics of the 3592-55E, 3592-55F, 3592-EH8 and 3592-EH7. For better performance, the block size of the data should be 256K or greater.

Table 2-8   Access performance specifications and drive characteristics

Parameter	3592-EH8, 55E and 55F	3592-EH7
Tape speed, locate/rewind	12.4 mps	12.4 mps
Drive load/ready time	12 seconds (s)	15 s
Block locate time from load point average	40 s for JC and JY 45 s for JD and JZ 11 s for JK 13 s for JL 12 s 20% scaled JC 13 s 20% scaled JD	37 s for JB and JX 40 s for JC and JY 11 s for JK 15 s 20% scaled JB 12 s 20% scaled JC
Time to first data average (load/ready + locate)	50 s for JC and JY 55 s for JD and JZ 22 s for JK 23 s for JL 23 s 20% scaled JC 23 s 20% scaled JD	42 s for JB and JX 55 s for JC and JY 26 s for JK 30 s for 20% scaled JB 27 s for 20% scaled JC
Unload time	36 s for JD, JZ, JL, JC, JY, and JK	24 s for JB and JX 36 s for JC, JY, and JK
Maximum rewind time	76 s 100% scaled JC and JY 26 s 20% scaled JC 18 s JK 94 s 100% scaled JD and JZ 34 s 20% scaled JD and JZ 34 s JL	72 s 100% scaled JB and JX 24 s 20% scaled JB 76 s 100% scaled JC and JY 26 s 20% scaled JC 18 s JK
Native data rate	360 MBps	250 MBps
Device data rate: Maximum that is sustained with maximally compressible data	700 MBps 600 Mbps for 3592-55E	650 MBps
Interface burst transfer rate: Maximum	800 MBps (FC-8)	800 MBps (FC-8)
Number of tracks	J5A format, 7680 JD J5 format, 5120 JD, JZ, and JL J5 format, 4608 JC, JK, and JY	J4 format, 1792 JB and JX J4 format, 2560 JC, JK, and JY
Number of passes (from BOT to EOT)	J5A format 249 JD J5 format 160 JD, JZ, and JL J5 format 144 JC, JK, and JY	J4 format 56 JB and JX J4 format 80 JC, JK, and JY
Linear density	510 kilo bits per inch (Kbpi)	500 Kbpi
Servo regions	5	5
Data tracks recorded simultaneously	32	32
Buffer size	2 GB	1 GB

2.2.6 Emulation

The TS1150 supports drive emulation, but not emulation mode.

Emulation mode

The TS1150 does not support any emulation modes. Because the drive cannot write the TS1130, TS1120, or J1A logical format, it cannot fully emulate all format behaviors of a previous model 3592 drive.

Drive emulation

The TS1155 and the TS1150 tape drive do not support emulation, The TS1155 can read and write in J5A and J5 format with compatible IBM 3592 tape cartridges. The TS1150 can read and write in J5 and J4 format with compatible IBM 3592 tape cartridges.

The TS1155 tape drive can reformat any compatible J5 tape when it is writing from BOT and the TS1150 can reformat any J4 format tape. Table 2-9 shows the available modes for TS1150 and TS155.

Table 2-9   Drive emulation for TS1150

Drive mode setting	Formats read	Format that is used when the writing cartridge is at BOT	Format that is used when the writing cartridge is not at BOT	Model type that is reported to host in response to the Inquiry command
EH8 J5 format	J4 J5	J5	J5 if format at J5 J4 if format at J4	E08
55E and 55F J5A format	J5A J5	J5A	J5A if format at J5A J5 if format at J5	55E or 55F

The TS1150 can reformat a tape written in J5A format, but cannot read in this format.

2.2.7 IBM Spectrum Archive and LTFS support

TS1155 and TS1155 tape drives are compatible with the IBM Spectrum Archive software application and the underlying IBM LTFS. LTFS uses media partitioning functionality. LTFS provides a standard tape cartridge format at low cost, which can be used without other database applications. LTFS presents tape media as though it were a disk file system. IBM Spectrum Archive supports the IBM LTO Ultrium 8, 7, 6, and 5, and IBM TS1155, TS1150, and TS1140 tape drives.

Tape as a storage medium offers many benefits. Tape is reliable, portable, low-cost, low-power, and high-capacity. However, tape is not particularly easy to use. It has no standard format, and data often cannot be used unless the data is copied to disk first.

With IBM Spectrum Archive and LTFS, accessing data that is stored on an IBM tape cartridge became as intuitive as the use of a USB flash drive. With IBM Spectrum Archive, reading data on a tape cartridge is as easy as dragging and dropping a file. Users can run any application that is designed for disk files against tape data without concern that the data is physically stored on tape.

LTFS implements a true file system for tape. IBM Spectrum Archive also supports library automation, including the ability to find data on a tape in a library without mounting and searching tape volumes.

IBM Spectrum Archive Library Edition (LE) supports IBM tape automation and the single drive edition IBM Linear Tape File System. With IBM Spectrum Archive LE, you can create a single file system mount point for a logical library that is managed by a single instance of the software, which is running on a single server. In addition, it provides for caching of tape indexes, and for searching, querying, and displaying tapes' contents within an IBM tape library without the requirement to mount tape cartridges.

The TS1150 and TS1155 provides the same LTFS support as the TS1140, but with increased capacity and performance. LTFS is provided with the following features:

► Ability to configure up to four partitions
► Wrap-wise and longitudinal-wise partitioning
► Support on all non-WORM TS1140 formats (JC, JK, and JB formats)
► `Format` command support

For more information about IBM Spectrum Archive and LTFS, see 2.9, "IBM Spectrum Archive" on page 138.

2.2.8 Data safe mode

The TS1155 and TS1150 supports *data safe mode*. This mode is controlled by the application and prevents inadvertent overwrite. Data safe mode treats the tape volume that is mounted as a WORM drive and prevents inadvertent overwrite. This mode is set by the application or host system.

2.2.9 Upgrade considerations

A drive-field *Miscellaneous Equipment Specification* (MES)conversion feature is available for a 3592-EH7 model to 3592-EH8 model conversion to a TS1150.

> **Important:** If you choose this MES to replace the TS1140 drive, only the drive changes. The canister remains the same. The serial number of the original drive is written by the library to the vital product data (VPD) of the replacement drive. The MES is valid for both the TS4500 tape library and a rack-mounted drive.

TS1150 Field MES support
The following drive MES conversions are supported:

► 3592 EH8 drive > 3592 55F model upgrade
► 3592 E07 drive > 3592 E08 model upgrade
► 3592 E07 drive > 3592 EH7 model upgrade
► 3592 EH7 drive > 3592 EH8 model upgrade
► 3592 E08 drive > 3592 EH8 model conversion

> **Important:** You must load the IBM Assembly and Deploy Tools (IADT)-capable microcode for a TS1140 drive before the conversion to the EH8 model. Without it, communication to the library is not possible. The IADT-capable microcode can be obtained from IBM Fix Central. Only one MES model upgrade is supported in the life of the drive.

2.2.10 Firmware updates

No changes were made to the firmware update mechanisms for the TS1155 and TS1150 as compared to TS1140 tape drives:

► The TS1155 and TS1150 continues to support concurrent Licensed Internal Code (LIC) load with deferred activation.

► The TS1155 and TS1150 has a single LIC image that is unique from previous models.

Unique LIC is required for the model EH7 drives because the LOAD ID differs from the LOAD ID that is required for previous versions of 3592. The firmware for the 3592 55E, 55F, and EH8 drives can be updated by using one of the following methods, depending on where the drive is installed:

► Through the TS4500 management GUI
► Through the host attachment by using the write buffer command or IBM TotalStorage Tape Diagnostic Tool (ITDT)

2.2.11 RAS

The RAS features are improved or maintained relative to the TS1140. Similar to their predecessor models, the TS1155 and TS1150 are single FRU, which are hot-pluggable without a maintenance window and support nondisruptive code loading. As with the TS1140, fan speed management and unique device microcode file management are available through a LOAD ID.

The end of life usage alert for media activates on full-file pass usage. The Nearing Media Life alert occurs at 19,900 mounts or 295 full-file passes. The Media Life alert for JD or JL media use within a TS1150 drive is now rated for 20 M motion meters as opposed to 300 Full-File Passes (FFPs).

2.2.12 Improved media Statistical Analysis and Reporting System

The TS1155 and TS1150 supports Statistical Analysis and Reporting System (SARS) in a similar manner to previous drive models.

The tape drive uses SARS to help isolate failures between media and hardware. SARS uses the cartridge performance history (which is saved in the cartridge memory (CM) module) and the drive performance history (which is kept in the drive flash electrically erasable programmable read only memory (EEPROM)) to determine the likely cause of failure. SARS can cause the drive to request a cleaning tape to mark the media as degraded, and to indicate that the hardware is degraded.

SARS information is reported through the TapeAlert flags and through media information messages (MIMs) or service information messages (SIMs).

The 3592 drive maintains a history of the last 100 mounts for both Volume Statistical Analysis and Reporting System (VSARS) and Hardware Statistical Analysis and Reporting System (HSARS).

Note: Media SARS information is preserved when media is reformatted.

The TS1150 implements an enhanced SARS function that is known as client-centric SARS (ccSARS). This function improves the overall amount of information that is maintained, and the presentation means to the client in concert with the automation system.

The media SARS function for the drives includes the following actions:

► Tape alerts are generated when media passes usage life, as determined by full-file passes, meters of tape that were processed, or the write pass count, and the total number of mounts (which was already supported).

► A media SARS summary is maintained in the cartridge memory in a manner where it can be rebuilt on tape if the SARS records on tape cannot be read and must be reinitialized. This cartridge memory copy is also readable on an earlier level TS1140 drive to preserve SARS information between logical format conversions.

2.2.13 Encryption

The TS1155 and TS1150 tape drives are encryption-capable. Like the TS1140, you do not need to enable the drive explicitly.

Encryption support includes the following enhancements:

► LME, AME, and SME (for TS7700).

► T10 default method support.

► Continued encrypted data key (EEDK) wrapped key support in LME and SME.

► Enhanced protocol support for Internet Printing Protocol (IPP), which can be configured for security, and Java Platform, Enterprise Edition 2 historical mode (as used by IBM Spectrum Protect™), T10 default method, Security Protocol IN (SPIN), and Security Protocol OUT (SPOUT).

► Enhanced drive cryptographic upgrades to change the default authentication means from Secure Hash Algorithm-1 (SHA-1) to SHA-2 when you use IBM Security Key Lifecycle Manager.

► T10 standards-based encryption control on a logical block basis (not tied to format identifier) and writes encrypted data and clear data to the same tape cartridge.

2.3 IBM TS1140 tape drive (Model 3592 EH7)

The TS4500 tape library supports the TS1140 tape drive 3592 Model EH7.

The TS1140 tape drive offers a dual-port Fibre Channel (FC) host attachment interface. This feature provides flexibility in open systems environments because the drives can directly attach to open systems servers with FC attachments. All TS1140 tape drives are encryption-capable.

Currently, the IBM TS1140 tape drive (Model 3592 EH7) is the only HD2-compatible 3592 tape drive that is supported by the TS4500 HD2 frames.

Note: Drive Model 3592 E08 and E07 or earlier drives' models are not supported by the HD2 frames of the TS4500 tape library.

The 3592 tape drive communicates with the TS4500 tape library through an internal Ethernet interface and uses Statistical Analysis and Reporting System (SARS) to isolate failures between media and hardware.

The IBM TS1140 tape drive is the fourth tape drive generation of the IBM 3592 tape family, and it is designed to provide higher levels of performance, reliability, and cartridge capacity than the previous models of 3592 tape drives.

The TS1140 has a high-technology, 32-channel giant magneto-resistive (GMR) head design, and it provides a native data rate performance of up to 250 MBps versus the 160 MBps data rate of the TS1130 tape drive Model E06.

The TS1140 Model EH7 tape drive has a dual-port 8 Gbps Fibre Channel interface for Fibre Channel attachment to host systems, or a switched fabric environment.

The TS1140 records in two recording formats, supporting both encryption and non-encryption. Enterprise Format 4 (EFMT4) is used to represent the non-encrypted recording format. Enterprise Encrypted Format 4 (EEFMT4) is used to denote the encrypted recording format. With these recording formats, the noncompressed capacity of the extended length MEDIA11 and MEDIA12 cartridges is increased from 1 TB to 4 TB.

> **Note:** The 3592 JA, JW, and JJ (EMFMT1 and EMFMT2) media are not supported by the TS4500 tape library.

The TS1140 supports integration into the IBM TS4500 library by using a new compact drive sled. Figure 2-12 shows the IBM TS1140 tape drive sled.

Figure 2-12   TS1140 (3592 EH7)

The TS1140 has a new front bezel with a chevron fiducial. The buttons and display remain the same as for all previous models of the 3592 drives.

Figure 2-13 shows the front of the 3592 EH7 drive.
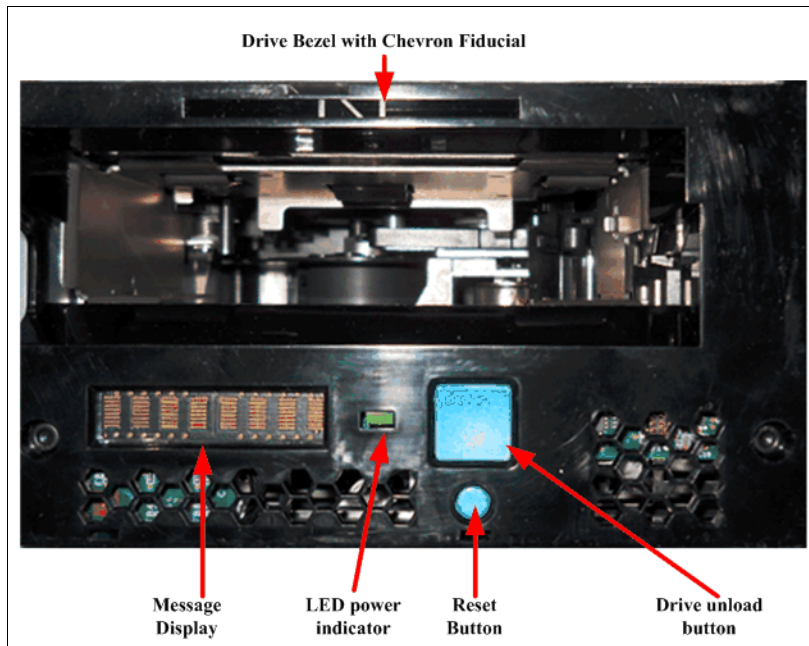
Figure 2-13   TS1140 EH7 front panel

The TS1140 tape drive maintains the same features and technology enhancements that were introduced with the TS1120 and extended by the TS1130. In addition, the TS1140 offers several enhancements, which are explained in more detail on the following pages, over the predecessor models.

The TS1140 offers the following key features, including those features that were introduced with the 3592-J1A, 3592-E05, and 3592 E07:

► Digital speed matching
► Channel calibration
► High-resolution tape directory
► Recursive accumulating backhitchless flush or nonvolatile caching (NVC)
► Backhitchless backspace
► Streaming lossless data compression (SLDC) algorithm
► Capacity scaling
► Single field-replaceable unit (FRU)
► Error detection and reporting
► Statistical Analysis and Reporting System (SARS)
► Revised encryption support
► Dual-stage 32-head actuator
► Offboard data string searching
► Enhanced logic to report logical end of tape
► Added partitioning support
► End-to-end logical block protection support
► Data safe mode
► Enhanced Ethernet support
► New enhanced Barium Ferrite (BaFe) particle media types
► Eight Gbps Fibre Channel dual port interface

2.3.1 Drive attachment

The TS1140 Model EH7 is supported for attachment in the IBM TS4500 only. The 3592 tape drive communicates with the TS4500 tape library through an internal Ethernet interface and uses SARS to isolate failures between the media and the hardware.

The TS1140 tape drive offers a dual-port 8 Gbps Fibre Channel host attachment interface. This feature provides flexibility in open systems environments because the drives can directly attach to open systems servers with Fibre Channel attachments.

The TS1140 Model EH7 has a new back panel, which is shown in Figure 2-14.
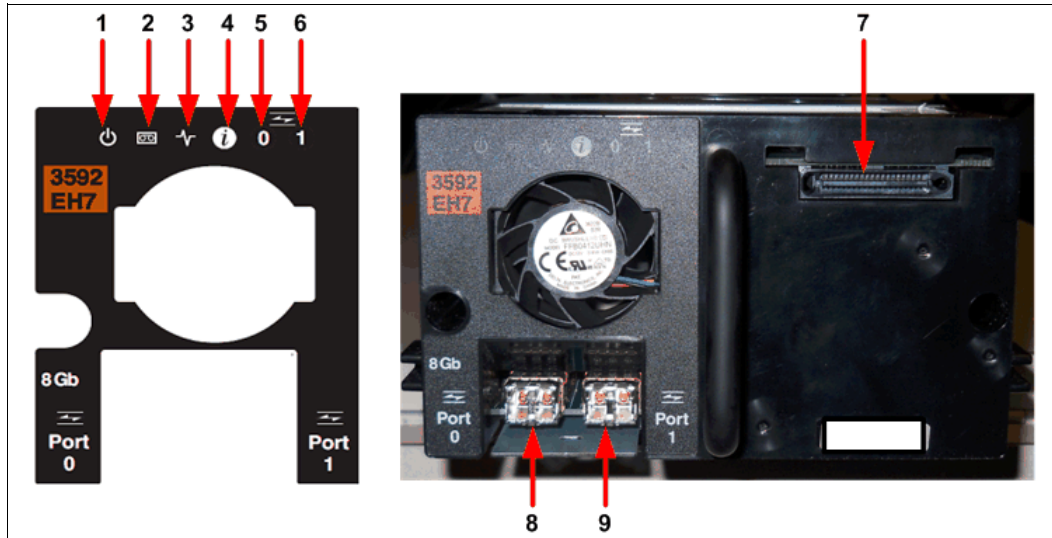
Figure 2-14   TS1140 rear panel

Table 2-10 describes all components on the rear panel and shows the normal status of the light-emitting diodes (LEDs). The numbers relate to the numbers in Figure 2-14.

Table 2-10   Rear panel

Number	Description	LED color or description
1	Power status	Green
2	Drive status	Yellow or green
3	Library connection	Green
4	Information	Blue
5	Port 0 Fibre Channel activity	Green or yellow
6	Port 1 Fibre Channel activity	Green or yellow
7	TS4500 interface connector	TS4500 communication and power
8	Port 0, 8 Gbps fiber connection	Supports N_ports and NL_ports, which can autoconfigure between using the FC-AL protocol and the Direct Fabric attach protocol
9	Port 1, 8 Gbps fiber connection	Supports N_ports and NL_ports, which can autoconfigure between using the FC-AL protocol and the Direct Fabric attach protocol

2.3.2 3592 media

The following information relates to TS1140 media.

Data cartridge

The TS1140 uses enhanced Barium Ferrite (BaFe) particle media types. The media can be read/written up to 250 MBps native sustained data rate (up to 650 MBps at 3:1 compression) in the 32-channel Generation-4 logical format. The following types of tape cartridges are available:

► IBM Enterprise Advanced Tape Cartridge (JC) - MEDIA11
► IBM Enterprise Advanced WORM Tape Cartridge (JY) - MEDIA12
► IBM Enterprise Advanced Economy Tape Cartridge (JK) - MEDIA13

The following TS1140 tape drive capacity and performance improvements are provided on the existing 3592 media:

► The TS1140 tape drive reuses certain TS1130 and TS1120 supported media types:

    – IBM 3592 Extended Tape Cartridge (JB) - MEDIA9
    – IBM 3592 Extended WORM Tape Cartridge (JX) - MEDIA10

> **Note:** Media types JA, JW, and JJ are not supported by the TS4500 tape library.

► The TS1140 improves capacity and performance by writing and reading the EH7 logical format by using a new 32-channel enhanced error correction code (ECC) recording format with a higher track density and higher linear density on the same media types.

> **Design feature:** This design supports a common scratch pool by media type regardless of the last written format or allocation target drive.

The 3592 tape drives can reuse different types of tape and multiple densities (logical formats) across various drive generations. Enterprise format 4 (EFMT4) records 2,560 tracks on 32 channels. These logical formats can be divided into multiple subformat options, such as segmentation and capacity scaling.

2.3.3 Capacity and performance

Capacity and performance are improved compared to the IBM TS1130 tape drive for all media types and for all formats that the TS1140 reads or writes.

Capacity improvement

The use of the 3592 EH7 logical format offers native capacity improvement on existing cartridges and new cartridges:

► IBM Enterprise Extended data (JB) or WORM (JX) media, a 60% capacity uplift from 1 TB to 1.6 TB (by using a 3:1 compression ratio 4.8 TB)

► IBM Enterprise Advanced data (JC) or WORM (JY) media, a capacity of 4.0 TB (by using a 3:1 compression ratio 12 TB)

► IBM Enterprise Economy Data media, JK media, a capacity of 500 GB (by using a 3:1 compression ratio 1.5 TB)

Performance improvement

The overall performance is increased by various improvements:

► Improved data rate
► Larger 1 GB main data buffer
► Better backhitching
► Improved speed with digital speed matching
► Enhanced read-ahead buffer management
► High access performance for locate or search
► Improved communication links with dual 8 Gbps Fibre Channel ports
► SkipSync and FastSync write performance accelerators
► New 32-channel enhanced ECC recording format
► IBM Spectrum Archive and IBM LTFS Single Drive Edition, Library Edition, and Enterprise Edition support

Note: *Backhitching* is the condition that occurs when a data cartridge stops, reverses, and restarts motion. A *backhitch* is the result of a mismatch between the data rates of the connected server and the tape drive.

Higher data rates

Performance is improved from the TS1130 up to 64% in TS1140 mode, 50% in TS1130 mode for read and writes, and 50% in TS1120 mode for reads only:

► The EH7 format data rates go up to 250 MBps maximum native and to 650 MBps maximum compressed.

► The E06 format data rates go up to 200 MBps maximum native and to 650 MBps maximum compressed.

Table 2-11 summarizes the capacity and performance characteristics for native data.

Table 2-11   Capacity and performance summary

Media	EH7 format capacity data rate (minimum - maximum)	E06 format capacity data rate (minimum - maximum)
JB and JX	1.6 TB (1.46 TiB) 80 MBps - 200 MBps	1 TB (.9 TiB) 50 MBps - 160 MBps
JC and JY	4 TB (3.6 TiB) 90 MBps - 250 MBps	N/A
JK	500 GB (.48 TiB) 60 MBps - 250 MBps	N/A

Buffer

The TS1140 EH7 tape drive has a 1 GB internal data buffer. In addition to enabling higher performance characteristics, the data buffer is designed to support the "read-ahead" capability of compressed data from tape. The data buffer provides high-performance random skip forward sequential (short hop) locates, which are common in database search and tape software recycle operations.

This buffer improves the drive agility, file access, and small file handling. Furthermore, the buffer reduces backhitches for all workloads and improves overall read/write performance.

Offboard data string searching

The TS1140 EH7 tape drive can search the data content of host records for string matches offboard from the host server. The tape drive can perform this search at the maximum data rate (250 MBps native). It takes much longer for a host server to read the data, buffer the data to disk, and then parse the actual data stream with host software routines.

Enhanced logic to report logical end-of-tape (LEOT)

LEOT is now reported, based on a combination of capacity-based and position-based LEOT indicators. The TS1140 EH7 monitors the total accumulated number of physical tape data sets that is written to the volume and reports LEOT based on this capacity-based LEOT value. LOET allows tape copies to complete without overflow more often.

High-resolution tape directory

The TS1140 EH7 tape drive maintains a tape directory structure with a high granularity of information about the physical position of data blocks on the media. This high-resolution tape directory (HRTD), plus the increased search speed, improves the TS1140 EH7 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 TS1140 tape drives also use dynamic adaptive equalization hardware on an ongoing basis to adjust the read equalization response.

Speed matching

The *speed matching* function is improved on the TS1140 tape drive because both the number of speeds and the range of supported data rates are improved. The data rate range depends on the logical format and the media type:

▶ Thirteen speeds, 76 MBps - 251 MBps for 3592 JC, JK, and JY cartridges that are initialized in Generation 4 format

▶ Thirteen speeds, 74 MBps - 203 MBps for 3592 JB or JX cartridges that are initialized in Generation 4 format

▶ Thirteen speeds, 41 MBps - 163 MBps for 3592 JB or JX cartridges that are initialized in Generation 3 format

▶ Thirteen speeds, 39 MBps - 151 MBps for 3592 JB or JX cartridges that are initialized in Generation 2 format

The TS1140 tape drive increases throughput through speed matching while the drive performs the following functions:

▶ Adjusts tape speed based on host data rate
▶ Calculates effective host data rate (EHDR)
▶ Optimizes data rate by selecting optimal EHDR
▶ Forces speed changes mid-wrap if advantageous
▶ Minimizes time to record data

Virtual backhitch

The TS1140 key feature improvements are listed:

► Virtual backhitch (transaction write with sync)
► Single wrap backhitchless flush (large transaction writes with sync)
► Backhitchless backspacing (ANSI file writes)

The TS1140 function is improved with Recursive Accumulating Backhitchless Flush (RABF) and the addition of a new same wrap backhitchless flush (SWBF) function that extends virtual backhitch effectiveness for large files.

Read-ahead feature

On sequential reads, the tape drive automatically runs the read-ahead feature and fills the buffer with data sequentially beyond the target block (*N*). If one of these blocks is a target of the next command (such as *N*+200), it is already in the buffer. Therefore, transfer is fast. The drive then automatically fills the buffer sequentially with data past *N*+200.

The 3592-EH7 supports read ahead of approximately 1,000 MB of compressed data from tape. When the drive processes a command to locate or read a block, the drive automatically continues to stream down the tape and to read ahead until the data buffer is full, which allows subsequent `Locate` or `Read` commands to be fulfilled from the data buffer at faster speeds, rather than requiring access to the tape. The drive outperforms competitive drives, which simply stop and wait for the next command, with this unique functionality.

Performance scaling and segmentation

The 3592 EH7 tape drives support capacity scaling for tape cartridges of media types JB and JC over a broad range of capacities. The effect of capacity scaling is to contain data in a specified fraction of the tape, yielding faster locate and read times. Alternatively, you can purchase economy tapes (JK media type).

Performance scaling limits the data that is written to the first 20% of the cartridge. When you use the *performance segmentation* option, the overall capacity of the cartridge is limited to 86.6% of the total capacity.

The fast access segment occupies the first 20% of the cartridge, which is followed by the slower access segment. For example, with the Model EH7 tape drive operating in EFMT4 format, the 3592 Advanced Data Tape Cartridge (type JC) can be scaled to 800 GB. And, by using performance segmentation, the 4,000 GB Extended Data cartridge can be segmented into an 800 GB fast access segment and a 3,200 GB slower access segment. Segmentation is only available within a specified range of capacity scaling settings to achieve this faster performance.

Cartridges that are performance-scaled or performance-segmented can be reused (reformatted) to their full capacity, to the performance-scaled capacity, or to the performance segmentation format as indicated through the assigned data class.

Note: Capacity scaling is supported for economy (JK) or WORM tapes (JX, JY, and JR) in read-only mode.

Tip: Check with the device driver user guide for capacity scaling limitations and instructions for setup.

Data safe mode

The 3592 EH7 supports data safe mode. Data safe mode is controlled by the application and prevents inadvertent overwrite. Data safe mode treats the tape volume that is mounted as a WORM drive and prevents inadvertent overwrite. Data safe mode is set by the application or host system.

Drive mechanical and electrical reliability

The mechanism of the TS1140 tape drive is specified at a mean-cycles-between-failure rate of 300,000 cycles. 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.

Access performance specifications and drive characteristics

Table 2-12 summarizes the improvements in the access performance, that is, time to first data, block locate time from load point, or random locate times, and the drive characteristics.

Table 2-12   Access performance specifications and drive characteristics

Parameter	3592-EH7 EFMT4 or EEFMT4
Tape speed, locate, and rewind	12.4 mps
Drive load and ready time	15 seconds (s)
Block locate time from load point average	37 s for JB or JX 40 s for JC or JY 11 s for JK 15 s 20% scaled JB 12 s 20% scaled JC
Time to first data average (load and ready + locate)	42 s for JB or JX 55 s for JC or JY 26 s for JK 30 s for 20% scaled JB 27 s for 20% scaled JC
Unload time	24 s for JB or JX 36 s for JC, JY, or JK
Maximum rewind time	72 s 100% scaled JB or JX 24 s 20% scaled JB 76 s 100% scaled JC or JY 26 s 20% scaled JC 18 s JK
Native data rate	250 MBps
Device data rate: Maximum that is sustained with maximally compressible data	650 MBps
Interface burst transfer rate: Maximum	800 MBps (FC-8)
Number of tracks	1,792 JB or JX 2,560 JC, JK, or JY
Number of passes (from BOT to EOT)	56 JB or JX 80 JC, JK, or JY
Linear density	500 Kbpi

Parameter	3592-EH7 EFMT4 or EEFMT4
Servo regions	5
Data tracks that are recorded simultaneously	32
Buffer size	1 GB

End-to-end logical block protection

The TS1140 supports end-to-end logical block protection, which allows the host application to append a cyclic redundancy check (CRC) to logical blocks. Data is validated in the following manner:

► Validated by the drive as data is received, and written to the media
► Validated by the drive and application on the data read-back
► Validated at full line speed with the `VERIFY` command

The write path is independent from the read path:

► Can read without a CRC and can write with a CRC
► Can write without a CRC and can read with a CRC
► Can write without a CRC and can read without a CRC
► Can write with a CRC and can read with a CRC

The CRC is generated and checked at the tape drive end and the application end. The CRC might be checked at any point along the path, at the host bus adapter (HBA), or at any system or software that is in the middle.

On write, the CRC is appended to each logical block at the source and the CRC is checked at any point that you want in the transfer. If corruption occurs, the exact location of the problem is known. The logical block with the CRC is validated before it is committed to media. Data is known to be on tape in uncorrupted form before the source data is released. The CRC is stored with each logical block.

On read, the logical block with the CRC is read and validated. The CRC is transferred with each logical block. The CRC is checked at any point that you want in the transfer, then the CRC is validated and removed at the destination. Logical block protection uses the `VERIFY` command as defined in the SCSI Stream Commands - 4 (SSC-4) standard, which adds new options to perform the following functions:

► Check that the protection information (that is, CRC) is the same protection information that is configured.

► Check the protection information (that is, CRC) and validate each logical block from the current position for the number (*n*) of files (that is, file marks (FMKS)):

  – No blocks are transferred over the SCSI interface.
  – Happens at the native data rate.

► Check that protection information (that is, CRC) validates on each logical block from the current position to EOD:

  – No blocks are transferred over the SCSI interface.
  – Happens at the native data rate.

2.3.4 IBM Spectrum Archive and LTFS support

The TS1140 provided LTFS support with the following features:

- ► Ability to configure up to four partitions.
- ► Wrap-wise and longitudinal-wise partitioning.
- ► Supported on all non-WORM TS1140 formats (JC, JK, and JB formats).
- ► `Format` command support.
- ► Each partition can use a separate encryption method, or none.

Tape as a storage medium offers many benefits. Tape is reliable, portable, low-cost, low-power, and high-capacity. However, tape is not particularly easy to use. It has no standard format, and data often cannot be used without first copying the data to disk.

With IBM Spectrum Archive and the LTFS, accessing data that is stored on an IBM tape cartridge became as intuitive as the use of a USB flash drive. With LTFS, reading data on a tape cartridge is as easy as dragging and dropping. Users can run any application that is designed for disk files against tape data without concern that the data is physically stored on tape.

LTFS, which works with LTO-8, LTO-7, LTO-6, LTO-5, TS1155, TS1150, and TS1140 tape drives, implements a true file system for tape. IBM Spectrum Archive also supports library automation, including the ability to find data on a tape in a library without mounting and searching tape volumes.

IBM Spectrum Archive Library Edition (LE) supports IBM tape automation, and the Single Drive Edition is packaged with stand-alone drives. With IBM Spectrum Archive LE, you can create a single file system mount point for a logical library that is managed by a single instance of the software, which is running on a single server. In addition, it provides for caching of tape indexes, and for searching, querying, and displaying tapes' contents within an IBM tape library without the requirement to mount tape cartridges.

For more information about IBM Spectrum Archive and LTFS, see 2.9, "IBM Spectrum Archive" on page 138.

2.4 IBM LTO Ultrium tape drives for the TS4500 tape library

Two LTO formats (Ultrium and Accelis) were introduced in 1997, and licenses for the technology were made available. Since then, the Accelis format was not actively pursued by manufacturers because it is apparent that the Ultrium format meets market needs. The three LTO sponsoring companies also took steps to protect the client's investment by providing a roadmap up to LTO generation 10, which illustrates native capacity (Figure 2-15). The three LTO sponsoring companies also established an infrastructure to enable compatibility between products. At the time of this writing, five generations were available.

> **Important:** IBM, Hewlett-Packard, and Quantum reserve the right to change the information in this migration path without notice.
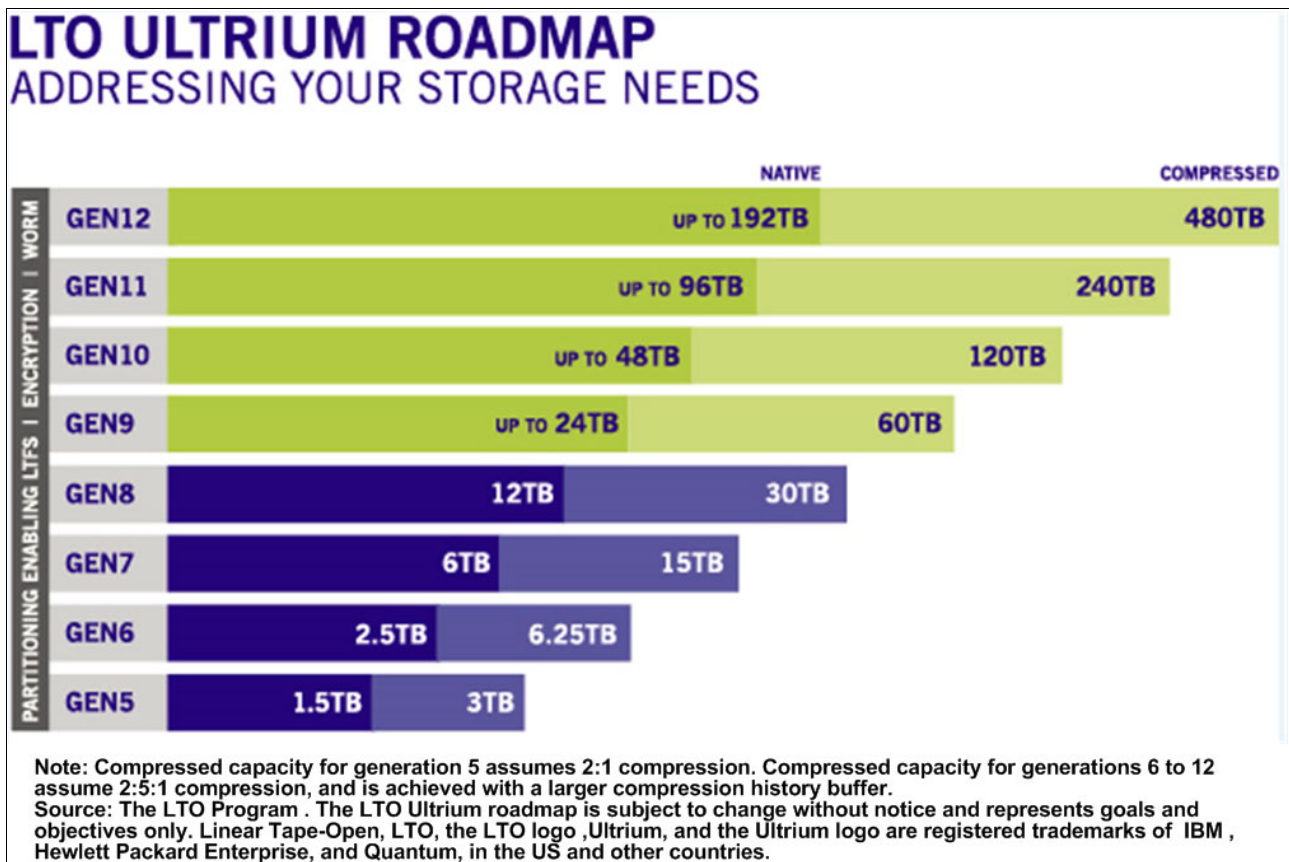
Figure 2-15   Eight-generation roadmap[1]

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[1] For more information, see "What is LTO Technology?" at http://www.lto.org/technology/what-is-lto-technology/.

The LTO Ultrium compatibility investment protection is provided based on the following principles:

► Ultrium drive before LTO 7 are expected to read data from a cartridge in its own generation and at least the two previous generations

► Ultrium 8 drive expected to read data from its own generation and from the immediate previous generation in the format of that generation

► An Ultrium drive is expected to write data to a cartridge in its own generation and to a cartridge from the immediate previous generation in the format of that generation

The three technology provider companies (IBM, HP, and Quantum) all made significant contributions of time and expertise to the definition of the LTO format specifications. All three companies have deep knowledge of clients' needs. They provided expert knowledge and engineering skill in the critical areas of magnetic recording technology, mechanism design, media materials, and cartridge design. This cooperative process created stronger LTO format definitions.

2.4.1 LTO core technology

Multichannel linear serpentine recording is at the core of the LTO formats. It enables an optimum balance of reliability and data integrity, performance, and high capacity. In the LTO recording format, data is written in tracks that run down the length of the tape.

The LTO Ultrium 8 format records data on 6656 tracks across the ½-inch tape width. This linear recording format has a *serpentine characteristic*. The drive mechanism makes multiple passes from the beginning of the tape to the end of the tape and back to read or write the full capacity of the cartridge

In the LTO Ultrium 8 format, the 6656 tracks are split into four data bands of 1664 tracks each, and 32 read/write channels. Table 2-13 shows the values for the Ultrium 8 and previous LTO generations.

Table 2-13   Data tracks, density, and channels

LTO generation	Data tracks	Tracks/band	Linear density	Read/write channels
Ultrium 1	384	96	124 Kbpi	8
Ultrium 2	512	128	188 Kbpi	8
Ultrium 3	704	176	250 Kbpi	16
Ultrium 4	896	224	328 Kbpi	16
Ultrium 5	1,280	320	368 Kbpi	16
Ultrium 6	2,176	544	385 Kbpi	16
Ultrium 7	3,584	896	485 Kbpi	32
Ultrium 8	6,656	1,664	524 Kbpi	32

Data is written to the innermost bands first to provide protection to the data that was recorded earliest in the process by writing it in the center, which is the most physically stable area on the tape. Data also is verified as it is written.

On the first pass of a round trip down the length of the tape and back, 32 tracks at LTO Ultrium 8 format are concurrently read or written. See the Read/write channels column in Table 2-13 on page 111. At the end of the tape, the second pass of the round trip starts. The read/write heads are indexed and positioned over 32 new tracks, and the tape reverses direction back toward the beginning of the tape to complete the round trip. For the next round trip, the heads again are indexed to a new position over a new group of 32 tracks.

Because track densities (as shown in Table 2-13 on page 111) are high and because the tape is subject to lateral movement as it is moved, for performance and data integrity, the read/write heads must always be positioned precisely over the correct tracks. This positioning is accomplished by using the *timing-based servo* technique. This technique makes it possible to use high track densities (now and in the future) without changing the format of the media. This technique allows data with media imperfections to be read.

In the LTO system, electronic signals are generated through the real-time reading of servo data bands that are pre-recorded on the LTO tape. These signals enable the servo system to dynamically control the positioning of the read/write heads across the width of the tape. Similar magnetically based, track-following servo systems are used successfully in tens of thousands of tape drives that are in use today, such as the IBM TS1100 tape drive (IBM 3592).

The LTO formats also use advanced error correction codes for data integrity. These systems automatically correct most cross-track errors and provide data correction even if a full track is lost. Data is further protected by the demarcation of bad areas of the tape (for example, where servo signals are unreliable) and through dynamically rewriting bad blocks.

Cartridge memory is embedded in the LTO cartridges to record usage and error information. A noncontacting radio frequency (RFI) module, with nonvolatile memory capacity of 16,320 bytes for Ultrium 8, 7 and 6, and 8192 bytes for Ultrium 5 and 4, provides storage and retrieval.

Note: The TS4500 supports three LTO tape drives, the HD2-compatible models of the LTO-8, LTO-7, LTO-6, and LTO-5.

Interleaved recording

The LTO drive uses an interleaved, serpentine, longitudinal recording format that is similar to the method that is used in 3592 drives. The first set of 16 or 32 data tracks is written from near the physical beginning of the tape to near the physical end of the tape. The head then repositions to the next set of tracks for the return. This process continues until all tracks are written and the tape is full.

The format of the recording of the data and servo tracks is defined as part of the LTO specification to meet the requirement for interchange among implementations of different manufacturers.

Servo tracks

Servo tracks or *bands* enable the accurate positioning of the tape drive head over the data track, which ensures that the head does not stray onto an adjacent track. They are necessary to support high-data densities on the tape where the tracks are extremely close together. The servo bands are written when the cartridge is manufactured before the cartridge is usable for data storage and retrieval. If the servo bands are erased, the tape becomes unusable.

2.4.2 Data compression

The LTO Consortium created a superior data compression technique that is known as *LTO Data Compression* (LTO-DC). Although an excellent data compression algorithm, adaptive lossless data compression (ALDC) is not optimized for incompressible data, such as encrypted or previously compressed data.

For incompressible data, it is best not to apply any data compression algorithm, but rather to pass the input data directly to the compressed data stream (pass-through). ALDC might be preferable, and at other times, a simple pass-through is better, because of the variations in data. For example, if ALDC-based data compression is used, it is best if all segments of incompressible data are recorded without expansion by using a pass-through technique.

Figure 2-16 shows the LTO-DC data compression technique that uses the two schemes.
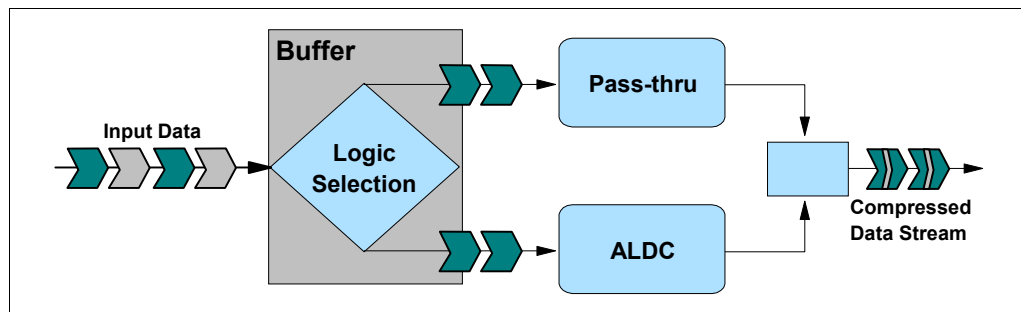
Figure 2-16   LTO-DC block diagram

The ability to swap schemes between ALDC and a pass-through mode gives a tape drive the power to automatically adapt to the incoming data stream.

No standardization of when to swap modes (scheme swap) when data is compressed was specified by LTO-DC. LTO-DC was approved by Ecma International as the Streaming Lossless Data Compression (SLDC) standard. For more information, see the Standard ECMA-321 Streaming Lossless Data Compression Algorithm - (SLDC) page on the Ecma International website:

http://www.ecma-international.org/publications/standards/ECMA-321.htm

Compression technique: LTO uses the SLDC technique for compression. The IBM 3592 tape drive also uses the SLDC compression technique.

Because no standardization is specified, all vendor implementations might perform scheme swapping differently. What is specified and tested is that the resultant compressed data stream is decompressible by the defined set of LTO-DC rules. This capability enables interchange between drives from multiple vendors. Each vendor's Ultrium drive can read and decompress the LTO-DC streams of the other vendors' Ultrium drives.

2.4.3 Ultrium tape media

The IBM Ultrium cartridges, which are distinguished by color. The Ultrium 6 cartridge is colored black. The Ultrium 7 cartridge is colored purple and the Ultrium 8 cartridge colored is burgundy. The IBM WORM cartridges are two-tone cartridges with a platinum bottom.

The top is like the normal LTO Ultrium cartridges. For the third generation of IBM WORM cartridges, the top is slate-blue. The Ultrium 6 WORM cartridge is colored black with a platinum bottom. The Ultrium 7 WORM cartridge is purple with a platinum bottom and the Ultrium 8 WORM is burgundy with platinum bottom.

Data cartridge

The Ultrium tape format specification is the implementation of LTO that is optimized for high capacity and performance with outstanding reliability, in a stand-alone or automated environment. The Ultrium cartridge uses a larger single-reel design (see Figure 2-17 on page 114) and ½-inch tape to provide ultra-high storage capacity. The tape is extracted from the cartridge by the tape drive through a leader pin and is wound onto a take-up reel that is contained within the drive. This design is focused on client requirements for high capacity and performance and is ideally suited for backup, restore, and archive applications.

Ultrium drive technology is intended to meet the needs of the enterprise on a roadmap, or migration path, that extends well into the future. The Ultrium tape format established a new benchmark for large volume backup and archive options.

An LTO-7 data cartridge and a WORM tape cartridge are shown in Figure 2-17.

Figure 2-17   LTO-7 media

In addition to standard read/write data cartridges, WORM cartridges are available. IBM WORM data cartridges are two tones to distinguish them from other data cartridges. Each WORM cartridge is the same color as the same generation of data cartridge on the top, but it is gray on the bottom. All generations of cartridges contain ½-inch, dual-coat, metal-particle tape. The capacities for the three types of cartridges are listed:

▶ LTO-8 and LTO-8 WORM tape cartridges have a native data capacity of 12 TB (10.91 TiB) (30 TB [28.61 TiB] at 2.5:1 compression).

▶ LTO-7 media formatted to M8 format, have a native data capacity of 9 TB (8.185 TiB) (22.5 TB [20.954 TiB] at 2.5:1 compression).

▶ LTO-7 and LTO-7 WORM tape cartridges have a native data capacity of 6 TB (5.46 TiB) (15 TB [13.64 TiB] at 2.5:1 compression).

▶ LTO-6 and LTO-6 WORM tape cartridges have a native data capacity of 2.5 TB (2.273 TiB) (6.25 TB [5.68 TiB] at 2.5:1 compression).

▶ LTO-5 and LTO-5 WORM tape cartridges have a native data capacity of 1.5 TB (1.364 TiB) (3 TB [2.73 TiB] at 2:1 compression).

The IBM WORM cartridges are two-tone cartridges with a platinum bottom. The top is like the normal LTO Ultrium cartridges.

WORM tape format

Beginning with LTO Ultrium format generation 3, WORM functionality provides nonerasable, nonrewritable operation with tape media. WORM is for long-term, tamper-resistant record retention. LTO Ultrium 8, 7, 6, 5, and 4 drives provide the same WORM capability.

The format specification for WORM for LTO Ultrium generations includes low-level encoding in the cartridge memory, and the encoding is mastered into the servo pattern as part of the manufacturing process. This encoding prevents tampering.

Data can be appended at the end of a WORM cartridge to which data was previously written, which allows the full use of the high-capacity tape media.

Bar code labels

Each LTO data, cleaning, and diagnostic cartridge that is processed by the TS4500 tape library must bear a bar code label. The label contains the following information:

- ▶ A volume serial (VOLSER) number that you can read
- ▶ A bar code that the library can read

> **Note:** Client-printed bar code labels are not recommended for use on the TS4500. Certain bar code labels that were previously successfully scanned by the TS3500 are not readable by the TS4500. Issues with reading media labels are most often issues with those labels that were printed by the client.

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 identifies the cartridge as an LTO cartridge. M8 media type denoted a LTO 7 cartridge formatted for LTO 8 use only. The possible values for the second character are described in the following list:

- ▶ 1 indicates that the cartridge is the first generation of its type.

- ▶ 2, 3, 4, 5, 6, 7, M8, 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

- ▶ Y indicates that the cartridge is a generation 8 WORM cartridge

Figure 2-18 shows a sample bar code label for the LTO-8 tape cartridge.

Figure 2-18   View of the LTO-7 tape cartridge label

Apply the following guidelines whenever you use LTO bar code labels:

► Use only bar code labels that are approved by IBM.

► 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 bar code labels that do not leave a residue after they are removed. If glue residue is 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 voids or smears are in the printed characters or bar code. An application's inventory operation takes 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.

► Position the label within the recessed bar code label area.

► 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 it 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.

Bar code label specifications are listed on the IBM LTO Ultrium Cartridge Label Specification web page:

http://www.ibm.com/support/docview.wss?uid=ssg1S7000429

Cleaning cartridges

The IBM LTO Ultrium Cleaning Cartridge (which is known as the *universal cleaning cartridge*) and the LTO Ultrium Cleaning Cartridge are compatible with all LTO tape drives.

The cleaning cartridge also contains a cartridge memory device, which automatically tracks the number of times that it was used. Cleaning cartridges must be replaced after 50 cleaning cycles. The firmware in the drive detects whether a cleaning tape is expired.

The volume serial (VOLSER) number on the cleaning cartridge's bar code label must begin with **CLNI** or **CLNU**, or the library treats the cleaning cartridge as a data cartridge during an inventory.

> **Note:** The average number of mounts that a cleaning cartridge is mounted before it is marked for replacement is 50. Because the count for cleaning is based on the tape length that is used during the cleaning, this number can be more or fewer than 50 mounts.

Cartridge memory

Within the cartridge is the LTO Cartridge Memory (LTO-CM), which is a passive, contactless silicon storage device that is physically a part of the cartridge. The memory chip is also known as medium auxiliary memory (MAM). For more information, see the *IBM TotalStorage LTO Ultrium Tape Drive SCSI Reference (LTO-5 through LTO-7)*, GA32-0928:

http://www.ibm.com/support/docview.wss?uid=ssg1S7003556

Information about the cartridge and tape is written to the LTO-CM. The LTO-CM is only accessible and used by the drive itself and contains no client data. The LTO-CM is serial Electronically Erasable Programmable Read-Only Memory (EEPROM) with read-only and rewritable areas. It is housed inside the cartridge casing at the left rear (label side) corner.

The LTO-CM is used to hold usage and error information about the cartridge, the media inside that cartridge, and the data on the media. The storage capacity of the Generation 8, 7, and 6 LTO-CM is 16,320 bytes, double the 8,160-byte capacity of the Generation 5 and 4 LTO-CM. The Generation 1, 2, and 3 cartridges use a 4,096-byte LTO-CM. The LTO-CM is in the left rear corner of the cartridge. A copy of this information also is kept in the first data set within the user data area, and it is given the data set number zero.

Communication between the drive and the LTO-CM is performed by a low-level radio frequency (RF) field that is generated (in the IBM implementation) by the drive. The LTO-CM is nonvolatile storage that is updated by using the RF field. It requires no other power source. This type of technology has an expected shelf life of more than 30 years.

Although transparent to the user, keeping this type of information enhances the efficiency of the drive and the cartridge. Data and block locations are stored in memory. For example, the end-of-data location is stored so that when the tape is next loaded, the drive can use the fast locate function to move directly to the recording area and begin recording.

Storing data about the age of the cartridge, the number of times that it was loaded, and the number of errors that it accumulated helps determine the reliability of the cartridge. This data is of particular value if it is stored with the cartridge itself, so that whenever the cartridge is mounted on any host system, the history is accessible.

This product is not the first tape product where information was kept on the cartridge. However, previously it was written on the tape medium itself in a portion of the tape (that users were not allowed to access) before the beginning-of-tape marker, such as in the IBM 3590 tape drive.

2.5 IBM LTO Ultrium 8 tape drive (Model 3588 F8C)

Ultrium 8 is the latest LTO generation, which was released in November 2017. The IBM LTO Ultrium 8 offerings represent significant improvements in capacity, performance, and reliability over the previous generation, Ultrium 7, while they still protect the client's investment in the previous technology.

The Ultrium 8 tape drive is a high-performance, high-capacity tape drive. The drive records data by using a linear serpentine recording format on half-inch tape that is housed within a cartridge. The data tracks are located by using preformatted servo tracks.

The Ultrium 8 tape drive provides the following improvements over the older Ultrium 7 models:

► The Ultrium 8 tape drive increases the native transfer speed to 360 MBps compared with 300 MBps for the Ultrium 7 tape drive.

► The Ultrium 7 tape drive compressed speed of 700 MBps for Fibre Channel interface

► The Ultrium 8 tape drive more than doubles the potential capacity of a cartridge in Ultrium 7 format

3588 F8C tape drive features at a glance

The LTO-8 (3588 F8C) tape drive has the following characteristics:

► Native data transfer rate of up to 360 MBps

► Compressed data transfer rate of up to 700 MBps

► LTO Ultrium 8 data and WORM tape cartridge native physical capacity of up to 12 TB

► 8 Gbps Fibre Channel attachment option

► 1024 MB internal data buffer

► Application-managed encryption support

► Library-managed encryption support

► Sixteen KB cartridge memory with Ultrium 8 media

► IBM Spectrum Archive Single Drive Edition, Library Edition, and Enterprise Edition support

► LTFS partitioning support

The LTO Ultrium 8 supports integration in the IBM TS4500 library by using a new compact drive sled.

The TS4500 LTO drive sled is shown in Figure 2-19.

Figure 2-19   LTO Ultrium 8 (3588 F8C)

The LTO Ultrium 8 Model F8C drive has a front bezel with a chevron fiducial. The buttons and display remain the same as for all previous models of LTO tape drives. Figure 2-20 shows the front of the LTO-8 (3588 F8C) tape drive.
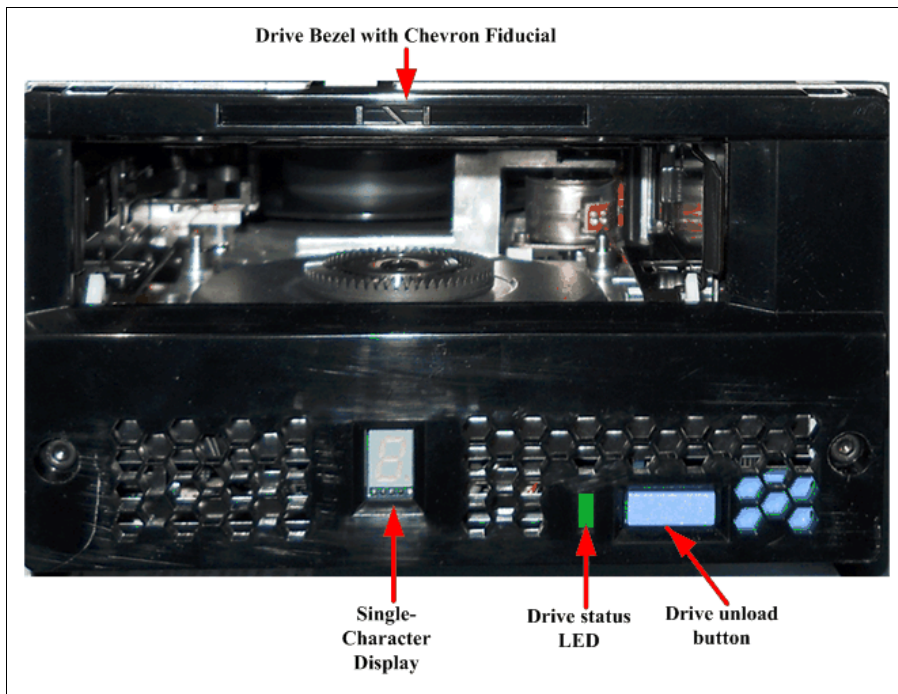
Figure 2-20   LTO Ultrium 8 (3588 F8C) front panel

The LTO Ultrium 8 Model F8C back panel is the same back panel that is used in LTO-7 and LTO-6, as shown in Figure 2-21.
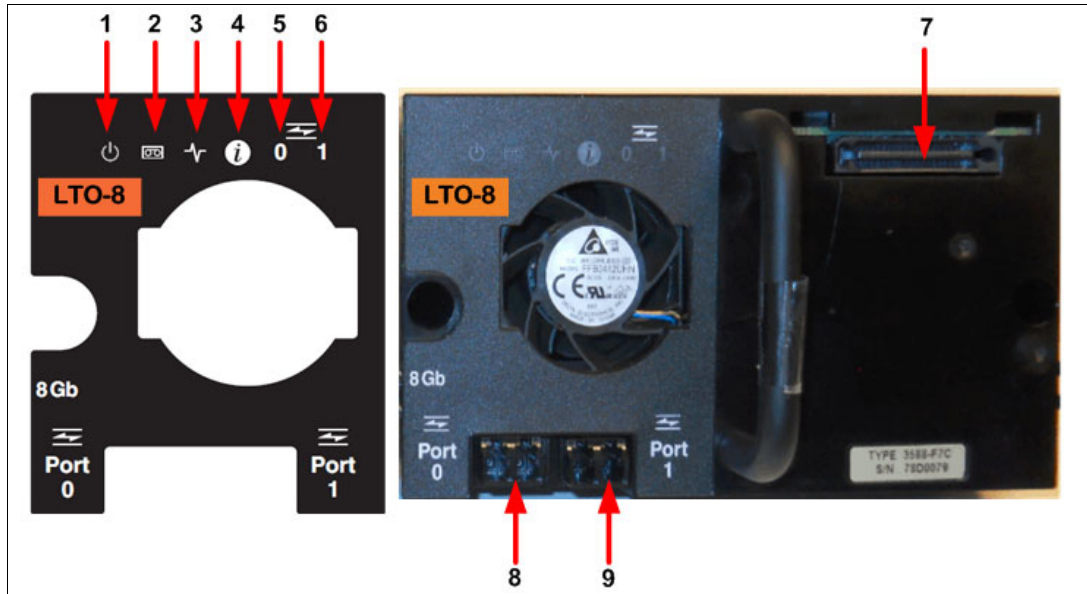
Figure 2-21   LTO Ultrium 8 Model F8C rear panel

Table 2-14 describes all of the components on the rear panel and shows the normal status of the LEDs. The numbers in Table 2-14 refer to Figure 2-21.

Table 2-14   LTO Ultrium 8 rear panel

Number	Description	LED color or description
1	Power status	Green
2	Drive status	Yellow or green
3	Library connection	Green
4	Information	Blue
5	Port 0 Fibre Channel activity	Green or yellow
6	Port 1 Fibre Channel activity	Green or yellow
7	TS4500 interface connector	TS4500 communication and power
8	Port 0, 8 Gbps fiber connection	Supports N_ports and NL_ports, which can autoconfigure between using the FC-AL protocol and the Direct Fabric attach protocol
9	Port 1, 8 Gbps fiber connection	Supports N_ports and NL_ports, which can autoconfigure between using the FC-AL protocol and the Direct Fabric attach protocol

Compatibility

Ultrium 8 drives can only read and write on Ultrium 8 and Ultrium 7 cartridges, it cannot read Ultrium 6 cartridges. Ultrium 8 drives can additionally read and write on Ultrium 7 cartridges at 9 TB capacity. For more information about M8 format, see "M8 format media" on page 121.

The drive also writes to tapes that can be read by other licensed LTO Ultrium 7 drives. In addition to using the IBM LTO Ultrium 7 data cartridge, with up to 6 TB capacity, the drive offers read/write capability for certified LTO Ultrium 7 tape cartridges.

> **Note:** The LTO-8 tape drive can only read or write to LTO8 and LTO7 format cartridges.

Table 2-15 shows the native data transfer rate when a data cartridge of another generation is processed.

Table 2-15   Native data transfer rate with various media

	12 TB (Ultrium 8)	9 TB M8 Format (Ultrium 7 media)	6 TB L7 Format (Ultrium 7)
Supported methods of operating	Read/write	Read/write	Read/write
Native data rate Fibre Channel (MBps)	360	360	300
Native Capacity	12TB (11.176 TiB)	9TB (7.450 TiB)	6TB (5.587 TiB)
2.5:1 compression capacity	30TB (28.61 TiB)	22.5TB (20.954 TiB)	15TB (13.64 TiB)

M8 format media

The LTO Program introduced a new capability with LTO-8 tape drives. The LTO-8 drives can 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 7 initialized LTO 8 Type M cartridge. These LTO 8 Type M cartridges are identifiable by using an automation barcode label ending with the last two characters $M8$.

Only new, unused LTO Ultrium 7 cartridges can be initialized as M8 cartridges. After 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. LTO7 tape drives cannot read initialized M8 cartridges.

M8 cartridges can be purchased as either pre-initialized M8 data cartridges or un-initialized M8 data cartridges. 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.

> **Note:** M8 WORM cartridges are not supported.

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. The tape drive establishes the density of the media at that time.

> **Important:** If an un-initialized M8 cartridge is not initialized in a tape library that supports un-initialized M8 cartridges, then the cartridge can be initialized at the L7 density even if the barcode label states M8. This situation 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 the M8 label.
>
> 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, but they will remain limited to the 6 TB native capacity.

The TS4500 tape library requires a minimum firmware version of 1.4.1.2. The drive needs a minimum LTO 8 tape drive firmware version of HB82 to support un-initialized M8 cartridges and to support for pre-initialized M8 cartridges.

3588 Field MES support

The following drive MES conversions are supported:

- ▶ 3588 F8A drive > 3588 F8C model upgrade
- ▶ 3588 F7A drive > 3588 F7C model upgrade
- ▶ 3588 F6A drive > 3588 F6C model upgrade
- ▶ 3588 F5A drive > 3588 F5C model upgrade
- ▶ 3592 E08 drive > 3592 EH8 model conversion

Connectivity

The LTO-8 tape drive family offers high capacity, performance, and technology for the midrange open systems environment. These tape drives are dual-ported tape 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.

IBM LTO-8 tape drives can connect to many types of servers. For a list of server interface cards or host bus adapters (HBAs) that are supported by the LTO tape drives, see the IBM System Storage Interoperation Center (SSIC) web page:

http://www.ibm.com/systems/support/storage/ssic

Performance

The LTO Ultrium 7 tape drive uses 3584 data tracks to read and write to Ultrium 8 tape. These tracks are grouped in four servo bands. The high-bandwidth servo system features a low-mass servo to help more effectively track servo bands and improve data throughput with damaged media in less-than-optimal shock and vibration environments.

The native data transfer rate for Ultrium 8 tape drives is 360 MBps. Compressed data rates can reach a peak rate of 800 MBps on the FC interface. IBM suggests the use of the IBM LTO Ultrium 8 12 TB data cartridge, which provides up to 30 TB of storage with a 2.5:1 compression ratio.

Dynamic speed matching

The LTO Ultrium 8 tape drive performs *dynamic speed matching* at one of 12 speeds to adjust the native data rate of the drive as closely as possible to the net host data rate (after it factors out data compressibility). This approach helps to reduce the number of backhitch repositions and improves throughput performance. *Backhitching* is the condition that occurs when a data cartridge stops, reverses, and restarts motion. A backhitch is the result of a mismatch between the data rates of the connected server and the tape drive.

Table 2-16 shows the data rates for the LTO Ultrium 8 drives.

Table 2-16   LTO-8 drive speed matching data rates

Performance parameters	Generation 8 media	Generation 7 media M8 Format	Generation 7 media
Speed matching data rates in MBps	365.0 341.0 318.0 306.4 273.0 249.5 226.0 203.0 180.0 157.5 135.0 112.0	365.0 341.0 318.0 306.4 273.0 249.5 226.0 203.0 180.0 157.5 135.0 112.0	306.00 287.52 268.56 250.66 231.86 213.06 194.26 175.46 157.67 138.52 120.11 101.46

Encryption

The LTO Ultrium 8 tape drive family is encryption-capable and supports application-managed tape encryption at no charge on Fibre Channel tape drives. For library use, system-managed tape encryption and library-managed tape encryption are supported by the Transparent LTO Encryption features (FC 5901 for TS2900, FC 1604 for TS3500, and FC 5900 for all other libraries). IBM Security Key Lifecycle Manager is required for encryption key management with LTO Ultrium 8 drives.

Statistical Analysis and Reporting System

The Ultrium 8 tape drives use Statistical Analysis and Reporting System (SARS) to help isolate failures between media and hardware. SARS uses the data cartridge performance history that is saved in the cartridge memory module and the drive performance history that is kept in the drive flash Electrically Erasable Programmable Read-Only Memory (EEPROM) to help determine the likely cause of the failure. SARS can cause the drive to request a cleaning tape, mark the media as degraded, and indicate that the hardware is degraded.

IBM Spectrum Archive software application

IBM Ultrium 8 tape drives are compatible with the IBM Spectrum Archive software application, and the underlying LTFS. LTFS uses the LTO media partitioning functionality, which is present on Ultrium 8, 7, 6, and 5 cartridges.

LTFS provides a standard tape cartridge format at low cost that can be used without other database applications. LTFS presents tape media as though it were a disk file system. IBM Spectrum Archive supports the IBM LTO Ultrium 8, 7, 6, and 5, and IBM TS1155, TS1150, and TS1140 tape drives. IBM Spectrum Archive supports the LTO-7 initialized LTO-8 Type M cartridge. For more information, see "M8 format media" on page 121.

Tape as a storage medium offers many benefits. It is reliable, portable, low-cost, low-power, and high-capacity. However, tape is not particularly easy to use. Tape has no standard format, and data often cannot be used without first copying the data to disk.

With LTFS, accessing data that is stored on an IBM tape cartridge became as easy and intuitive as using a USB flash drive. With LTFS file manager, reading data on a tape cartridge is as easy as dragging and dropping. Users can run any application that is designed for disk files against tape data without concern that the data is physically stored on tape.

LTFS implements a true file system for tape. LTFS also supports library automation, including the ability to find data on a tape in a library without mounting and searching tape volumes.

IBM Spectrum Archive supports IBM tape automation in addition to the single drive edition. By using IBM Spectrum Archive Library Edition, you can create a single file system mount point for a logical library that is managed by a single instance of the software, which runs on a single server. In addition, it provides for caching of tape indexes and for searching, querying, and displaying tapes' contents within an IBM tape library without the requirement to mount tape cartridges.

For more information about IBM Spectrum Archive and LTFS, see 2.9, "IBM Spectrum Archive" on page 138.

2.6 IBM LTO Ultrium 7 tape drive (Model 3588 F7C)

Ultrium 7 is the latest LTO generation, which was released in late 2015. The IBM LTO Ultrium 7 offerings represent significant improvements in capacity, performance, and reliability over the previous generation, Ultrium 6, while they still protect the client's investment in the previous technology.

The Ultrium 7 tape drive is a high-performance, high-capacity tape drive. The drive records data by using a linear serpentine recording format on half-inch tape that is housed within a cartridge. The data tracks are located by using preformatted servo tracks.

The Ultrium 7 tape drive provides the following improvements over the older Ultrium 6 models:

► The Ultrium 7 tape drive increases the native transfer speed to 300 MBps compared with 160 MBps for the Ultrium 6 tape drive.

► The Ultrium 7 tape drive increases the compressed speed to 700 MBps for Fibre Channel compared with 400 MBps for the Ultrium 6 tape drive.

► The Ultrium 7 tape drive more than doubles the potential capacity of a cartridge in Ultrium 6 format.

3588 F7C tape drive features at a glance

The LTO-7 (3588 F7C) tape drive has the following characteristics:

► Native data transfer rate of up to 300 MBps

► Compressed data transfer rate of up to 750 MBps

► LTO Ultrium 7 data and WORM tape cartridge native physical capacity of up to 6 TB

► Eight Gbps Fibre Channel attachment option

► 1,024 MB internal data buffer

► Application-managed encryption support

► Library-managed encryption support

- ► Sixteen KB cartridge memory with Ultrium 7 media
- ► IBM Spectrum Archive Single Drive Edition, Library Edition, and Enterprise Edition support
- ► Linear Tape File System (LTFS) partitioning support

The LTO Ultrium 7 supports integration in the IBM TS4500 library by using a new compact drive sled.

The TS4500 LTO drive sled is shown in Figure 2-22.

Figure 2-22   LTO Ultrium 7 (3588 F7C)

The LTO Ultrium 7 Model F7C drive has a new front bezel with a chevron fiducial. The buttons and display remain the same as for all previous models of LTO tape drives. Figure 2-23 shows the front of the LTO-7 (3588 F7C) tape drive.
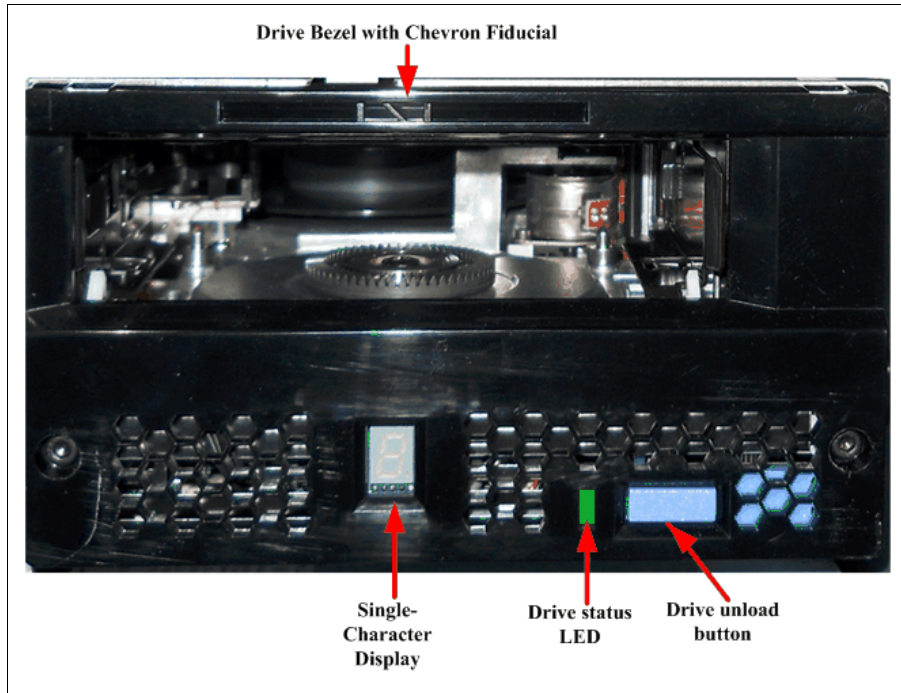
Figure 2-23   LTO Ultrium 7 (3588 F7C) front panel

The LTO Ultrium 7 Model F7C back panel is the same back panel that is used in LTO-6 and LTO-5, as shown in Figure 2-24.
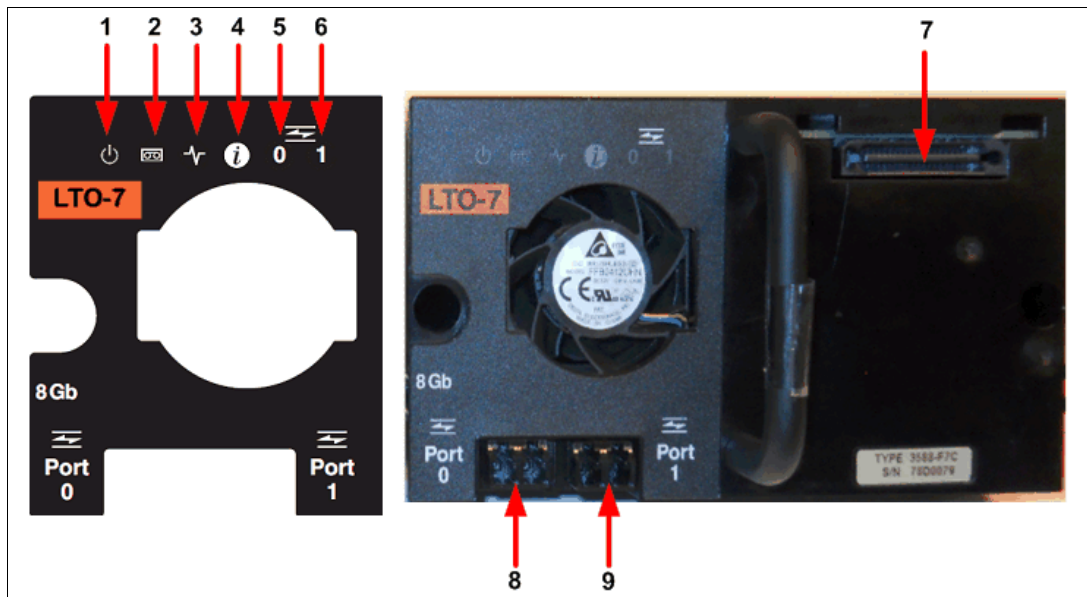
Figure 2-24   LTO Ultrium 7 Model F7C rear panel

Table 2-17 describes all of the components on the rear panel and shows the normal status of the LEDs. The numbers in Table 2-17 refer to Figure 2-24 on page 126.

Table 2-17   LTO Ultrium 7 rear panel

Number	Description	LED color or description
1	Power status	Green
2	Drive status	Yellow or green
3	Library connection	Green
4	Information	Blue
5	Port 0 Fibre Channel activity	Green or yellow
6	Port 1 Fibre Channel activity	Green or yellow
7	TS4500 interface connector	TS4500 communication and power
8	Port 0, 8 Gbps fiber connection	Supports N_ports and NL_ports, which can autoconfigure between using the FC-AL protocol and the Direct Fabric attach protocol
9	Port 1, 8 Gbps fiber connection	Supports N_ports and NL_ports, which can autoconfigure between using the FC-AL protocol and the Direct Fabric attach protocol

Compatibility

In addition to reading and writing to LTO Ultrium 7 tape cartridges, the Ultrium 7 tape drives can read and write to LTO Ultrium 6 cartridges and read LTO Ultrium 5 cartridges. They cannot read Ultrium 4, Ultrium 3, Ultrium 2, or Ultrium 1 cartridges.

The drive also writes to tapes that can be read by other licensed LTO Ultrium 7 drives. In addition to using the IBM LTO Ultrium Data Cartridge with up to 6 TB capacity, the drive offers read/write capability for certified LTO Ultrium 7 tape cartridges.

> **Note:** The LTO-7 tape drive cannot read or write LTO-1, LTO-2, LTO-3, or LTO-4 tape cartridges.

Table 2-18 shows the native data transfer rate when a data cartridge of another generation is processed.

Table 2-18   Native data transfer rate with various media

	Generation 7 media	Generation 6 media	Generation 5 media
Supported methods of operating	Read/write	Read/write	Read only
Native data rate Fibre Channel (MBps)	300	160	140

3588 Field MES support

The following drive MES conversions are supported:

- ► 3588 F7A drive > 3588 F7C model upgrade
- ► 3588 F6A drive > 3588 F6C model upgrade
- ► 3588 F5A drive > 3588 F5C model upgrade

Connectivity

The LTO-7 tape drive family offers high capacity, performance, and technology for the midrange open systems environment. These tape drives are dual-ported tape 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.

IBM LTO-7 tape drives can connect to many types of servers. For a list of server interface cards or host bus adapters (HBAs) that are supported by the LTO tape drives, see the IBM System Storage Interoperation Center (SSIC) web page:

http://www.ibm.com/systems/support/storage/ssic

Performance

The LTO Ultrium 7 tape drive uses 3584 data tracks to read and write to Ultrium 7 tape. These tracks are grouped in four servo bands. The high-bandwidth servo system features a low-mass servo to help more effectively track servo bands and improve data throughput with damaged media in less-than-optimal shock and vibration environments.

The native data transfer rate for Ultrium 7 tape drives is 300 MBps. Compressed data rates can reach up to 750 MBps on the FC interface and 600 MBps on the serial-attached SCSI (SAS) interface. IBM suggests the use of the IBM LTO Ultrium 7 6 TB data cartridge, which provides up to 10 TB of storage with a 2.5:1 compression ratio.

Dynamic speed matching

The LTO Ultrium 7 tape drive performs *dynamic speed matching* at one of 12 speeds to adjust the native data rate of the drive as closely as possible to the net host data rate (after it factors out data compressibility). This approach helps to reduce the number of backhitch repositions and improves throughput performance. *Backhitching* is the condition that occurs when a data cartridge stops, reverses, and restarts motion. A backhitch is the result of a mismatch between the data rates of the connected server and the tape drive.

Table 2-19 shows the data rates for the LTO Ultrium 7 drives.

Table 2-19   LTO-7 drive speed matching data rates

Performance parameters	Generation 7 media	Generation 6 media	Generation 5 media
Speed matching data rates in MBps	306.00 287.52 268.56 250.66 231.86 213.06 194.26 175.46 157.67 138.52 120.11 101.46	160.00 150.77 141.54 132.31 123.08 113.85 104.62 95.38 86.15 76.92 67.69 58.46 49.23 40.00	140.0 130.0 120.0 112.7 105.5 98.2 90.9 83.6 76.4 69.1 61.8 53.5 46.3 40.0

Encryption

The LTO Ultrium 7 tape drive family is encryption-capable and supports application-managed tape encryption at no charge on the SAS and Fibre Channel tape drives. In library use, system-managed tape encryption and library-managed tape encryption are supported by the Transparent LTO Encryption features (FC 5901 for TS2900, FC 1604 for TS3500, and FC 5900 for all other libraries). IBM Security Key Lifecycle Manager is required for encryption key management with LTO Ultrium 6 drives.

Statistical Analysis and Reporting System

The Ultrium 7 tape drives use Statistical Analysis and Reporting System (SARS) to help isolate failures between media and hardware. SARS uses the data cartridge performance history that is saved in the cartridge memory module and the drive performance history that is kept in the drive flash Electronically Erasable Programmable Read-Only Memory (EEPROM) to help determine the likely cause of the failure. SARS can cause the drive to request a cleaning tape to mark the media as degraded and to indicate that the hardware is degraded.

IBM Spectrum Archive software application

IBM Ultrium 7 tape drives are compatible with the IBM Spectrum Archive software application, and the underlying Linear Tape File System (LTFS). LTFS uses the LTO media partitioning functionality, which is present on Ultrium 7, 6, and 5 cartridges. LTFS provides a standard tape cartridge format at low cost that can be used without other database applications. LTFS presents tape media as though it were a disk file system. IBM Spectrum Archive supports the IBM LTO Ultrium 8, 7, 6, and 5, and IBM TS1155, TS1150, and TS1140 tape drives.

Tape as a storage medium offers many benefits. It is reliable, portable, low-cost, low-power, and high-capacity. However, tape is not particularly easy to use. Tape has no standard format, and data often cannot be used without first copying the data to disk.

With LTFS, accessing data that is stored on an IBM tape cartridge became as easy and intuitive as using a USB flash drive. With LTFS file manager, reading data on a tape cartridge is as easy as dragging and dropping. Users can run any application that is designed for disk files against tape data without concern that the data is physically stored on tape.

LTFS implements a true file system for tape. LTFS also supports library automation, including the ability to find data on a tape in a library without mounting and searching tape volumes.

IBM Spectrum Archive supports IBM tape automation in addition to the single drive edition. By using IBM Spectrum Archive Library Edition, you can create a single file system mount point for a logical library that is managed by a single instance of the software, which runs on a single server. In addition, it provides for caching of tape indexes and for searching, querying, and displaying tapes' contents within an IBM tape library without the requirement to mount tape cartridges.

For more information about IBM Spectrum Archive and LTFS, see 2.9, "IBM Spectrum Archive" on page 138.

2.7 IBM LTO Ultrium 6 tape drive (Model 3588 F6C)

The IBM LTO-6 tape drive was released in 2012. At the time, IBM LTO-6 tape drive offerings represented significant improvements in capacity and performance over the previous generation, LTO-5, while they protected the client's investment in the previous technology.

The 3588 F6C tape drive is a high-performance, high-capacity tape drive. The drive records data by using a linear serpentine recording format on half-inch tape that is housed within a cartridge. The data tracks are located by using preformatted servo tracks.

The 3588 F6C tape drive provides the following improvements over the older LTO models:

► The 3588 F6C tape drive increases the native transfer speed to 160 MBps compared with 140 MBps for the LTO-5 tape drive.

► The 3588 F6C tape drive increases the compressed speed to 400 MBps compared with 280 MBps for the LTO-5 tape drive.

► The 3588 F6C tape drive more than doubles the potential capacity of a cartridge in LTO-5 format.

3588 F6C tape drive features at a glance

The LTO-6 (3588 F6C) tape drive has the following characteristics:

► Native data transfer rate of up to 160 MBps

► Compressed data transfer rate of up to 400 MBps

► LTO-6 data and WORM tape cartridge native physical capacity of up to 2.5 TB

► Dual-ported 8 Gbps Fibre Channel attachment option

► 1,024 MB internal data buffer for full-high drives

► Application-managed encryption (AME) and Library-managed encryption (LME) support

► Sixteen KB cartridge memory with LTO-6 media

► IBM Spectrum Archive Single Drive Edition, Library Edition, and Enterprise Edition support

► IBM Linear Tape File System (LTFS) partitioning support

The LTO Ultrium 6 supports integration in the IBM TS4500 library by using a compact drive sled.

The TS4500 LTO drive sled is shown in Figure 2-25.

Figure 2-25   LTO Ultrium 6 (3588 F6C)

The LTO Ultrium 6 Model F6C drive has a front bezel with a chevron fiducial. The buttons and display remain the same as for all previous models of LTO drives, and the buttons and display are the same as the LTO Ultrium 7 that is shown in Figure 2-20 on page 119.

Compatibility

In addition to reading and writing to LTO-6 tape cartridges, the LTO 6 tape drives can read and write to LTO-5 tape cartridges and read LTO-4 tape cartridges.

Note: The LTO-6 tape drive cannot read or write to LTO-3, LTO-2, or LTO-1 tape cartridges.

The drive also writes to tapes that can be read by other licensed LTO-6 drives. In addition to using the IBM LTO Tape Cartridge with up to 2.5 TB capacity, the drive offers read/write capability for certified LTO-6 tape cartridges.

Table 2-20 shows the native data transfer rate when a data cartridge of another generation is processed.

Table 2-20   Native data transfer rate with various media

	LTO-6 media	**LTO-5 media**	**LTO-4 media**
Supported methods of operating	Read/write	Read/write	Read only
Native data rate Fibre Channel (MBps)	160	140	120

3588 Field MES support

The following drive MES conversions are supported:

- ► 3588 F6A drive > 3588 F6C model upgrade
- ► 3588 F5A drive > 3588 F5C model upgrade

Connectivity

The LTO-6 tape drive family offers high capacity, performance, and technology for the midrange open systems environment. These tape drives are dual-ported tape 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.

IBM LTO-6 tape drives can connect to many types of servers. For a list of server interface cards or host bus adapters (HBAs) that are supported by the LTO tape drives, see the IBM System Storage Interoperation Center (SSIC) web page:

http://www.ibm.com/systems/support/storage/ssic

The LTO Ultrium 6 Model F6C has a new back panel, which is shown in Figure 2-26.
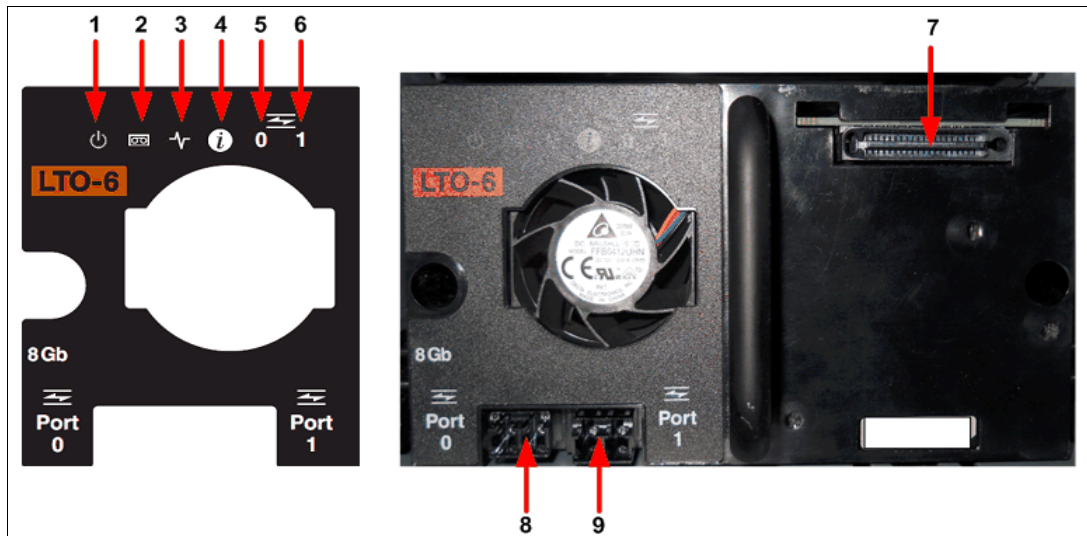
Figure 2-26   LTO Ultrium 6 Model F6C rear panel

Table 2-21 describes all of the components on the rear panel and shows the normal status of the LEDs. The numbers in Table 2-21 refer to Figure 2-26.

Table 2-21   LTO Ultrium 6 rear panel

Number	Description	LED color or description
1	Power status	Green
2	Drive status	Yellow or green
3	Library connection	Green
4	Information	Blue
5	Port 0 Fibre Channel activity	Green or yellow
6	Port 1 Fibre Channel activity	Green or yellow
7	TS4500 interface connector	TS4500 communication and power
8	Port 0, 8 Gbps fiber connection	Supports N_ports and NL_ports, which can autoconfigure between using the FC-AL protocol and the Direct Fabric attach protocol
9	Port 1, 8 Gbps fiber connection	Supports N_ports and NL_ports, which can autoconfigure between using the FC-AL protocol and the Direct Fabric attach protocol

Performance

The LTO-6 tape drive uses 2,176 data tracks to read and write to an LTO-6 tape cartridge. These tracks are grouped in five servo bands. Like the LTO-5 tape drives, the high-bandwidth servo system features a low-mass servo to help more effectively track servo bands and improve data throughput with damaged media in less-than-optimal shock and vibration environments.

The native data transfer rate for LTO-6 tape drives is 160 MBps. Compressed data rates can reach 400 MBps. IBM suggests the use of the IBM LTO-6 2.5 TB tape cartridge, which provides up to 6.25 TB of storage with a 2.5:1 compression ratio.

Dynamic speed matching

The LTO-6 tape drive performs *dynamic speed matching* at one of 14 speeds to adjust the native data rate of the drive as closely as possible to the net host data rate (after it factors out data compressibility). This approach helps to reduce the number of backhitch repositions and improves throughput performance.

Table 2-22 shows the data rates for the LTO-6 tape drives.

Table 2-22   LTO-6 tape drive speed matching data rates

Performance parameters	LTO-6 tape cartridge	LTO-5 tape cartridge	LTO-4 tape cartridge read only
Speed matching data rates in MBps	160.00	140.0	120.0
	150.77	130.0	113.1
	141.54	120.0	106.1
	132.31	112.7	99.2
	123.08	105.5	92.3
	113.85	98.2	85.3
	104.62	90.9	78.6
	95.38	83.6	71.4
	86.15	76.4	64.6
	76.92	69.1	57.6
	67.69	61.8	50.8
	58.46	53.5	43.8
	49.23	46.3	36.9
	40.00	40.0	30.5

The LTO-6 tape drives are encryption capable, which means that they can convert data into a cipher that ensures data security. System-managed encryption and library-managed encryption and associated IBM Security Key Lifecycle Manager (SKLM) access are all available as a chargeable licensed key (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.

Certain data management applications can manage keys. For an alternative solution, IBM provides a key manager that works with the keystore of your choice to perform all necessary key management tasks. No recovery exists for lost encryption keys.

Surface Control Guiding Mechanism

The *Surface Control Guiding Mechanism* is designed to guide the tape along the tape path in the LTO-6 tape drive. This method uses the surface of the tape rather than the edges to control tape motion.

LTO-6 tape drives use flangeless rollers so that the media can float naturally. The Surface Control Guiding Mechanism helps to reduce tape damage (especially to the edges of the tape) and tape debris that comes from the damaged edges and can accumulate in the head area.

Statistical Analysis and Reporting System (SARS)

The LTO-6 tape drives communicate with the TS4500 tape library through an internal Ethernet interface and use Statistical Analysis and Reporting System (SARS) to isolate failures between media and hardware. SARS uses the data cartridge performance history that is saved in the cartridge memory module and the drive performance history that is kept in the drive flash Electronically Erasable Programmable Read-Only Memory (EEPROM) to help determine the likely cause of the failure. SARS can cause the drive to request a cleaning tape to mark the media as degraded and to indicate that the hardware is degraded.

Media partitioning

Media partitioning is now available with the LTO-6 tape drive. Media partitioning allows for faster data access by splitting the cartridge into two media partitions. WORM media is not partitionable.

IBM Spectrum Archive software application

IBM Ultrium 6 tape drives are compatible with the IBM Spectrum Archive software application. IBM Spectrum Archive and the underlying Linear Tape File System (LTFS) use the LTO Ultrium 6 and Ultrium 5 media partitioning functionality. LTFS provides a standard tape cartridge format at low cost, and it can be used without other database applications. LTFS presents tape media as though it were a file system on a disk drive. LTFS supports only IBM IBM LTO Ultrium 8, 7, 6, and 5, and IBM TS1155, TS1150, and TS1140 tape drives.

Tape as a storage medium has many benefits. Tape is reliable, portable, low-cost, low-power, and high-capacity. However, tape is not particularly easy to use. It has no standard format, and data often cannot be used without first copying the data to disk.

With LTFS, accessing data that is stored on an IBM tape cartridge became as easy and intuitive as using a USB flash drive. With LTFS file manager, reading data on a tape cartridge is as easy as dragging and dropping. Users can run any application that is designed for disk files against tape data without concern that the data is physically stored on tape.

LTFS implements a true file system for tape. LTFS also supports library automation, including the ability to find data on a tape in a library without mounting and searching tape volumes.

IBM Spectrum Archive supports IBM tape automation in addition to the single drive edition. By using IBM Spectrum Archive Library Edition, you can create a single file system mount point for a logical library that is managed by a single instance of the software, which runs on a single server. In addition, it provides for caching of tape indexes and for searching, querying, and displaying tapes' contents within an IBM tape library without the requirement to mount tape cartridges.

For more information about IBM Spectrum Archive and LTFS, see 2.9, "IBM Spectrum Archive" on page 138.

2.8 IBM LTO Ultrium 5 tape drive (Model 3588 F5C)

The IBM LTO-5 tape drive was released in 2010. At the time, IBM LTO-5 tape drive offerings represented significant improvements in capacity and performance over the previous generation, LTO-4, while they protected the client's investment in the previous technology.

The LTO-5 tape drive is a high-performance, high-capacity tape drive. The drive records data by using a linear serpentine recording format on half-inch tape that is housed within a cartridge. The data tracks are located by using preformatted servo tracks.

LTO-5 tape drive features at a glance

The LTO-5 tape drive has the following characteristics:

► Native data transfer rate of up to 140 MBps

► Compressed data transfer rate of up to 280 MBps

► LTO-5 data and WORM tape cartridge native physical capacity of up to 1.5 TB

► Eight Gbps Fibre Channel attachment option

► 512 MB internal data buffer for full-high drives

► Application-managed encryption (AME) support

► Library-managed encryption (LME) support

► IBM Spectrum Archive Single Drive Edition, Library Edition, and Enterprise Edition support

► IBM Linear Tape File System (LTFS) partitioning support

► Eight KB cartridge memory with LTO-5 media

The LTO-5 tape drive is physically the same as the LTO-6 tape drive, as shown in Figure 2-25 on page 130, except the only physical difference is that the rear panel shows as an LTO-5 tape drive, as shown in Figure 2-27.

Figure 2-27   LTO-5 tape drive rear view

Connectivity

The LTO-5 tape drive family offers high capacity, performance, and technology for the midrange open systems environment. These tape drives are dual-ported tape drives that facilitate 8 Gbps Fibre Channel connectivity. These tape drives are differentiated from other LTO tape 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.

IBM LTO tape drives can connect to many types of servers. For a list of server interface cards or host bus adapters (HBAs) that are supported by the LTO tape drives, see the IBM System Storage Interoperation Center (SSIC) web page:

http://www.ibm.com/systems/support/storage/ssic

The LTO Ultrium 5 Model F5C back panel is the same as the one for the LTO Ultrium 6, which is shown in Figure 2-26 on page 132. All indicators and LEDs are the same as described in Table 2-21 on page 132.

Compatibility

In addition to reading and writing to LTO-5 tape cartridges, the LTO-5 tape drives can read and write to LTO-4 tape cartridges and read LTO-3 tape cartridges. However, the LTO-5 tape drive cannot read LTO-2 or LTO-1 tape cartridges.

The drive also writes to tapes that can be read by other licensed LTO-5 tape drives. In addition to the use of the IBM LTO Tape Cartridge with up to 1.5 TB capacity, the drive offers read/write capability for certified LTO-5 tape cartridges.

Table 2-23 shows the native data transfer rate when a tape cartridge of another generation is processed.

Table 2-23   Native data transfer rate with various media

	LTO-5 tape cartridge	LTO-4 tape cartridge	LTO-3 tape cartridge
Supported methods of operating	Read/write	Read/write	Read only
Native data rate Fibre Channel (MBps)	140	120	80

The LTO-5 tape drive family offers high capacity, performance, and technology for the midrange open systems environment. The LTO-6 tape drive (Model 3588 F6C) provides dual-ported 8 Gbps Fibre Channel connectivity for point-to-point or Fibre Channel Arbitrated Loop (FC-AL) attachment.

IBM LTO tape drives can connect to many types of servers. For a list of server interface cards or HBAs that are supported by the LTO tape drives, see the IBM System Storage Interoperation Center (SSIC) web page:

http://www.ibm.com/systems/support/storage/ssic

3588 Field MES support

The following drive MES conversions are supported:

► 3588 F5A drive > 3588 F5C model upgrade

Performance

The LTO-5 tape drive uses 1,280 data tracks to read and write to the LTO-5 tape cartridge. These tracks are grouped in five servo bands. Like the LTO-4 tape drives, the high-bandwidth servo system features a low-mass servo to help more effectively track servo bands and improve data throughput with damaged media in less-than-optimal shock and vibration environments.

The native data transfer rate for LTO-5 tape drives is 140 MBps. Compressed data rates can reach 280 MBps. IBM advises the use of the IBM LTO-5 1.5 TB tape cartridge, which provides up to 3.0 TB of storage with a 2:1 compression ratio.

Dynamic speed matching

The LTO-5 tape drive performs *dynamic speed matching* at one of 14 speeds to adjust the native data rate of the drive as closely as possible to the net host data rate (after it factors out data compressibility). This approach helps to reduce the number of backhitch repositions and improves throughput performance.

Table 2-24 shows the speed matching data rates for the LTO-5 tape drives.

Table 2-24   LTO-5 tape drive speed matching data rates

Performance parameters	LTO-5 tape cartridge	LTO-4 tape cartridge	LTO-3 tape cartridge
Speed matching data rates in MBps	140.0 130.0 120.0 112.7 105.5 98.2 90.9 83.6 76.4 69.1 61.8 53.5 46.3 40.0	120.0 113.1 106.1 99.2 92.3 85.3 78.6 71.4 64.6 57.6 50.8 43.8 36.9 30.5	80.0 76.1 72.3 68.4 64.6 60.8 56.9 53.1 49.2 45.4 41.5 37.7 33.8 30.0

Giant magneto-resistive head design

The LTO-5 tape drive uses the giant magneto-resistive (GMR) head with beveled contouring for reducing friction ("*stiction*"), especially with the smoother LTO-5 media type. This head design is well-proven in enterprise tape products, and it helps minimize contact, edge damage, debris accumulation, and wear on the tape as it moves over the read/write heads.

Surface Control Guiding Mechanism

The Surface Control Guiding Mechanism is designed to guide the tape along the tape path in the LTO-5 tape drive. This method uses the surface of the tape rather than the edges to control tape motion. LTO-5 tape drives use flangeless rollers so that the media can float naturally. The Surface Control Guiding Mechanism helps to reduce tape damage (especially to the edges of the tape) and tape debris, which comes from the damaged edges and can accumulate in the head area.

Statistical Analysis and Reporting System

The LTO-5 tape drive uses Statistical Analysis and Reporting System (SARS) to help isolate failures between media and hardware. SARS uses the data cartridge performance history that is saved in the cartridge memory module and the drive performance history that is kept in the drive flash Electronically Erasable Programmable Read-Only Memory (EEPROM) to help determine the likely cause of the failure. SARS can cause the drive to request a cleaning tape to mark the media as degraded and to indicate that the hardware is degraded. When a drive memory dump is taken from the drive, the IBM Support Center can determine whether the failure is in the tape drive or on the data cartridge.

Media partitioning

Media partitioning is now available with the LTO-5 drive. Media partitioning allows for faster data access by splitting the cartridge into two media partitions. WORM media is not partitionable.

IBM Spectrum Archive software application

The IBM Spectrum Archive software application and the underlying Linear Tape File System (LTFS) use the LTO Ultrium Generation 5 media partitioning functionality. LTFS provides a standard tape cartridge format at low cost, and it can be used without more database applications. LTFS presents tape media as though it were a file system on a disk drive. It supports only IBM LTO Ultrium 5 tape drives or higher-generation IBM LTO Ultrium tape drives.

Tape as a storage medium has many benefits. Tape is reliable, portable, low-cost, low-power, and high-capacity. However, tape is not particularly easy to use. It has no standard format, and data often cannot be used without first copying the data to disk.

With LTFS, accessing data that is stored on an IBM tape cartridge became as intuitive as the use of a USB flash drive. With LTFS file manager, reading data on a tape cartridge is as easy as dragging and dropping. You can run any application that is designed for disk files against tape data without concern that the data is physically stored on tape.

LTFS, which works on IBM LTO-8, 7, 6, 5, and IBM TS1155, TS1150, and TS1140 tape drives, implements a true file system for tape. LTFS also supports library automation, including the ability to find data on a tape in a library without mounting and searching tape volumes.

IBM Spectrum Archive supports IBM tape automation in addition to the single drive edition. With IBM Spectrum Archive Library Edition, you can create a single file system mount point for a logical library that is managed by a single instance of the software, which is running on a single computer system. In addition, it provides for caching of tape indexes, and for searching, querying, and displaying tapes' contents within an IBM tape library without the requirement to mount tape cartridges.

For more information about IBM Spectrum Archive and LTFS, see 2.9, "IBM Spectrum Archive" on page 138.

2.9 IBM Spectrum Archive

IBM Spectrum Archive, a member of the IBM Spectrum Storage™ family, enables direct, intuitive, and graphical access to data that is stored in IBM tape drives and libraries by incorporating the Linear Tape File System (LTFS) format standard for reading, writing, and exchanging descriptive metadata on formatted tape cartridges.

IBM Spectrum Archive eliminates the need for additional tape management and software to access data.

IBM Spectrum Archive offers three software solutions for managing your digital files with the LTFS format: Single Drive Edition (SDE), Library Edition (LE), and Enterprise Edition (EE). With IBM Spectrum Archive Enterprise Edition and IBM Spectrum Scale™, a tape tier can now add savings as a low-cost storage tier. Network-attached unstructured data storage with native tape support by using LTFS delivers the best mix of performance and low-cost storage.

Key capabilities

IBM Spectrum Archive options can support small, medium, and enterprise businesses:

► Seamless virtualization of storage tiers
► Policy-based placement of data
► Single universal namespace for all file data
► Security and protection of assets
► Open, non-proprietary, and cross-platform interchange
► Integrated functionality with IBM Spectrum Scale

Benefits

IBM Spectrum Archive enables direct, intuitive, and graphical access to data that is stored in IBM tape drives and libraries by incorporating the LTFS format standard for reading, writing, and exchanging descriptive metadata on formatted tape cartridges.IBM Spectrum Archive eliminates the need for additional tape management and software to access data.

IBM Spectrum Archive takes advantage of the low cost of tape storage and makes it as easy to use as drag-and-drop. Several IBM Spectrum Archive benefits are listed:

► Enable easy-as-disk access to single or multiple cartridges in a tape library
► Improve efficiency and reduce costs for long-term, tiered storage
► Optimize data placement for cost and performance
► Enable data file sharing without proprietary software
► Scale at a low cost
► Access and manage all data in stand-alone tape environments as simply as though the data was on disk

2.9.1 Linear Tape File System (LTFS)

IBM addressed the growing storage needs of marketplace segments, such as media and entertainment, by introducing the first release of the Linear Tape File System (LTFS) in 2010. IBM developed IBM Spectrum Archive Single Drive Edition (SDE) to enable a self-describing cartridge that is based on dual partition in the LTO-5 technology. LTFS is a true file system that makes tape look and work like any removable media. IBM Spectrum Archive SDE is available as a no-charge download for single TS1155, TS1150, TS1140, LTO-8, LTO-7, LTO-6, or LTO-5 tape drives from the IBM Fix Central web page:

http://www.ibm.com/support/fixcentral

LTFS is the first file system that works with LTO generation 8, 7, 6, 5, TS1155, TS1150, and TS1140 tape technology, to set a new standard for ease of use and portability for open systems tape storage. With this application, accessing data that is stored on an IBM tape cartridge is as easy and intuitive as using a USB flash drive. Tapes are self-describing, and you can quickly recall any file from a tape without reading the whole tape from beginning to end.

Furthermore, any LTFS-capable system can read a tape that is created by any other LTFS-capable system (regardless of the operating system platform). Any LTFS-capable system can identify and retrieve the files that are stored on it. LTFS-capable systems have the following characteristics:

► Files and directories are displayed to you as a directory tree listing.

► More intuitive searches of cartridges and library content are now possible due to the addition of file tagging.

► Files can be moved to and from LTFS tape by using the familiar drag-and-drop technique that is common to many operating systems.

- Many applications that were written to use files on disk can now use files on tape without any modification.
- All standard File Open, Write, Read, Append, Delete, and Close functions are supported.

Archival data storage requirements are growing at over 60% annually. The LTFS format is an ideal option for long-term archiving of large files that need to be easily shared with other individuals. This option is important because the LTO tape media that LTFS uses are designed for a 15-year to 30-year lifespan (depending on the number of read/write passes).

Industries that benefit from this tape file system are the banking, digital media, medical, geophysical, and entertainment industries. Many users in these industries use Linux or iOS (Apple) systems, which are fully compatible with LTFS.

> **Important:** LTO Ultrium cartridges from earlier LTO generations (that is, LTO-1 through LTO-4) are not partitionable. Therefore, they cannot be used by LTFS. If LTO Ultrium 4 cartridges are used in an LTO Ultrium 5 drive to write data, the LTO-4 cartridge is treated like an unpartitioned LTO-5 cartridge. Even if an application can work with partitions, it is not possible to partition the LTO-4 media that is mounted at an LTO Ultrium 5 drive. Similarly, WORM cartridges of any generation cannot be used by LTFS because they cannot be partitioned.

The TS1155, TS1150, and TS1140 tape drives are also supported by IBM Spectrum Archive SDE, IBM Spectrum Archive LE, and IBM Spectrum Archive EE.

Although LTFS presents the tape cartridge as a disk drive, the underlying hardware is still a tape cartridge and sequential in nature. Tape does not allow random access. Data is always appended to the tape, and no overwriting of files occurs. File deletions do not erase the data from tape but simply erase the pointers to the data.

So, although with LTFS, you can simultaneously copy two (or more) files to an LTFS tape, you get better performance if you copy files sequentially.

To operate the tape file system, the following components are necessary:
- Software in the form of an open source LTFS package
- Data structures that are created by LTFS on tape
- Hardware that consists of IBM LTO-8, LTO-7, LTO-6, LTO-5, TS1155, TS1150, or TS1140 tape drives and tape media

Together, these components can handle a file system on LTO media as though it is a disk file system for accessing tape files, including the tape directory tree structures. The metadata of each cartridge, after it is mounted, is cached in server memory. Therefore, metadata operations, such as browsing the directory or searching for a file name, do not require any tape movement and they are quick.

LTFS partitioning support

Tape as a storage medium has many benefits:
- Reliable
- Portable
- Low cost
- Low power use
- High capacity

However, tape is not particularly easy to use because it has no standard format, and data often cannot be used without first copying the data to a disk.

With LTFS, accessing data that is stored on an IBM tape cartridge became as easy and intuitive as the use of a USB flash drive. With LTFS file manager, reading data on a tape cartridge is as easy as dragging and dropping a file. Users can run any application that is designed for disk files against tape data without concern that the data is physically stored on tape.

With IBM Spectrum Archive Single Drive Edition, you can create a single file system mount point for a logical library that is managed by a single instance of LTFS, which is running on a single computer system. In addition, it provides for caching of tape indexes, and for searching, querying, and displaying tapes' contents within an IBM tape library without the requirement to mount tape cartridges.

For more information about IBM Spectrum Archive SDE, see *IBM Linear Tape File System Installation and Configuration*, SG24-8090.

The TS1155, TS1150, and TS1140 provide LTFS support with the following features:
► They provide the capability to configure up to four partitions.
► They support wrap-wise and longitudinal-wise partitioning.
► They support all non-WORM media formats.
► They provide `format` command support.
► Each partition can use a separate encryption method, or none.

The TS1155 and TS1150 drives support partitioning in an identical manner to the TS1140, except the capacity of a specific partition scales up with the newly supported J5 and J5A format and improved performance:

► These drives support both the wrap-wise and longitudinal partitioning models and the same number of partitions.

► These drives support the partitioning of WORM media types to enable LTFS support on WORM media.

► These drives support a default wrap-wise partitioning model with minimal capacity loss at the expense of Accumulating Backhitchless Flush (ABF) capability within all partitions at all times.

Partitioning allows a volume to be split into multiple logical partitions, each of which can be read, navigated, written, erased, appended, updated, and managed as separate logical entities, with unique logical block sequences.

The primary user of this partitioning capability is LTFS, which partitions a volume into two logical partitions: an index partition and a data partition. The TS1155 and TS1150 drives support both TS1140 style partitions.

The TS1155 and TS1150 support additional partitioning enhancements over the TS1140, specifically, both wrap-wise partitioning and longitudinal partitioning methods.

The following characteristics apply in general to partitioning support on the TS1155 (3592 55E and 55F) and TS1150 (3592 EH8):

► Partitioning is supported on media in the TS1155, TS1150 and TS1140 logical formats.

In JC media reuse, if you issue a `Format Medium` command, the system performs an implicit reformat to the TS1150 format if the media is in the TS1140 format.

In JD media reuse, if you issue a `Format Medium` command, the system performs an implicit reformat to the TS1155 format if the media is in the TS1150 format.

► Partitioning is only supported on unscaled R/W data and WORM media types that support writing in the TS1155, TS1150, or TS1140 format.

In scaled media, the `Format Medium` command is rejected.

Attempts to scale partitioned media are accepted. As part of scaling, the volume is set to a single data partition cartridge.

For more information about partitioning behavior, see *IBM 3592 SCSI Reference*, GA32-0562:

http://www.ibm.com/support/docview.wss?uid=ssg1S7003248&aid=1

Two types of partitioning are available:

► Wrap-wise partitioning (which is used on LTO-8, 7, 6, and 5, TS1155, TS1150, and TS1140).

► Longitudinal partitioning (maximum of two partitions) can be used on TS1155, TS1150, and TS1140 only.

Wrap-wise partitioning

LTO-8, 7, 6, and 5 support two wrap-wise partitions. The TS1155, TS1150, and TS1140 support four wrap-wise partitions.

Figure 2-28 depicts wrap-wise partitioning. The following information applies to wrap-wise partitioning:

► A maximum of four partitions are supported. Two or three partitions can be assigned, if preferred.

► A minimum of two wraps are allocated to a partition, regardless of the minimum selected capacity.

► The full length of the tape (LP3 to LP5) is always assigned to each partition.

► In general, two physical wraps between partitions are reserved as guard wraps. Therefore, a percentage of usable capacity might be lost, up to 3% for each partition boundary.

► RABF operations are performed in any partition if spare usable ABF wraps exist within a partition. In general, the last four wraps of a partition, or any partition that is smaller than four wraps, do not support RABF operations.
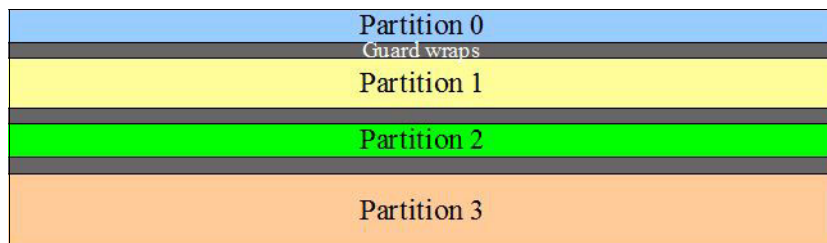
Figure 2-28   Wrap-wise partitioning

Longitudinal partitioning

The following conditions apply to longitudinal partitioning, which is supported on the TS1155, TS1150, and TS1140:

► A maximum of two partitions are supported.

► A minimum of 50 meters (164 ft.) are allocated to a longitudinal partition.

► The physical data wraps on the portion of tape that is assigned to the partition belong exclusively to each logical partition that is configured. Each partition starts from wrap 0 and ends on the last wrap.

► A guard gap between partitions is reserved to protect user data against systematic debris accumulation. The guardband is approximately 7 meters (22.9 ft.) and results in a capacity loss of less than 1%.

► RABF is performed within the boundaries of each partition, with the same wrap sequence as the base J5 RABF operation.

► Performance is slightly poorer due to less total ABF wrap length.

► As in non-partitioned media, the last four wraps' RABF cannot be used.

► Better performance is provided for random access because of shortened tape length for the partition.

Figure 2-29 depicts longitudinal partitioning.
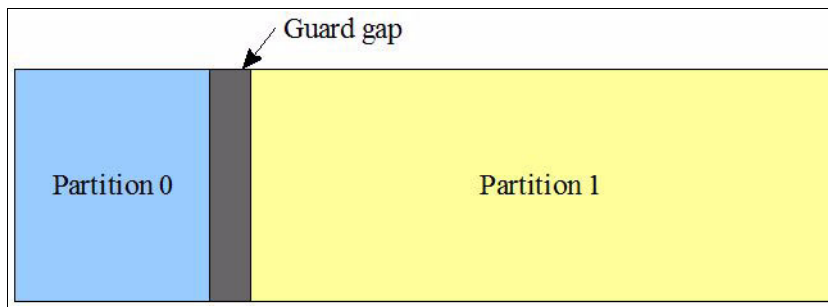
Figure 2-29   Longitudinal partitioning

2.9.2 IBM Spectrum Archive Editions

As shown in Figure 2-30, IBM Spectrum Archive is available in three editions that support small, medium, and enterprise businesses.
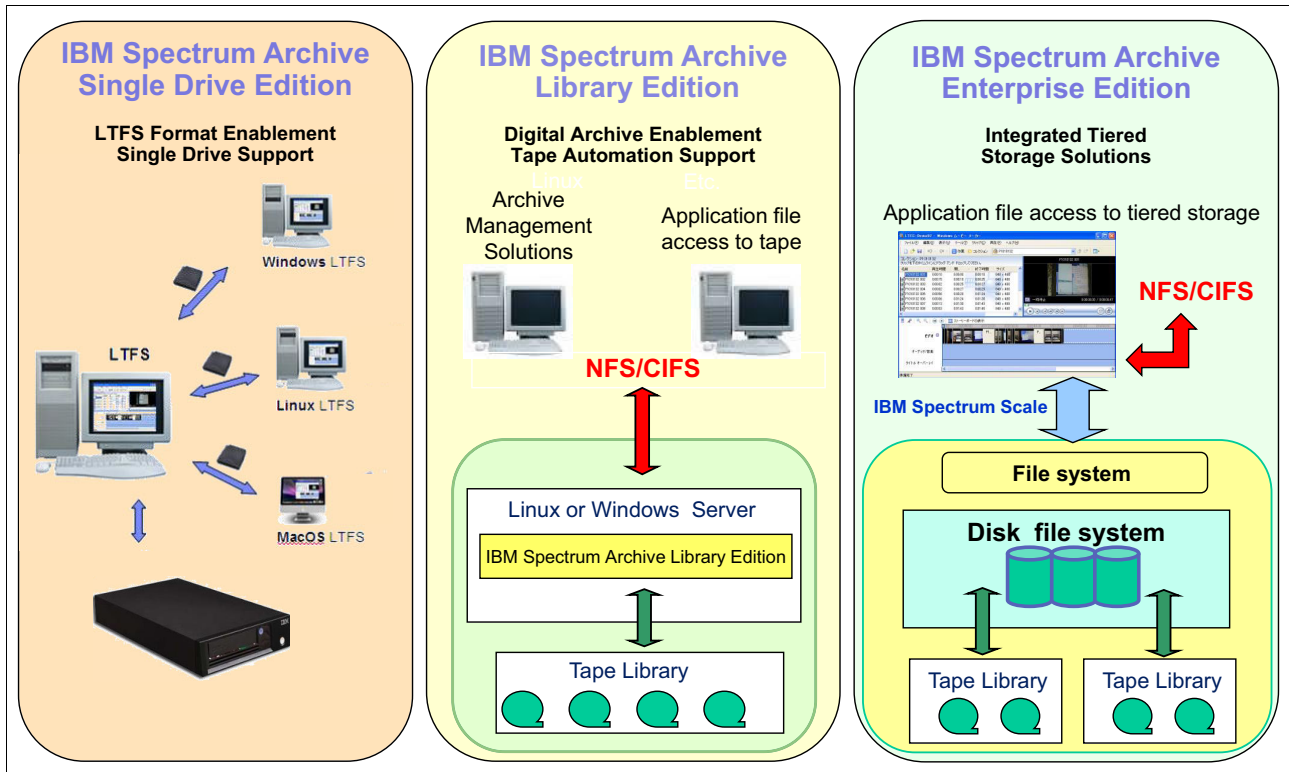
Figure 2-30   IBM Spectrum Archive SDE, LE, and EE

IBM Spectrum Archive Single Drive Edition

IBM Spectrum Archive Single Drive Edition (SDE) implements the LTFS format and allows tapes to be formatted as an LTFS volume. These LTFS volumes can then be mounted by using LTFS to allow users and applications direct access to files and directories that are stored on the tape. No integration with tape libraries exists in this edition. Access and manage all data in stand-alone tape environments as simply as though the data was on disk.

IBM Spectrum Archive Single Drive Edition file system works with LTO generation 8, 7, 6, 5, TS1155, TS1150, and TS1140 tape technology to set a new standard for ease-of-use and portability for open systems tape storage. These tape drives support media partitioning, which allows their media to be divided in segments. Accessibility is improved because you can quickly locate data to retrieve or update.

LTFS can write files directly to tape media without any specific application. The tape drive shows up on the operating system as though it were a USB-attached drive. With LTFS file manager, reading data on a tape cartridge is as easy as dragging and dropping. Users can run any application that is designed for disk files against tape data without concern that the data is physically stored on tape.

For more information about IBM Spectrum Archive SDE, see *IBM Linear Tape File System Installation and Configuration*, SG24-8090.

IBM Spectrum Archive Library Edition

IBM Spectrum Archive Library Edition (LE) extends the file manager capability of the IBM Spectrum Archive SDE. IBM Spectrum Archive LE is introduced with Version 2.0 of LTFS. Enable easy-as-disk access to single or multiple cartridges in a tape library.

LTFS is the first file system that works with IBM System Storage tape technology to optimize ease of use and portability for open systems tape storage. It manages the automation and provides operating system-level access to the contents of the library. IBM Spectrum Archive LE is based on the LTFS format specification, enabling tape library cartridges to be interchangeable with cartridges that are written with the open source SDE version of IBM Spectrum Archive. IBM Spectrum Archive LE supports most IBM tape libraries:

- ► TS2900 tape autoloader
- ► TS3100 tape library
- ► TS3200 tape library
- ► TS3310 tape library
- ► TS4300 tape library
- ► TS3500 tape library
- ► TS4500 tape library

IBM TS1155, TS1150, and IBM TS1140 tape drives are supported on IBM TS4500, and TS1150 and TS1140 are supported on the IBM TS3500 tape libraries only.

IBM Spectrum Archive LE enables the reading, writing, searching, and indexing of user data on tape and access to user metadata. *Metadata* is the descriptive information about user data that is stored on a cartridge. Metadata enables searching and accessing of files through the GUI of the operating system. IBM Spectrum Archive LE supports both Linux and Windows.

IBM Spectrum Archive LE provides the following product features:

- ► Direct access and management of data on tape libraries with LTO Ultrium 8, 7, 6, 5 tape drives, as well as the TS1155, TS1150, and TS1140 tape drives

- ► Tagging of files with any text, allowing more intuitive searches of cartridge and library content

- ► Exploitation of the partitioning of the media in the LTO-5 tape format standard

- ► One-to-one mapping of tape cartridges in tape libraries to file folders

- ► Capability to create a single file system mount point for a logical library that is managed by a single instance of LTFS and runs on a single computer system

- ► Capability to cache tape indexes and to search, query, and display tape content within an IBM tape library without needing to mount tape cartridges

The IBM Spectrum Archive LE offers the same basic capabilities as the SDE with additional support of tape libraries. Each LTFS tape cartridge in the library appears as an individual folder within the file space. The user or application can navigate into each of these folders to access the files that are stored on each tape. The IBM Spectrum Archive LE software automatically controls the tape library robotics to load and unload the necessary LTFS volumes to provide access to the stored files.

Figure 2-31 shows how IBM Spectrum Archive LE presents the tapes in the library as folders.
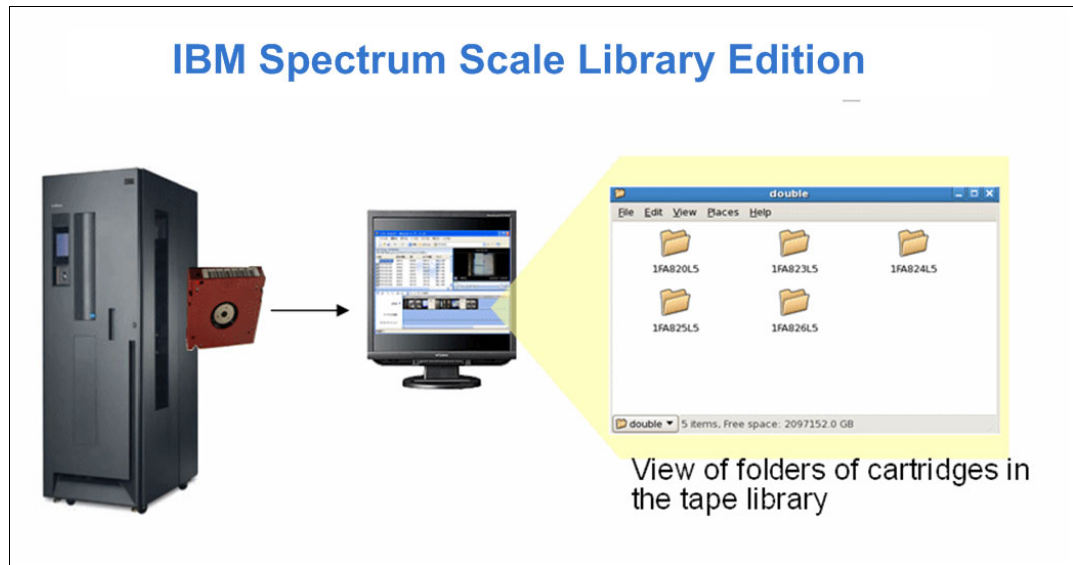
Figure 2-31   IBM Spectrum Archive LE view of tape folders

The following IBM tape libraries and tape autoloader support IBM Spectrum Archive LE:

► TS2900 tape autoloader
► TS3100 tape library
► TS3200 tape library
► TS3310 tape library
► TS4300 tape library
► TS3500 tape library
► TS4500 tape library

For more information about IBM Spectrum Archive LE, see *IBM Linear Tape File System Installation and Configuration*, SG24-8090.

IBM Spectrum Archive Enterprise Edition

IBM Spectrum Archive Enterprise Edition (EE) offers organizations an easy way to use cost-effective IBM tape drives and libraries within a tiered storage infrastructure. By using tape libraries instead of disks for tier 2 and tier 3 data storage (data that is stored for long-term retention), organizations can improve efficiency and reduce costs. In addition, IBM Spectrum Archive EE seamlessly integrates with the scalability, manageability, and performance of IBM Spectrum Scale, an IBM enterprise file management platform that enables organizations to move beyond simply adding storage to optimizing data management.

IBM Spectrum Archive Enterprise Edition offers the following benefits:

► Simplify tape storage with the IBM Linear Tape File System (LTFS) format in combination with the scalability, manageability, and performance of IBM Spectrum Scale

► Help reduce IT expenses by replacing tiered disk storage (tier 2 and tier 3) with IBM tape libraries

► Expand archive capacity simply by adding and provisioning media without affecting the availability of data that is already in the pool

► Add extensive capacity to IBM Spectrum Scale installations with lower media, less floor space, and lower power costs

IBM Spectrum Archive EE for the IBM TS4500, IBM TS3500, TS4300 and IBM TS3310 tape libraries provides seamless integration of IBM Spectrum Archive with IBM Spectrum Scale by creating an LTFS tape tier. You can run any application that is designed for disk files on tape by using IBM Spectrum Archive EE. IBM Spectrum Archive EE can play a major role in reducing the cost of storage for data that does not need the access performance of primary disk. Improve efficiency and reduce costs for long-term, tiered storage.

With IBM Spectrum Archive EE, you can enable the use of LTFS for the policy management of tape as a storage tier in an IBM Spectrum Scale environment and use tape as a critical tier in the storage environment. IBM Spectrum Archive EE supports IBM Linear Tape-Open (LTO) Ultrium 8, 7, 6, and 5 tape drives, and IBM System Storage TS1155, TS1150, and TS1140 tape drives that are installed in TS4500 and TS3500 tape libraries or LTO Ultrium 8, 7, 6, and 5 tape drives that are installed in the TS3310 tape library or LTO Ultrium 8, 7, and 6 tape drives that are installed in the TS4300 tape library.

The use of IBM Spectrum Archive EE to replace disks with tape in tier 2 and tier 3 storage can improve data access over other storage solutions because it improves efficiency and streamlines the management for files on tape. IBM Spectrum Archive EE simplifies the use of tape by making it transparent to the user and manageable by the administrator under a single infrastructure.

Figure 2-32 shows the integration of the IBM Spectrum Archive EE archive solution with IBM Spectrum Scale.
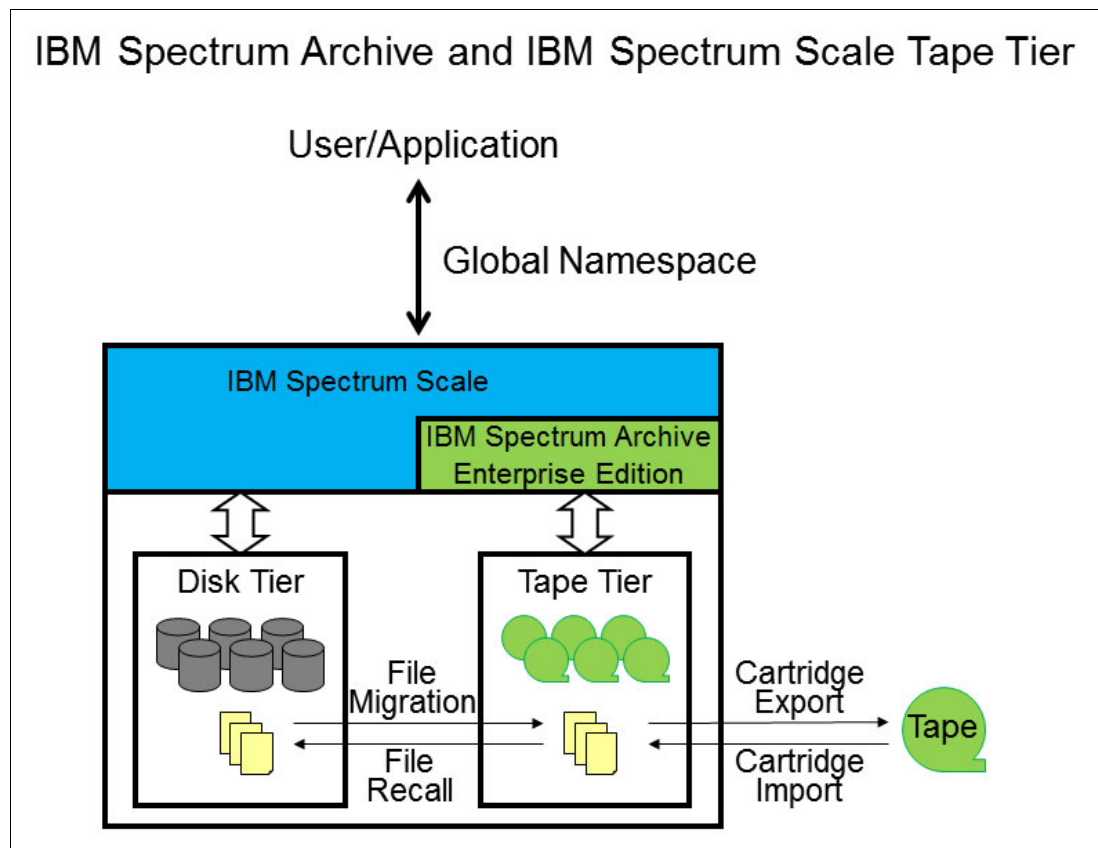
Figure 2-32   Integration of IBM Spectrum Scale and IBM Spectrum Archive Enterprise Edition

The seamless integration offers transparent file access in a continuous namespace. It provides the following capabilities:

- ► File-level write and read caching with a disk staging area
- ► Policy-based movement from disk to tape
- ► Creation of multiple data copies on different tapes
- ► Load balancing and high availability in multiple node clusters
- ► Data exchange on LTFS tape by using the import and export function
- ► Fast import of file namespace from LTFS tapes without reading data
- ► Built-in tape reclamation and reconciliation
- ► Simple administration and management

Note: For more information, see this website:

http://www.ibm.com/systems/storage/tape/ltfs

3

Encryption

The encryption policies, methods, and software capabilities for the IBM TS4500 tape library are described in this chapter.

This chapter includes the following topics:

► Tape encryption overview:

  – Encryption-enabled tape drives
  – Encryption key management

► Encryption policy:

  – Encryption methods
  – Managing encryption on the TS4500
  – Application-managed encryption (AME)
  – System-managed encryption (SME)
  – Library-managed encryption (LME)
  – Prerequisites for using encryption on the IBM TS4500 tape library

3.1 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 using processing power and without degrading performance.

3.1.1 Encryption-enabled tape drives

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 on the tape drives through the TS4500 management graphical user interface (GUI).

> **Note:** FC 1604, Transparent LTO Encryption, is required for library-managed encryption (LME) on Linear Tape-Option (LTO) tape drives. It is not required for application-managed encryption (AME).

3.1.2 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 on the operating environment where the encrypting tape drive is installed. Certain data management applications, such as IBM Spectrum Protect, 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. The suggested IBM Encryption Key Manager (EKM) for the TS4500 tape library and drives is IBM Security Key Lifecycle Manager.

IBM Security Key Lifecycle Manager is the IBM strategic platform for the storage and delivery of encryption keys to encrypt storage endpoint devices.

The IBM Security Key Lifecycle Manager can be used to provide encryption key management services for the encryption of data with encryption-capable drives. Host software has no direct knowledge of the key manager that is used.

IBM Security Key Lifecycle Manager serves data keys to the tape drive. The first release of IBM Security Key Lifecycle Manager focuses on ease of use and provides a new GUI to help with the installation and configuration of the key manager. With IBM Security Key Lifecycle Manager, the main encryption keys (*certificates*) can be created and managed. If you use the IBM Tivoli® Key Lifecycle Manager, you can migrate to the new IBM Security Key Lifecycle Manager.

For more detailed information about the IBM Security Key Lifecycle Manager, see IBM Knowledge Center for IBM Security Key Lifecycle Manager:

https://www.ibm.com/support/knowledgecenter/en/SSWPVP

3.2 Encryption policy

The *encryption policy* is the method that is used to implement encryption. It includes the rules that govern the volumes that are encrypted and the mechanism for key selection. How and where these rules are set up depends on the operating environment. For more information about each of the available methods, see 3.2.2, "Managing encryption on the TS4500" on page 152.

With the TS4500 tape library, the encryption policy is managed at the logical library level. The Logical Libraries page of the TS4500 management GUI is used to enable encryption for a logical library and modify the encryption method that is used. The Security page of the TS4500 management GUI 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 client. It is not configured and managed by the IBM service support representative (SSR). In certain instances, SSRs are required to enable encryption at a hardware level when service access or service password-controlled access is required. Client setup support is from a field technical sales specialist (FTSS), client documentation, and software support for encryption software problems.

3.2.1 Encryption methods

The encryption methods for the TS1155, TS1150, TS1140, LTO-8, LTO-7, LTO-6, LTO-5, and LTO-4 tape drives differ slightly. Those differences are described next. The following sections also contain a brief description of encryption methods. In these sections, we use the term *Key Manager* (KM) to refer to IBM Security Key Lifecycle Manager and any other key managers.

Symmetric key encryption

Encryption of data by using a symmetric key and algorithm is sometimes called *private key encryption* or *secret key*, which is not to be confused with the private key in an asymmetric key system. In a symmetric key system, the cipher key that is used for encrypting data is the same as the cipher key that is used for decryption.

The encryption and decryption ciphers can be related by a simple transformation on the key, or the encryption key and the decryption key can be identical. In the IBM Tape Encryption solution IBM Security Key Lifecycle Manager, the same encryption key is used for encryption and decryption of the data. This key is protected by an asymmetric key algorithm, and it is never available in clear text.

Symmetric key encryption is several orders of magnitude faster than asymmetric key encryption. Secret key algorithms can support encryption 1 bit at a time or by specified blocks of bits. The Advanced Encryption Standard (AES) supports 128-bit block sizes and key sizes of 128, 192, and 256. The IBM Tape Encryption solution uses the AES standard with a 256-bit key. Other well-known symmetric key examples are listed:

- ► Twofish
- ► Blowfish
- ► Serpent
- ► Cast5
- ► Data Encryption Standard (DES)

- ► Triple DES (TDES)
- ► International Data Encryption Algorithm (IDEA)
- ► Advanced Encryption Standard (AES)

Asymmetric key encryption

Another important method of encryption that is widely used today is referred to as *public/private key encryption* or *asymmetric encryption*. When this encryption methodology is used, ciphers are generated in pairs. The first key is used to encrypt the data. The second key is used to decrypt the data.

This technique was pioneered in the 1970s, and it represented a significant breakthrough in cryptography. The Rivest-Shamir-Adleman (RSA) algorithm is the most widely used public key technique. The power of this approach is a public key, which is used to encrypt the data.

This public key can be widely shared, and anyone who wants to send secure data to an organization can use its public key. The receiving organization then uses its private key to decrypt the data, which makes public/private key encryption useful for sharing information between organizations. This methodology is widely used on the internet today to secure transactions, including Secure Sockets Layer (SSL).

Asymmetric key encryption is much slower and more computationally intensive than symmetric key encryption. The advantage of asymmetric key encryption is the ability to share secret data without sharing the same encryption key.

3.2.2 Managing encryption on the TS4500

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 they decrypt information that is being read from tape media.

The TS4500 tape library supports the IBM Security Key Lifecycle Manager. For more information, see the IBM Security Key Lifecycle Manager V2.5 documentation section in IBM Knowledge Center:

http://www.ibm.com/support/knowledgecenter/SSWPVP_2.5.0/com.ibm.sklm.doc_2.5/welcome.htm?lang=en

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

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

Three methods are available for managing encryption in the TS4500 tape library:

- ► Application-managed encryption (AME)
- ► System-managed encryption (SME) for TS7700
- ► 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 the best method for you.

Key management and the encryption policy engine can be in any of the environment layers that are shown in Figure 3-1.
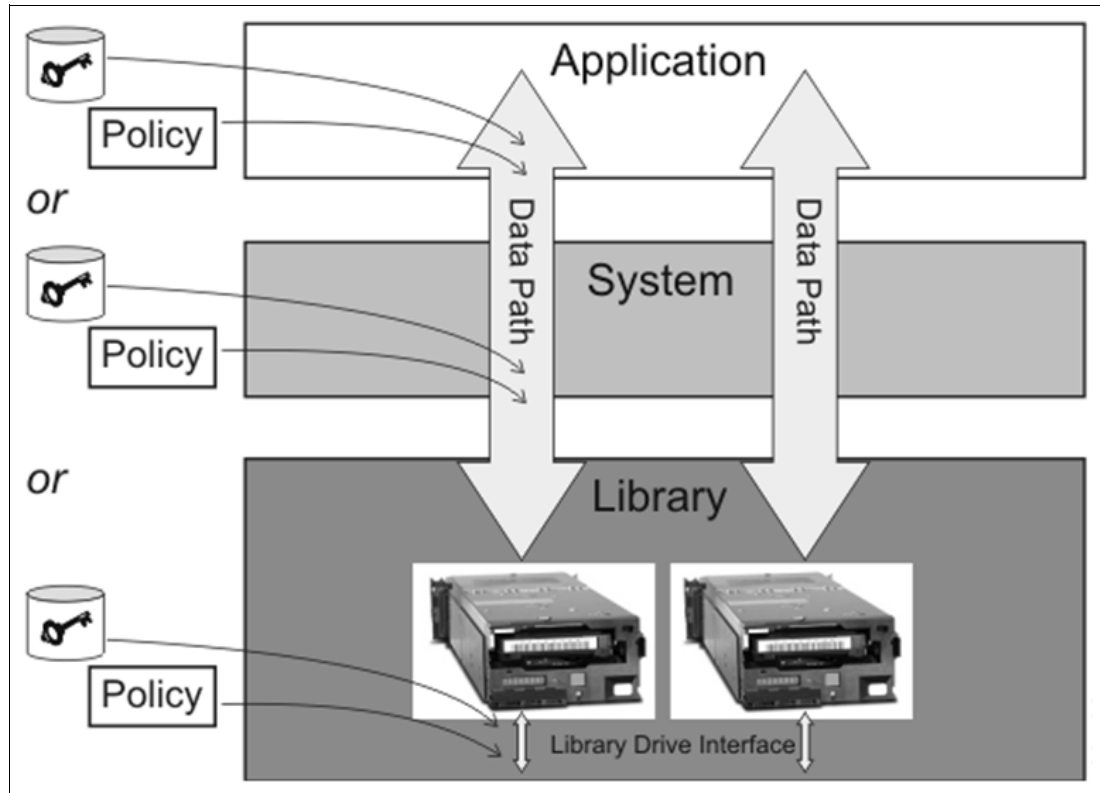
Figure 3-1   Possible locations for the encryption policy engine and key management

The application layer, for example, IBM Spectrum Protect, initiates the data transfer for tape storage.

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

3.2.3 Application-managed encryption (AME)

The application-managed tape encryption method is best in operating environments that run an application that already can generate and manage encryption policies and keys, such as IBM Spectrum Protect. 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 encryption-capable tape drives.

Encryption is the result of interaction between the application and the encryption-enabled tape drive, and it is transparent to the system and library layers. Because the application manages the encryption keys, volumes that are written and encrypted with the application method can be read only by using the application-managed tape encryption method.

> **Note:** The capability to use AME is not preset. The logical library must be set to use AME.

Application-managed tape encryption can use either of two encryption command sets:

► The IBM encryption command set that was developed for the key manager
► The T10 command set that was defined by the International Committee for Information Technology Standards (INCITS)

3.2.4 System-managed encryption (SME)

System-managed encryption is required for TS7700 support. Tape drives that attach to the TS7700 must be configured for system-managed encryption. The TS7700 can use the drives in this mode only, and it does not support library-managed or application-managed encryption.

After the TS7700 uses drives for encrypted physical tape volumes, it will place drives that are not correctly enabled for encryption offline to the subsystem.

System-managed encryption is best where the applications that write to or read from tapes are not capable of performing the key management that is required for application-managed encryption.

For IBM z Systems, encryption policies that specify when to use encryption can be set up in the z/OS Data Facility Storage Management Subsystem (DFSMS) or implicitly through each instance of an IBM device driver. Key generation and management are performed by an encryption key server. Policy controls and keys pass through the data path between the system layer and the encrypting tape drives. Encryption is transparent to the applications.

3.2.5 Library-managed encryption (LME)

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 preset. The logical library must be set to use LME.

Key generation and management are performed by the key manager, which is a Java application that is running on a library-attached host. The keys pass through the library-to-drive interface. Therefore, encryption is transparent to the applications when it is used with certain applications, such as IBM Spectrum Protect.

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 (VOLSERs). Library-managed encryption also allows other options, such as the encryption of all volumes in a library, independently 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.

When it is used with certain applications, such as Symantec NetBackup or the EMC Legato NetWorker, library-managed encryption 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.

Up to four library-managed encryption (LME) key paths per logical library are supported on the TS4500.

> **Note:** If you use LME and IBM device drivers that run on open systems platforms (AIX, Linux, Solaris, or Windows), information for bulk rekey is available in the *IBM Tape Device Drivers Installation and User's Guide,* GC27-2130. This guide is available on the web:
>
> `http://www.ibm.com/support/docview.wss?uid=ssg1S7002972`
>
> **Tip:** 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.

The following components are required to use encryption:

► Encryption-enabled tape drive
► Keystore
► Key manager

3.2.6 Prerequisites for using encryption on the IBM TS4500 tape library

Certain hardware and software prerequisites must be met before you use 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 must be attached to the TS4500 and configured for LME.

► Tape drives must be enabled for encryption from the Logical Libraries page of the TS4500 management GUI.

► If the tape drives connect to a TS7700, system-managed encryption must be used.

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 (FC) 1604, Transparent LTO Encryption, is required for LTO tape drives if you use LME.

► IBM Security Key Lifecycle Manager is required as the key manager when you use LME with LTO tape drives.

Encryption methods on the TS4500

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. Enable encryption, or modify the method that is used, on the Logical Libraries page, which is shown in more detail in 4.1, "Integrated management console (IMC)" on page 160.

To enable encryption or modify the method that is used, complete the following steps:

1. Select a logical library on the Logical Libraries page.
2. Then, select **Actions** → **Modify Encryption Method**.
3. Choose a method from the Encryption menu on the Modify Encryption Method window and click **Modify**, as shown in Figure 3-2.

For more information about this topic, see "Modify Encryption Method" on page 262.
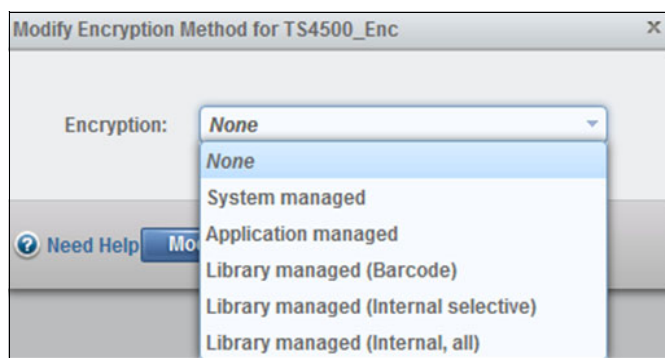
Figure 3-2   Modify Encryption Method window

The following methods can be used for encryption.

Application-managed encryption (AME)

Use this method if the application generates and manages encryption policies and keys. Applications, such as IBM Spectrum Protect, can manage encryption.

System-managed encryption (SME)

Select this method of encryption if the library is attached to a TS7700.

Library-managed encryption (LME) by bar code

Use this method to use the default key that is specified by the key manager for all VOLSER ranges. The encryption policy is specified based on cartridge volume serial numbers.

Library-managed encryption (LME) by internal label selective encryption

Use this method if you use Symantec NetBackup or the EMC Legato NetWorker. This encryption method encrypts cartridges with pool identifiers from 1500 - 9999 (inclusive) by using keys that are specific to each pool.

Labels for these keys are generated by the tape drive based on the pool identifier. For instance, key label `INTERNAL_LABEL_NBU_1505_A` is generated for a cartridge in pool `1505`. Go to **Settings** → **Security** → **Encryption Internal Label** and select the **Create mapping** tab to map these generated labels to the key-encrypting key labels that you want in the keystore of the Encryption Key Manager (EKM). All other cartridges remain unencrypted.

Library-managed encryption (LME) by internal label all encryption

Encrypt All Mode allows NetBackup to always request encryption and to specify the key labels to use. Certain ranges indicate that the default EKM key labels must be used and other ranges indicate that one or two key labels need to be constructed based on the pool ID.

For NetWorker, Encrypt All Mode allows NetWorker to request encryption for all but two cases. The mode is the same as the Selective Encryption Mode, except where the Encryption Control Field (ECF) is invalid, out of range, or not provided. In this case, the drive generates a special "NOTAG" key label or labels. If the keystore has keys with this label, encryption occurs. However, the intended use of the "NOTAG" key label is to flag jobs that did not update their ECF for encryption. If the "NOTAG" key is not in the keystore, the write fails and the job fails. This function allows the client to flag all jobs that were not altered for encryption.

4

TS4500 management graphical user interface (GUI)

The TS4500 provides advanced capabilities for integrated tape drive and media management, which are delivered within a "single-pane-of-glass" integrated management console (IMC). The TS4500 management graphical user interface (GUI) is based on a unified interface. This unified interface includes key features, which are used in other IBM storage solutions, to help guide storage administrators to complete critical tasks.

This chapter includes the following topics:

- ► Integrated management console (IMC)
- ► Using the TS4500 management GUI
- ► Settings
- ► Access menu
- ► Cartridges menu
- ► Drives menu
- ► Library menu
- ► Monitoring
- ► Tape System Library Manager (TSLM)
- ► Remote support

4.1 Integrated management console (IMC)

The integrated management console (IMC) is a built-in platform for tools that are used to locally manage the TS4500 tape library.

The IMC, which includes an LCD panel and a keyboard with a touchpad, can be mounted on either end of your TS4500 tape library. A library controller card (LCC) and power source are required within that end frame or within the adjacent frame. Alternatively, you can use Feature Code (FC) 2737, IMC Separate Power Source, to source the IMC power independently and to attach the IMC to an LCC anywhere in the library.

The IMC comes pre-installed with a system console application, which is a set of software tools that are 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. Figure 4-1 shows the IMC.

Figure 4-1   The integrated management console (IMC)

All IMC components are located inside the side panel, and they consist of a monitor, keyboard, Tiny PC, and two power supplies (one power supply for the monitor and the other power supply for the Tiny PC). Figure 4-2 shows the Tiny PC.
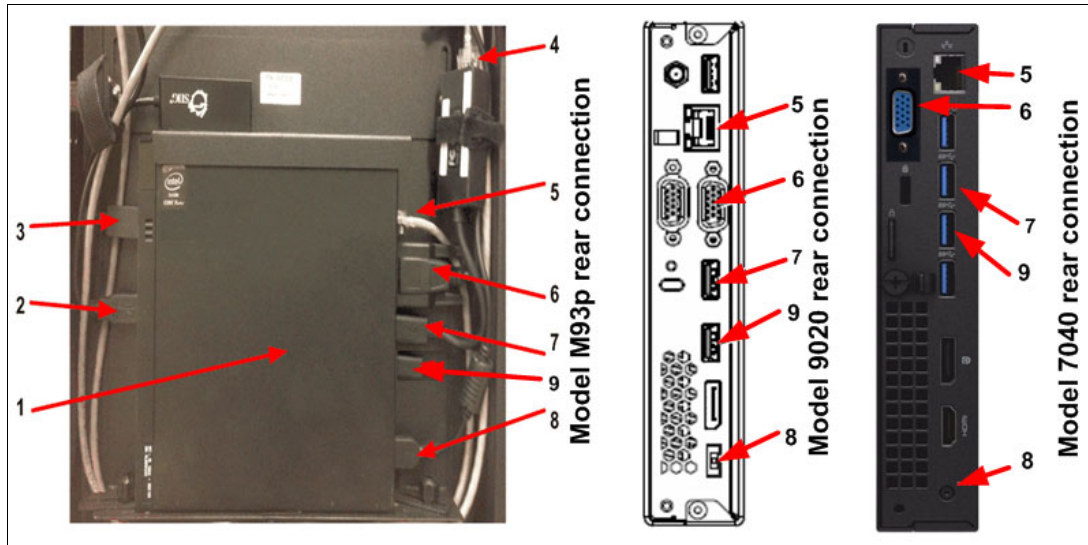
Figure 4-2   IMC Tiny PC

Table 4-1 lists the components of the Tiny PC. The numbers correspond to the numbers in Figure 4-2.

Table 4-1   Tiny PC components

Number	Component
1	Tiny PC (model M93p, 9020 or 7040)
2	USB to Ethernet adapter
3	USB to Ethernet adapter
4	Ethernet cable to adapter
5	Ethernet cable to library controller card (LCC)
6	IMC video connector
7	USB to IMC keyboard and mouse
8	Power
9	DVD drive

4.2 Using the TS4500 management GUI

Before you connect to the TS4500 management GUI, the TS4500 tape library must first be installed and configured by an IBM Engineer. In addition, you must use one of the supported web browsers that are listed in Table 4-2 to access the TS4500 management GUI. To ensure that all of the functions of the management GUI are usable, enable cookies and JavaScript in your browser and disable the browser's function of blocking pop-up windows.

During installation, the IBM service support representative (SSR) configures the IMC by using network settings that are provided by the user. Static IP assignment is the default, but Dynamic Host Configuration Protocol (DHCP) can be selected. For static IP assignment, the user must provide the SSR with a listing of the values to enter in the network setup for the library IP address, subnet mask, and gateway.

4.2.1 Connecting to the management GUI

To connect to the management GUI, perform the following steps:

1. Open one of the supported web browsers, as shown in Table 4-2.

Table 4-2   Supported web browsers

Browser	Supported versions[a]
Mozilla Firefox	38
Microsoft internet Explorer	11
Google Chrome	43

a. IBM supports higher versions of the browsers as long as the vendors do not remove or disable functionality that the product relies upon. For browser levels that are higher than the versions that are certified with the product, customer support accepts usage-related and defect-related service requests. As with operating system and virtualization environments, if IBM Support cannot re-create the issue in our lab, IBM Support might ask the client to re-create the problem on a certified browser version to determine whether a product defect exists. Defects are not accepted for cosmetic differences between browsers or browser versions that do not affect the functional behavior of the product. If a problem is identified in the product, defects are accepted. If a problem is identified with the browser, IBM might investigate potential solutions or workarounds that the client can implement until a permanent solution becomes available.

2. Type the Ethernet IP address of the frame on the URL line of the browser and press **Enter**.

3. If users are set up, enter your user name and password and click **Log in**. If this installation is new, log on to the TS4500 management GUI with the default user name and password (User Name: `admin` and Password: `admin`) to continue with the setup. After you log on with the default password, you must create a new password for the administrator account, which changes the default password.

> **Important:** Document the new administrator password because this password *cannot* be recovered if additional administrator users are not set up.

The TS4500 management GUI login window opens, as shown in Figure 4-3.

Figure 4-3   TS4500 login window

Setup wizard

If the TS4500 is a new installation, use the Initial Setup wizard, as shown in Figure 4-4. This wizard guides you through the basic configuration settings. The following settings are configured when you use the Initial Setup wizard. You can modify these settings from the Settings page of the management GUI.
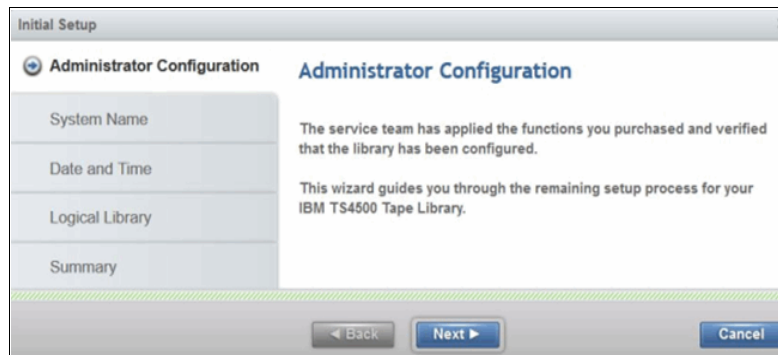
Figure 4-4   Setup wizard

Complete these steps:

1. In the window, as shown in Figure 4-5, you can enter the name of your library.
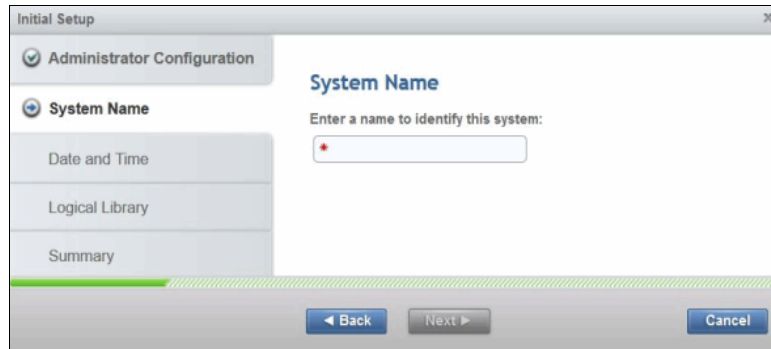
Figure 4-5   Setting the system name

2. In the next window, you can set the date and time for the library manually. Optionally, you can synchronize with a Network Time Protocol (NTP) server, as shown in Figure 4-6.
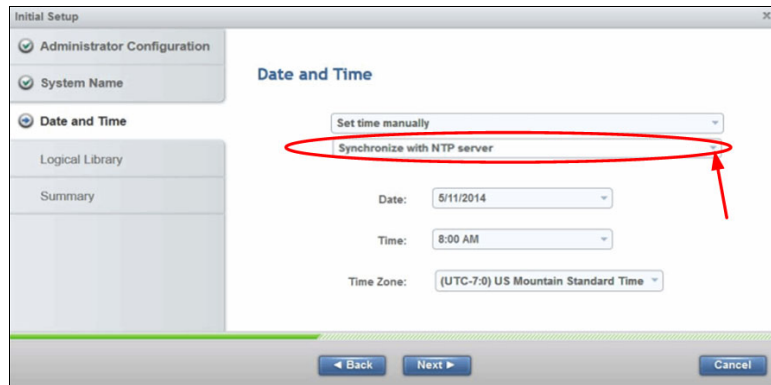
Figure 4-6   Date and time

3. Use the window that is shown in Figure 4-7 to configure a logical library, or you can skip this step and configure the logical library later.
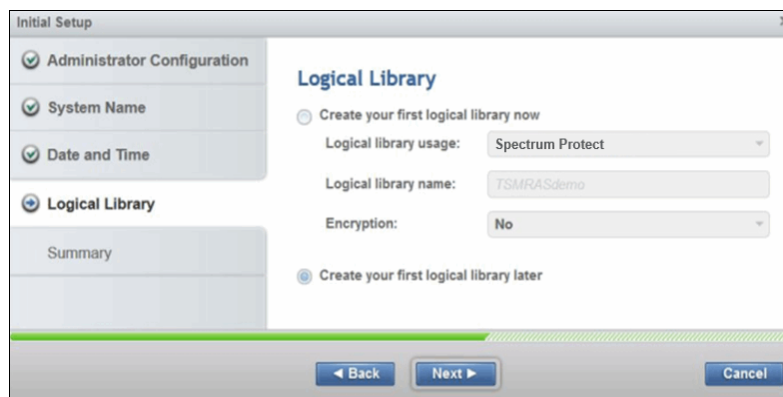
Figure 4-7   Logical libraries

4. The window that is shown in Figure 4-8 displays a summary of all of the settings that were configured in the previous steps. Select **Finish** to complete the wizard and go to the main menus.
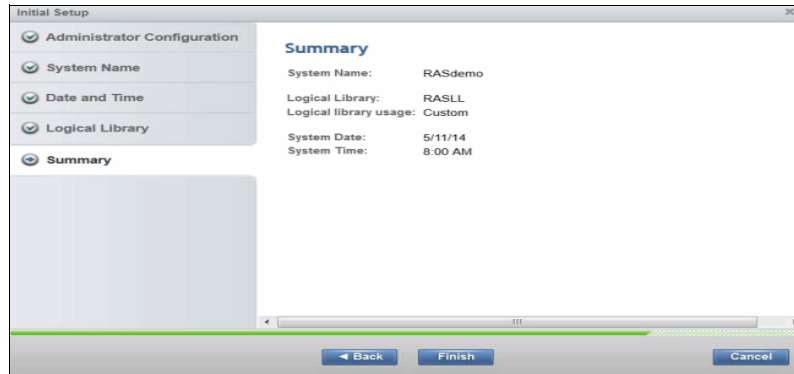
Figure 4-8   Summary

4.2.2 System summary display

After login the system summary window is shown, as in Figure 4-9.
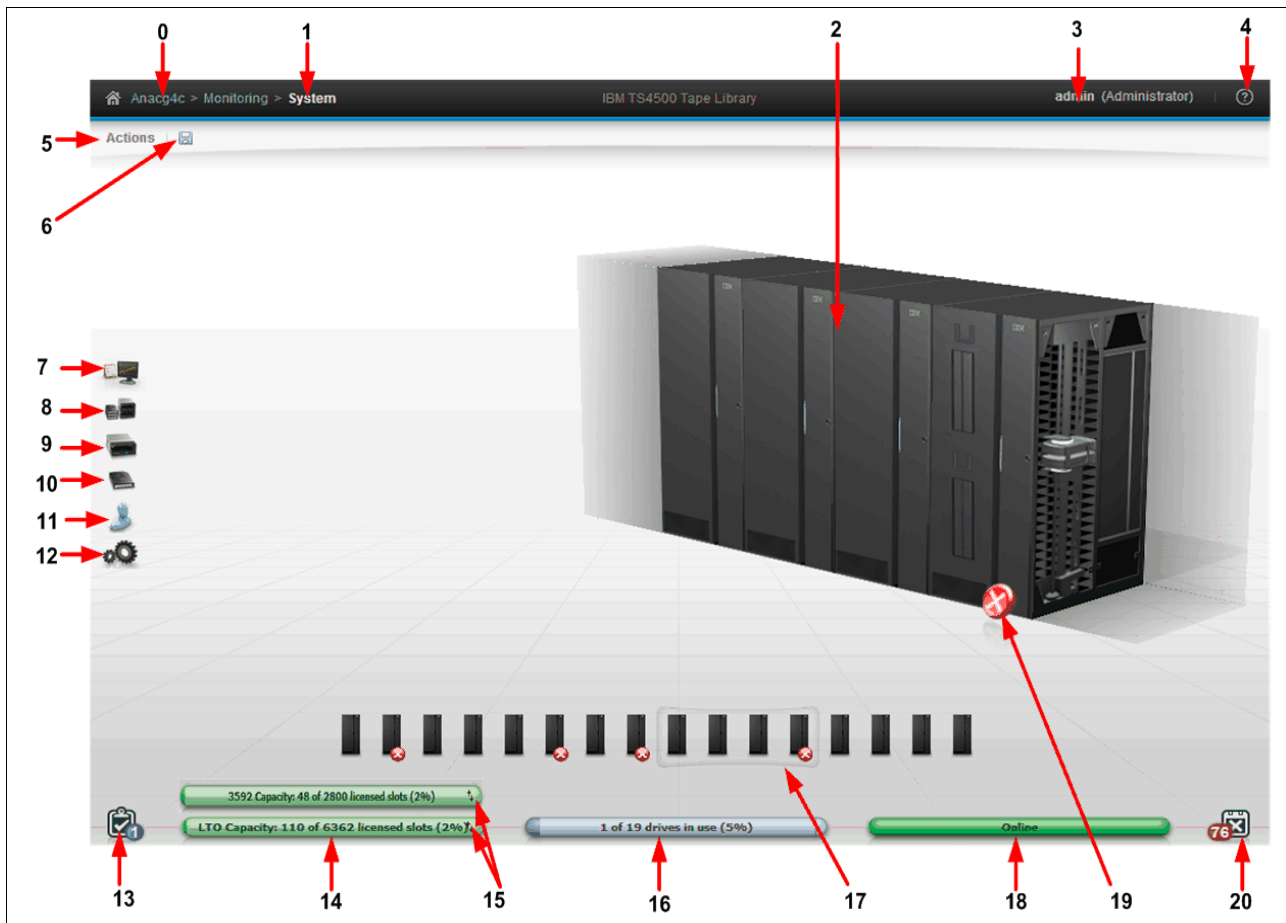
Figure 4-9   System summary display

For help and information about the Management Interface (MI) and the available functions, use the question mark (**?**) icon or **Help**, which is number 4 on Figure 4-9 on page 165.

Table 4-3 explains all of the fields that are shown on the window. The numbers refer to Figure 4-9 on page 165.

Table 4-3 System display

Number	Field
0	TS4500 tape library name.
1	Current menu tree position.
2	View of physical library that is installed.
3	Logged-in user name and role.
4	Help.
5	Library hardware actions menu.
6	Export Data menu.
7	Monitoring menu.
8	Library menu.
9	Drives menu.
10	Cartridges menu.
11	Access menu.
12	Settings menu.
13	Tasks icon. The Tasks icon displays when tasks are running.
14	The physical capacity pod displays the licensed capacity (Linear Tape-Open (LTO) and 3592). This pod changes color to yellow or red, depending on whether the capacity exceeds the thresholds.
15	Switch the display for physical capacity per drive type by using the arrow on a mixed library.
16	Drives in use status pod.
17	All installed frames and status. This area is grouped into four frames. When this area is selected, the four frames show in the main window.
18	Library health status pod. The color of the health status pod indicates the current state of the library by severity.
19	Frame health status pod for the selected frame. An icon is present in this field if an error or warning exists with a frame, tape drive, cartridge, or an accessor. Hover over the icon to see a list of the most important issues that cause this state. Click any issue to open the Events Page to see more information.
20	Library events icon. The library events icon displays if events are active.

4.3 Settings

Use this option to set up and manage system notifications, network, encryption, and date settings, as shown in Figure 4-10.

Figure 4-10   Settings

4.3.1 Library

Use the Library option to set the date and time of your library and to set whether to automatically eject expired cleaning cartridges.

Date and Time option

Use the Date and Time option to set the system date and time (Figure 4-11). You can choose whether to synchronize with the NTP server or set the time and date manually. If you select to use the NTP server, you can optionally insert a primary and secondary NTP server and test the connection from this display.
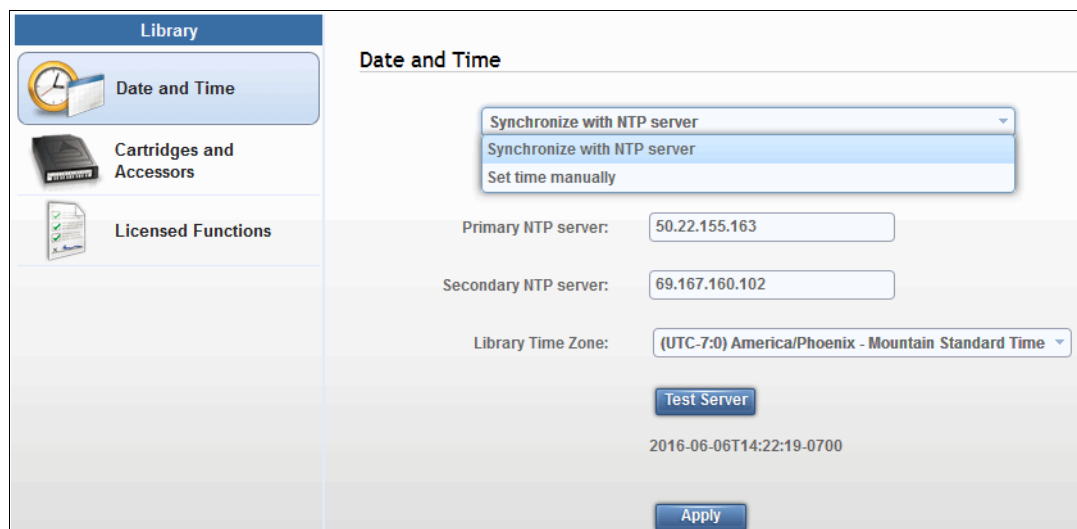
Figure 4-11   Date and Time

Cartridges and Accessors

Use the Cartridges and Accessors page to choose whether the system automatically moves expired cleaning cartridges to the I/O station or you can leave the tape cartridge in the library for manual ejection. This page is also used to manage elastic capacity and the accessors' status if the library has two accessors, as shown in Figure 4-12.
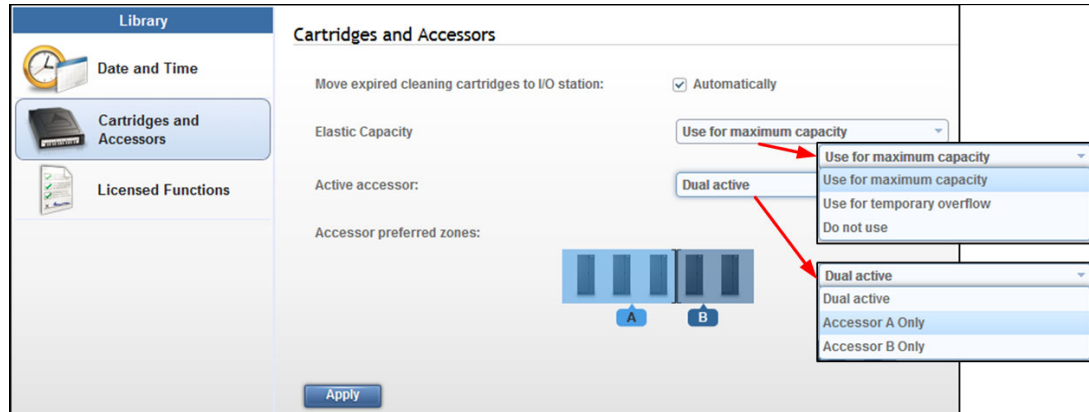
Figure 4-12   Cartridges and accessors

Move expired cleaning cartridges to I/O station

The library uses the cleaning cartridge to automatically clean tape drives as needed to maintain the efficiency of the tape drives. Each cleaning cartridge can be used 50 times. This option allows the TS4500 to automatically move expired cleaning cartridges to the I/O station.

Elastic Capacity option

If your library has the High Availability (HA) feature with two accessors, you can use this Elastic Capacity option to manage the way that cartridges are stored in the accessor service areas. The following settings are available:

► Use for maximum capacity: The least recently used cartridges are moved to an accessor service area when the non-service area is 98% full.

► Use for temporary overflow: The I/O station cartridges are imported to an accessor service area when the non-service area is 100% full.

► Do not use: Cartridges are never moved to an accessor service area.

The accessor service area consists of the storage slots that only one accessor can manage. For more information, see "Elastic Capacity option" on page 21.

Active accessor

Use this Active Accessor option to enable and disable accessors, if required. If a service issue occurs with one accessor, you can select the accessor that works to service the whole library and disable the accessor that requires service. Figure 4-13 shows the display for setting either accessor A or accessor B as active and shows a representation of the available slots with a single accessor set.
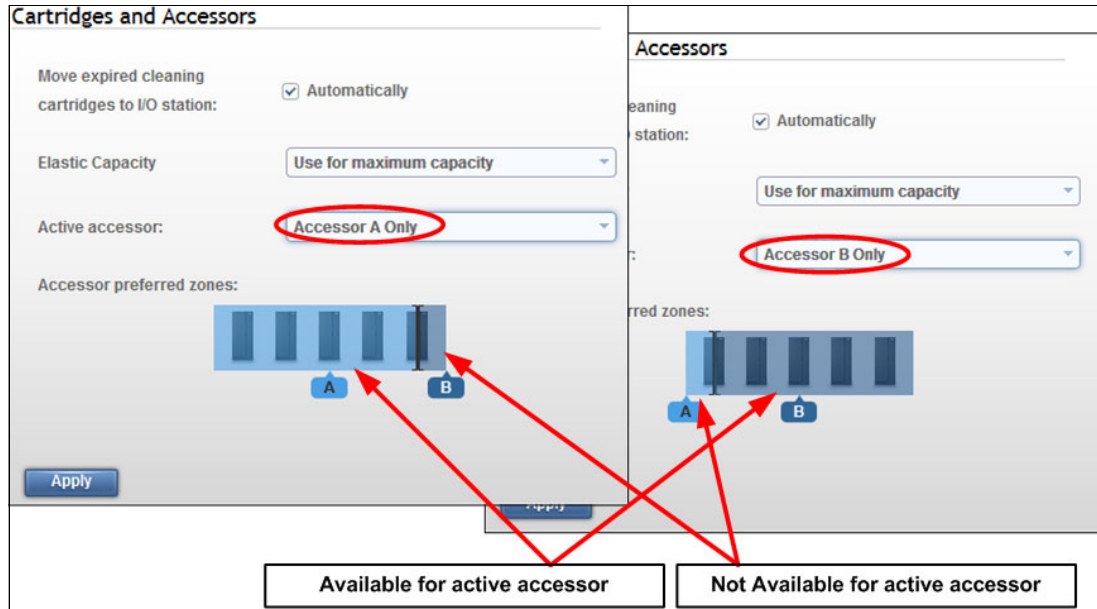
Figure 4-13   Single active accessor

Accessor preferred zone
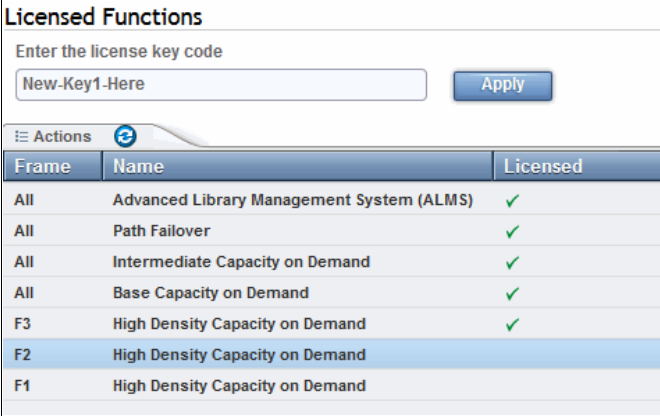
The Accessor preferred zones are read-only graphics, which display the preferred zone for each accessor, including the accessor service areas if Elastic Capacity is enabled.

Modifying the accessor zone configuration is done using the TS4500 `setAccessorZones` CLI command. This command can also be used to inactivate a accessor. This command is described in "setAccessorZones" on page 321.

Licensed Functions

Licensed functions enable extended library capabilities that are available only to users who purchase and upload a license key code for that particular capability. All of the available extended capabilities are listed in the table on the Licensed Functions page. A green check mark in the Licensed column indicates that the license is installed.

You are required to enter the license key in the license key code field. The license key file is generated by manufacturing, and it is a unique number that is based on the serial number of the library. Select the frame number and enter the license key, as shown in Figure 4-14.

Figure 4-14   Licensed function

> **Note:** Advanced Library Management System (ALMS), which comes standard on the TS4500, always shows as installed.

The following features are the extended library capabilities and they become available when the license key is uploaded:

- ► *Path failover* creates redundancy in the path from the application to the intended target (the library accessor or the drive mechanism).

- ► Intermediate high-density capacity on demand (HD CoD) increases storage from the entry capacity to the intermediate capacity. The Intermediate CoD feature (FC 1643) adds 100 slots, increasing the usable capacity of the L25 and L55 frames to 200 slots.

- ► Base capacity on demand (CoD) increases storage from the intermediate capacity to the base capacity. The Base CoD feature (FC 1644) adds 200 slots, increasing the usable capacity of the L25 and L55 frames to 400 slots.

- ► LTO transparent encryption is required to enable encryption on LTO tape drives if you use library-managed encryption (LME).

- ► High-density capacity on demand (HD CoD) increases storage to use all of the tiers of an HD frame. The initial capacity of the Dx5 frames is 500 slots. The initial capacity of the S25 frame is 600 slots. The initial capacity of the S55 frame is 660 slots. The HD CoD features can add 50 - 660 more slots anywhere, depending on the frame position and configuration. This license is required to be installed on each HD frame.
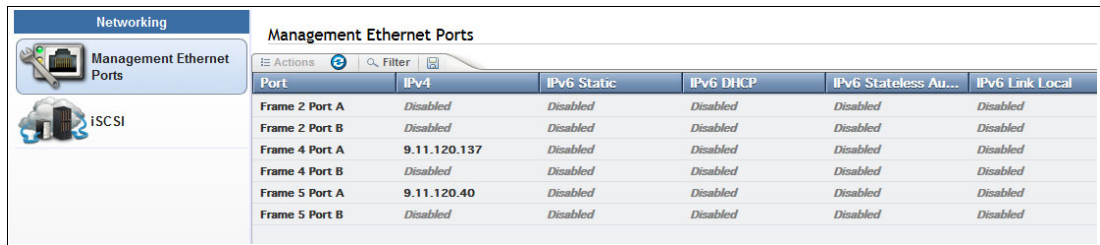
4.3.2 Networking

The Networking menu is used to set up the management Ethernet ports and to set up the iSCSI Ethernet ports on the TS1155 model 55E.

Management Ethernet Ports

Use the Management Ethernet Ports menu to display and configure the ports on each library controller card (LCC). Each port can enable or disable a particular protocol. The LCC that is specified for each port is the LCC to which that network connects when local hardware communicates with remote hardware.

By selecting the **Network** option, the Ethernet Ports window opens, as shown in Figure 4-15, which displays the current settings of all ports and displays their status.

Figure 4-15   Ethernet Ports window

Use this window to change the Internet Protocol (IP) address that you use to access the management GUI. Individual frames and ports can be configured to use IPv4, IPv6, or both types of IP addresses.

Use the Actions menu to modify an Ethernet port or display its properties, as shown in Figure 4-16.
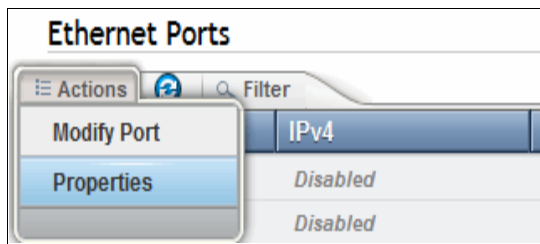
Figure 4-16   Ethernet ports

Modify port

To modify a port, highlight the port that you want to modify and select **Actions** → **Modify Port**. The Modify Frame window opens, as shown in Figure 4-17.

Figure 4-17   Modify Ethernet port settings

Use this window to change the IP address that you use to access the management GUI. You can configure individual frames, and ports can be configured to use IPv4, IPv6, or both types of IP addresses.

The following fields are available:

► The IPV4 assignment can be set to static, DHCP, or disabled:

  – Static or fixed IP addresses are manually assigned to each system by an administrator.

  – For Dynamic Host Configuration Protocol (DHCP), set this field to DHCP if you use a DHCP server, which automatically configures the IP address and network parameters.

► The IPV4 address, subnet, and gateway fields are used to set up a static IP configuration.

► The IPV4 primary and secondary Domain Name System (DNS) fields are used to set up the IP address of a DNS server, if required.

► The IPV6 assignment can be set to disabled, DHCP, stateless auto configure, or static:

  – The static or fixed IP addresses are manually assigned to each system by an administrator.

  – Set this field to DHCP if you use a DHCP server, which automatically configures the IP address and network parameters.

- Stateless auto configure allows a host to generate its own addresses. It uses a combination of the router prefix (identifies the subnet that is associated with a link) and a host-generated interface identifier (uniquely identifies an interface on a subnet).

► The IPV6 address, subnet, and gateway fields are used to set up a static IP configuration.

► The IPV6 primary and secondary DNS fields are used to set up the IP address of a DNS server, if required.

A link local address is an IP address that is intended only for communications within the segment of a local network. The link local address is not configurable. IPv6 is enabled per interface, and the IPv6 link local address is assigned to the interface where IPv6 is enabled.

Properties

This option displays the current configuration and link status of the selected port, as shown in Figure 4-18.
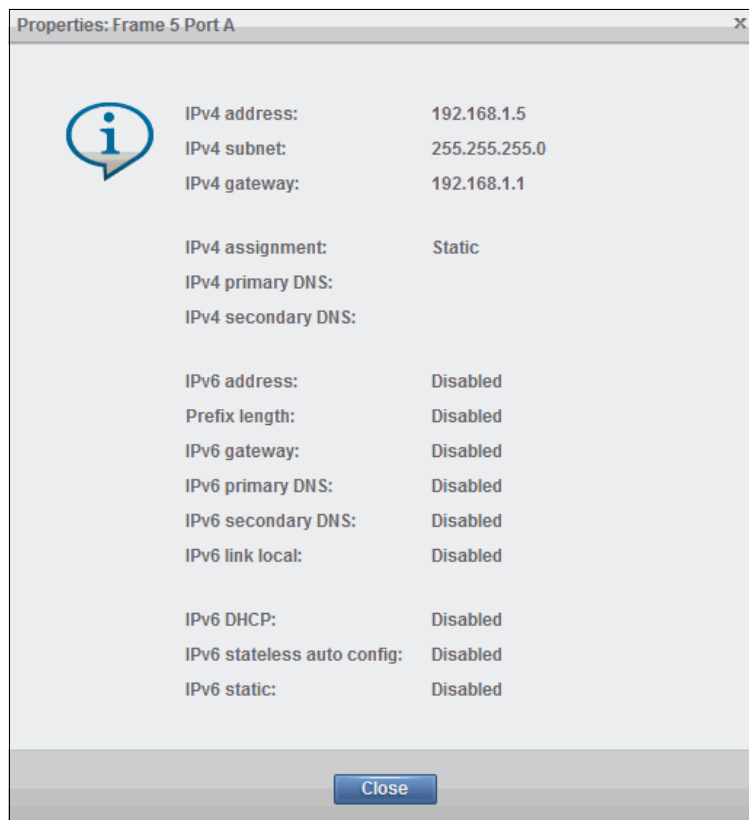
Figure 4-18   Ethernet port properties

iSCSI

This option provides for library-wide security setting for the TS1155 model 55E iSCSI Ethernet ports.

Figure 4-19 shows the security setup options available for iSCSI.

Figure 4-19   iSCSI library wide security settings

The following are possible authentication settings for discovery and normal use:

► Disabled, which is the default
► CHAP enabled
► CHAP and NONE enabled
► NONE enabled

When Challenge-Handshake Authentication Protocol (CHAP) support is enabled, hosts are securely authenticated by the system. This increases overall system security by verifying that only authenticated parties are involved in host-storage interactions.

CHAP is an authentication process of an iSCSI initiator by a target through comparing a secret hash that the initiator submits with a computed hash of that initiator's secret, which is stored on the target.

Note: Target authentication is disabled by default. Target user name and password are required if using CHAP and Target authentication is enabled.

4.3.3 Notifications

The Notifications menu is used to configure the sender information, recipient information, and library information for the various TS4500 tape library notifications. The Notifications menu contains several options, as shown in Figure 4-20.
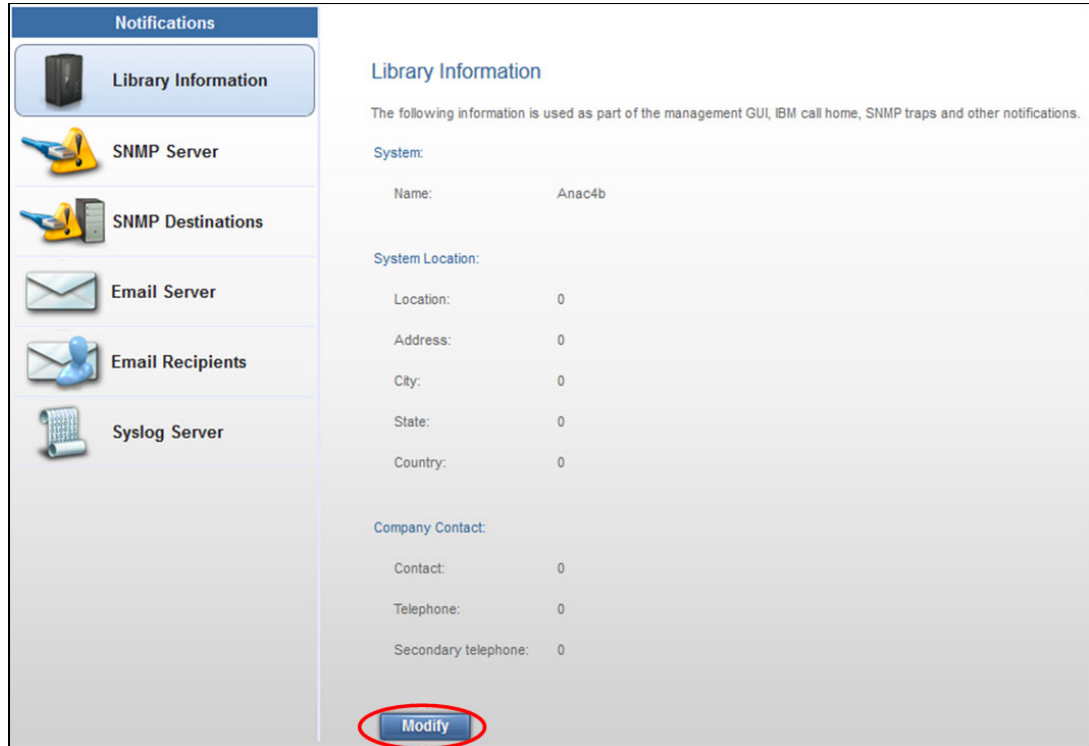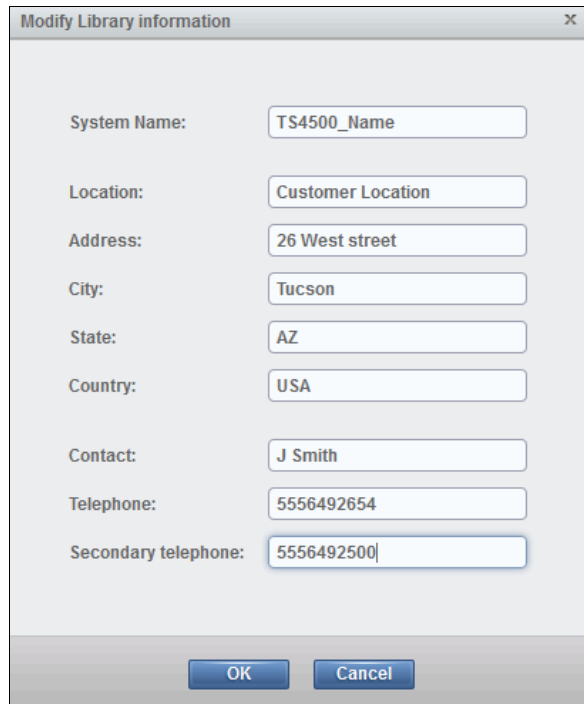
Figure 4-20   Notifications menu

Library Information

The Library Information page displays the configured system name, system location, and company contact information for the TS4500 tape library. The library information is sent in Simple Network Management Protocol (SNMP), email, syslog, and Call Home notifications.

To modify all fields, complete the following steps:

1. Click **Modify** on the Library information window, as shown in Figure 4-20 on page 175.

2. The Modify option opens the window that is shown in Figure 4-21. On the Modify Library information window, you can set all of the system information and configure the library name (which can be changed concurrently).

Figure 4-21 Modify Library information window

3. Use this window to set the TS4500 system name, system location, and company contact details. The system name that is shown in the library information profile references the system name that is set during the initial configuration of the library. The system name appears in the navigation tree and notifications.

4. After you complete all of the settings, click **OK** to apply the changes.

SNMP Server options

To set the SNMP Server options, complete the following steps:

1. Select **Notifications** on the Settings page, as shown in Figure 4-10 on page 167, to configure how the TS4500 tape library sends SNMP traps and requests. SNMP notifications include SNMP traps and SNMP requests.

   SNMP traps enable the tape library to send its profile to the SNMP server by way of an unsolicited SNMP message.

2. Under the Notifications menu, select **SNMP Server** to display the current settings, as shown in Figure 4-22.
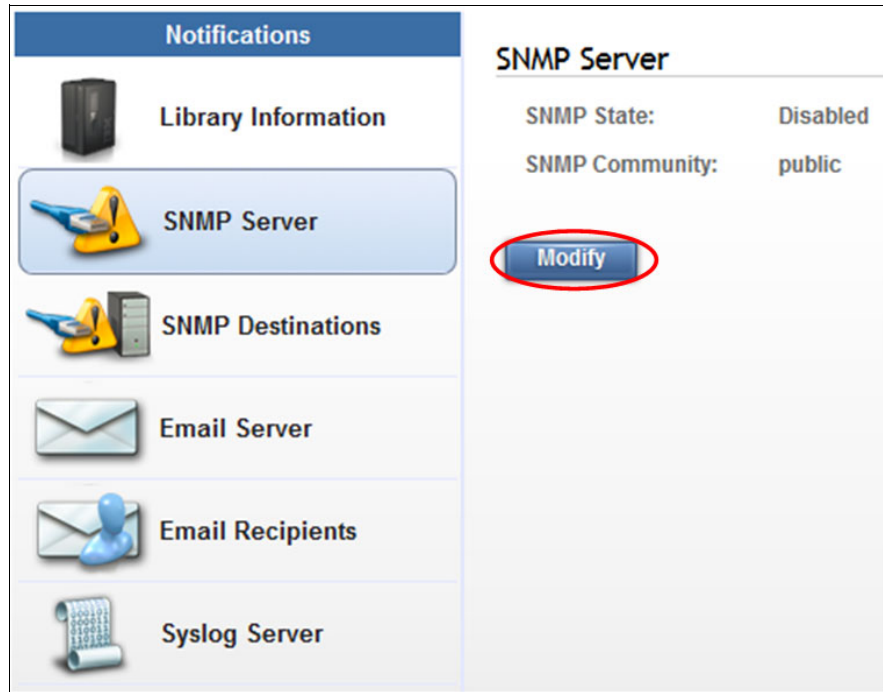
Figure 4-22   SNMP Notifications

3. To change the setting, select **Modify**, as shown in Figure 4-22, which opens the Modify SNMP Settings window, as shown in Figure 4-23.
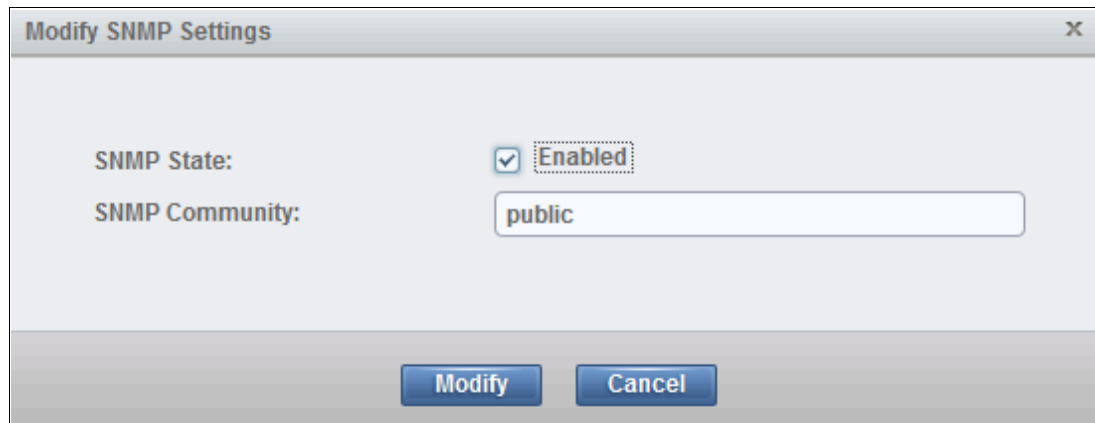
Figure 4-23   Modify SNMP Settings window

4. Select the SNMP state (Disabled or Enabled). When the SNMP state is disabled, the TS4500 tape library does not send messages to the network-attached devices for conditions that warrant administrative attention. When the SNMP status is enabled, the library sends traps to automatically notify an administrator if an issue arises.

Note: Disabling SNMP does not delete any destinations that were set up.

SNMP is a networking protocol that, when it is enabled, allows the TS4500 tape library to automatically gather information about alerts and status. The system then transmits this information to other entities, such as an SNMP monitoring server, in the network. The gathered information is called an *SNMP trap*.

SNMP traps enable the TS4500 tape library to send its profile to the SNMP server by way of an unsolicited SNMP message. If an issue arises with the library, network, or any port in the network, the tape library responds with an information profile to the SNMP server. The nature of the profile depends on the type of issue that arose.

The *SNMP community* is the name of the class of users that can access the statistics of network-attached devices. The trap community name is sent with a trap. For information about the SNMP trap community name, see the documentation for your monitoring station. To view or change the community name that is associated with the TS4500 tape library, click **Modify** on the Modify SNMP Settings page (Figure 4-23 on page 177).

By default, the TS4500 tape library SNMP community is set to `public`. During the initial system configuration, the administrator can change the community name and customize the access settings for each community name.

SNMP Destinations

Use the SNMP Destinations window to configure SNMP destination servers, send test SNMP traps, and download the SNMP Management Information Base (MIB) file. You can also specify the type of messages (errors, warnings, or informational messages) that each SNMP destination server receives:

1. From the SNMP Destinations window, select the **Create Destination** tab to display the Add Destination window, as shown in Figure 4-24.

2. Enter the destination SNMP server IP address and port number that are used, with the types of messages to send to the server.
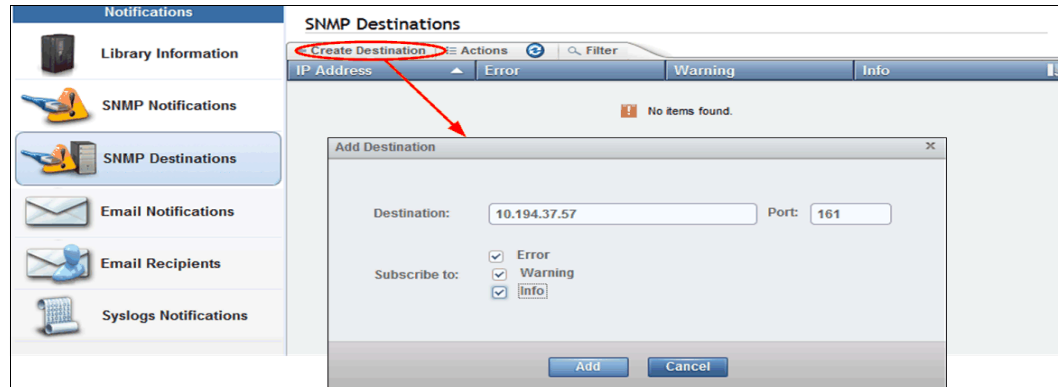
Figure 4-24   SNMP Destinations window

3. Select **Add** to add the server and continue to create new servers if you require multiple servers with different roles.

   You can select errors, warnings, and informational messages to send to the SNMP server.

4. From the SNMP Destinations window, select **Actions** to modify or delete an existing destination server, send a test trap, or download the SNMP MIB file. Figure 4-25 shows these options.
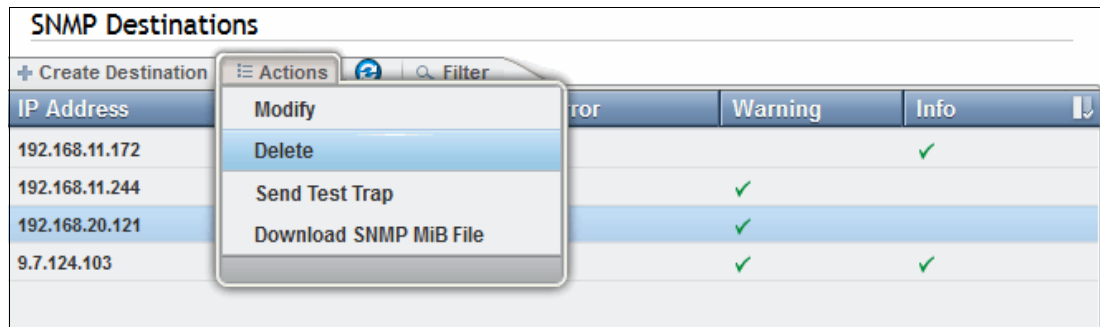

Figure 4-25 SNMP destination actions

The SNMP MIB file is used to interpret SNMP traps. When the GUI receives an SNMP trap, it compiles the SNMP trap into human-readable form so that you can gather information about the error.

The many components in a network are made by various manufacturers, and each component has unique properties and definitions. Data that is sent from the TS4500 tape library to any of the devices must be translated to a protocol that is understood by the device. An *MIB file* is a database that contains the properties and definitions of each network-attached device. The MIB file receives and translates the data when the TS4500 tape library sends the request for information.

SNMP query configuration

The TS4500 tape library stores its major configuration components in a standard Management Information Base (MIB) file. You can use an SNMP `GetRequest` to query the library and use the configuration MIB to translate the fields that gather configuration data for the TS4500 tape library and other IBM library types by using the SNMP query feature. The SNMP query feature is an easy way to gather configuration data from both local libraries and libraries that are in different geographic locations.

The following list shows all of the configuration data options that you can access for the frame or system configuration (frame or module):

► Logical Library
► 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

To download the configuration MIB file, select **SNMP Destinations**, as shown in Figure 4-25. Then, select **Actions** → **Download SNMP MiB File**.

Email Server

Email is a method, other than SNMP traps, to send information to users who need information about events that occur in the network. If your Simple Mail Transfer Protocol (SMTP) server requires authentication information before it accepts email notifications, you can set the authentication information, including the SMTP server port number, by using the Modify Email Settings page:

1. To access the Modify Email Settings page, click **Modify** on the Email Server page.

2. Then, enable **SMTP authentication**, as shown in Figure 4-26.

3. After you complete all fields, click **Test** on the Modify Email Settings page. If the test is successful, click **Modify** to save the settings.
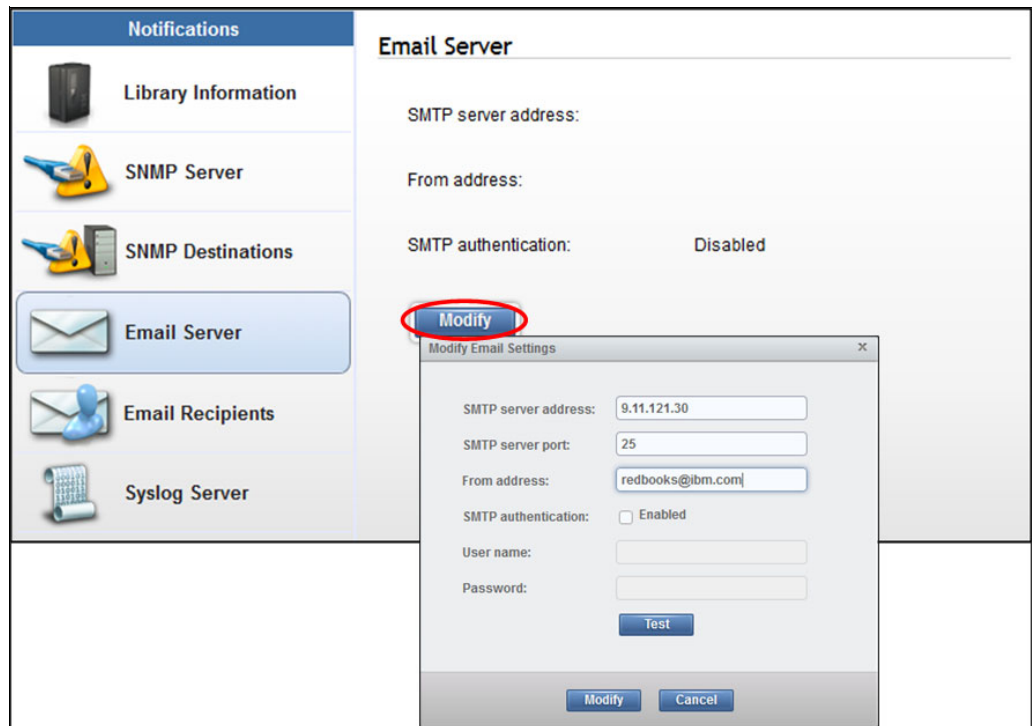
Figure 4-26   Email Server notifications page

You can define a specific email destination or a specific Short Message Service (SMS) gateway to use certain SMTP gateways only.

SMTP dictates that every email message must specify the email address of the sender. This sender address must be a valid address for two reasons:

► Many SMTP gateways require a valid sender address as a security measure to prevent unauthorized usage of the SMTP server. Otherwise, the SMTP gateway does not forward the email. Often, this sender address must be limited to a specific domain.

► The sender's address is used as the destination for error messages, such as an incorrect email address and a full email mailbox, that are generated by the SMTP gateways.

Note: The default SMTP server port value is set to 25, and can be changed to a secure port such as 465. Many email serves no longer permit port 25 so check with your email service provider or administrator for correct port to use.

Email Recipients

Use the Email Recipients page to add email addresses for recipients of the error notifications, warning notifications, and informational notifications:

1. Select **Email Recipients**.

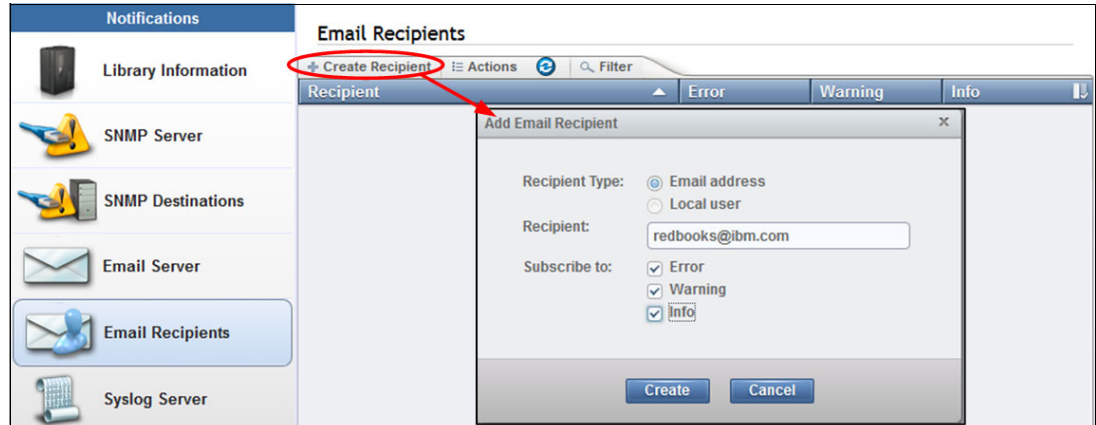2. Then, select the **Create Recipient** tab, as shown in Figure 4-27.

Figure 4-27   Email Recipients option

3. You can add a number of recipients, based on their email addresses and local user names. Specify the email address to which you want to send the events, or you can optionally select a user if an email address was specified for that user when that user was defined.

4. You can also select the type of alert that a specific user can receive. Select **Create** to create an email recipient.

5. After a recipient is created, you can then modify the user, delete the user, or send a test email to the user from the Actions menu, as shown in Figure 4-28.
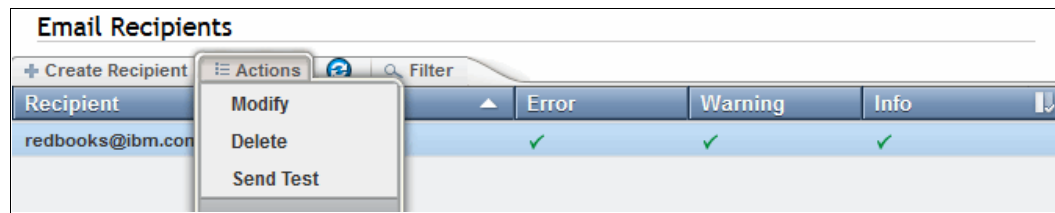
Figure 4-28   Email Recipients Actions menu

System log (Syslog) server

Use the **Syslog Server** option on the Notifications menu to set up a destination syslog server, as shown in Figure 4-29:

1. Click the **Create Recipient** tab.

2. Configure the IP address of the syslog server, the server port number and subscribe to the types of events to send to the syslog server. Click **Create**.
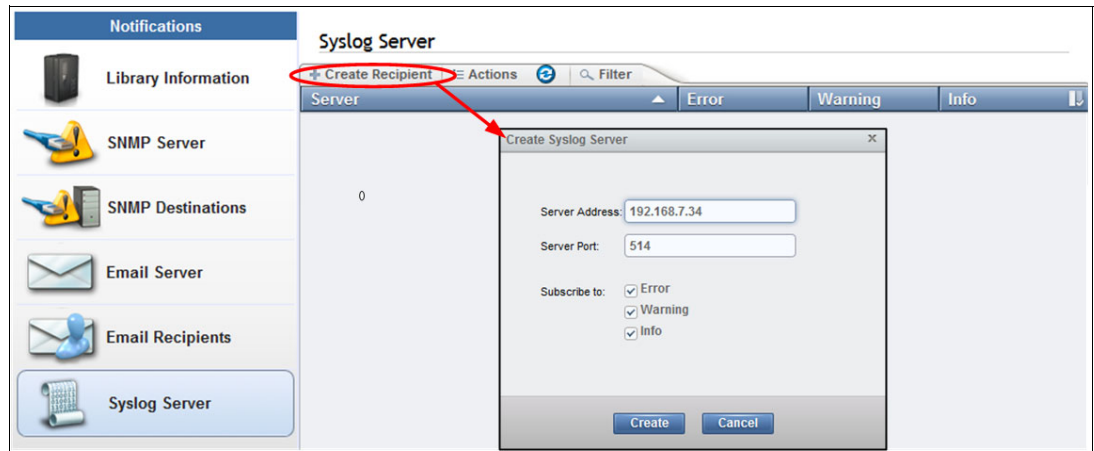
Figure 4-29   Syslog Server page

When system events occur, the TS4500 tape library creates a log of these events. You can configure the TS4500 tape library to send syslog notifications and send a notification of the event to the syslog server. The syslog server keeps its own log of system events. (The syslog server is a client-provided server.)

3. After the syslog server is set, you can use the **Actions** menu, as shown in Figure 4-30. You can modify, delete, or send a test to the IP address of a syslog server.
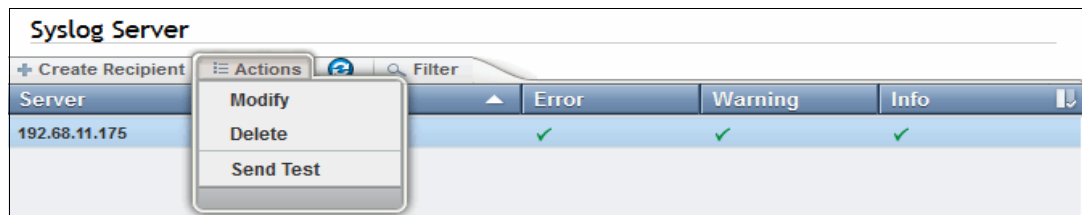
Figure 4-30   Syslog Server Notifications Actions menu

4.3.4 Security

Use the Security page for these functions:

► Disable remote authentication
► Enable and configure remote authentication
► Set access rules
► Enable or disable Secure Sockets Layer (SSL)
► Manage encryption

Note: The initial TS4500 implementation of remote authentication settings does not include a prompt for optional "service credentials".

If service credentials are not supported or not entered, the library uses the user credentials to bind to and query the Lightweight Directory Access Protocol (LDAP)/Active Directory (AD) server.

If the TS4500 user does not have sufficient privileges to query the LDAP server, the TS4500 user authentication process fails. When service credentials (with the correct privileges) are supported and entered into the settings, this error does not occur.

Authentication

With authentication, security tasks are centralized and user management can be performed from a single interface, without logging in to the TS4500 tape library. (This capability was referred to as the *Storage Authentication Service* (SAS) with the TS3500 tape library.) The default status for remote authentication is `Disabled`, as shown in Figure 4-31.
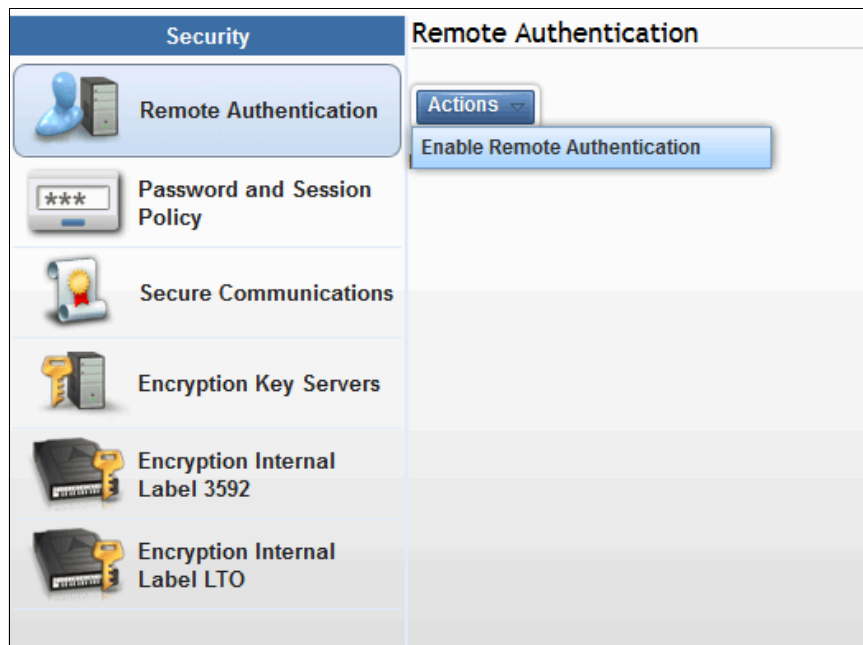
Figure 4-31   Security Remote Authentication page

Disabled status

With disabled status for remote authentication, users are defined on the local library and the library uses local authentication to manage the access.

Enabled status

With remote authentication enabled, the users are defined on the remote library and authentication requests are passed to a remote authentication server (LDAP) that verifies the user's name and password. For more information about user setup, see 4.4.1, "Users" on page 199.

To enable remote authentication, the following conditions are required:

► You must create a group and add users to that group on your remote authentication server.

► On the TS4500 tape library, create a custom role with a name that exactly matches the group name on the remote authentication server.

► Each custom role has unique access permissions.

► The primary LDAP repository Uniform Resource Identifier (URI) is required.

► The secondary LDAP repository URI is optional.

► The LDAP Transport Layer Security (TLS) certificate is optional.

► If you use Kerberos, you require the realm, key distribution center (KDC), domain mapping, and service keytab.

Lightweight Directory Access Protocol

LDAP is an open protocol that uses TCP/IP to provide access to directories that support an X.500 model. LDAP does not incur the resource requirements of the more complex X.500 Directory Access Protocol (DAP). For example, LDAP can be used to locate people, organizations, and other resources in an internet or intranet directory. The LDAP settings must conform to the following rules:

► The repository URI must start with `ldap://` and end with a port number.
► The secondary repository URI must also start with `ldap://` and end with a port number. If you do not have a secondary repository URI, leave this field blank.

The optional Transport Layer Security (TLS) certificate is purchased from a certifying entity. The TLS certificate is a plain text file that contains information about the web server. The TLS certificate verifies that it is indeed what it claims to be. (In this case, the web server is the TS4500 tape library.) The TLS certificate that is stored on the TS4500 tape library enables your web browser to access the TS4500 tape library without challenging its validity. The *credential* is the LDAP equivalent to a password.

Kerberos

Kerberos is a network authentication protocol that is based on symmetric key cryptography. Kerberos assigns a unique key, which is called a *ticket*, to each user who logs on to the network. The ticket is embedded in messages that are sent over the network. The receiver of a message uses the ticket to authenticate the sender.

Kerberos settings have these characteristics:

► The Kerberos realm is generally the same as your company's domain name. For example, if your company's domain name is `example.com`, your Kerberos realm is `EXAMPLE.COM`.

► The Key Distribution Center (KDC) (AD server) is the Key Distribution Center server. A KDC server generally has a prefix of "`Kerberos`" followed by your Kerberos realm, a colon, and the port number of the Kerberos server. (The port number of the Kerberos server is `88` for the TS4500 tape library.) So, if your company's domain name is `example.com`, a conventional name for your KDC server is `kerberos.example.com:88`.

► The Domain mapping field is optional.

The Service keytab must be stored on the TS4500 tape library. It is used as part of the authentication process to verify which user is connecting to it. A Service keytab that is stored on the TS4500 tape library enables automated authentication.

Custom roles

With remote authentication, custom roles are defined on the remote authentication server:

- ▶ You must create a group and add users to that group on the remote authentication server.
- ▶ On the TS4500 tape library, create a custom role with a name that exactly matches the group name on the remote authentication server.

Each custom role has unique access permissions. For more information about custom roles, see 4.4.2, "Roles" on page 205.

Enable remote authentication

After you complete all required preparation and configuration, select **Actions** to enable remote authentication, as shown in Figure 4-31 on page 183. The Remote authentication window opens. The first page lists the prerequisite actions before you can enable remote authentication, as shown in Figure 4-32.
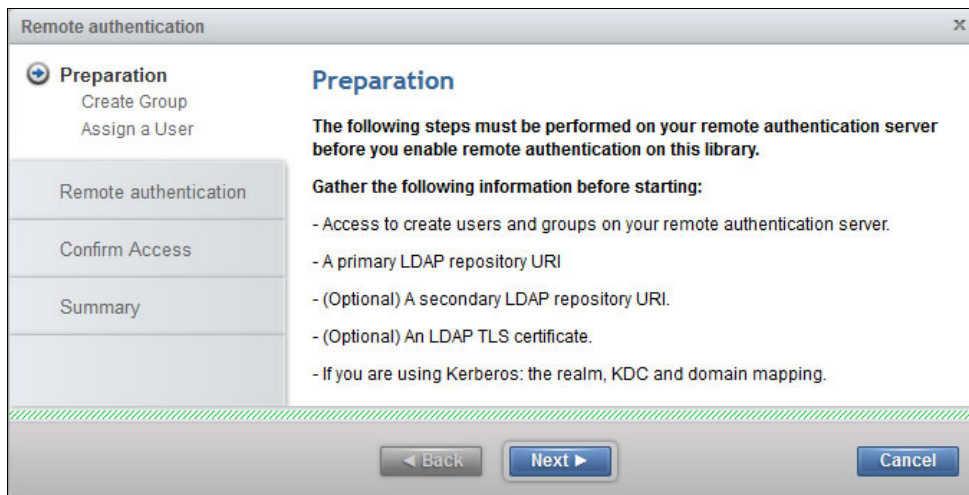
Figure 4-32   Remote authentication Preparation window

The next three steps require you to select the user group that was created for remote access on the Create Group window, and to confirm that this user group is the same user that is assigned to the server on the Assign a User window, then select the authentication method to use. See Figure 4-33.
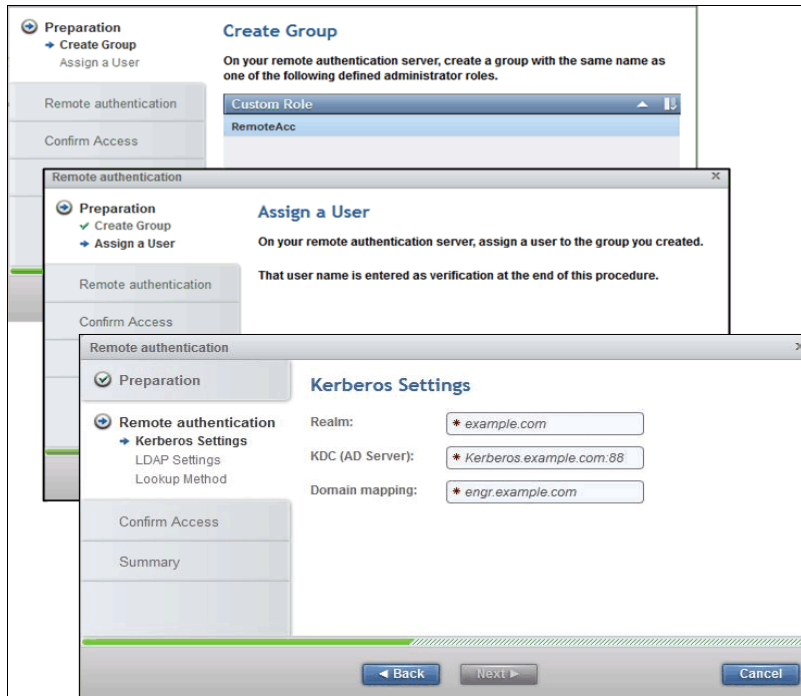
Figure 4-33   Remote authentication preparation

Kerberos

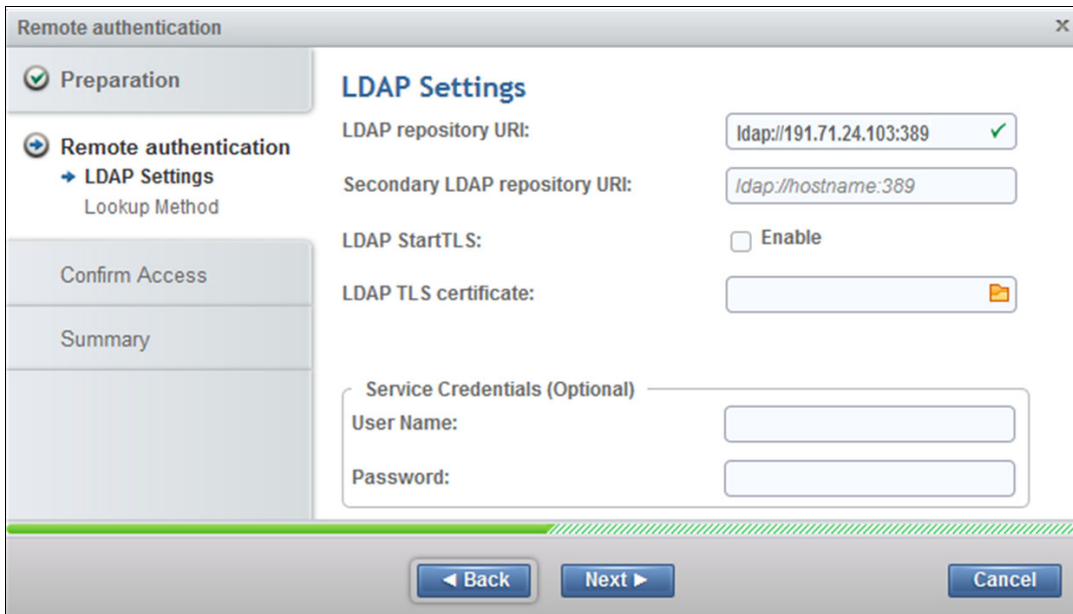If you selected the Kerberos authentication method, the Kerberos Settings window opens. See Figure 4-34.

Figure 4-34   Kerberos setting

Complete these steps on the Kerberos Settings window:

1. Enter the name of the realm setup for this machine.
2. Enter the KDC (AD) server name.
3. Enter the Domain mapping.

LDAP

If you selected LDAP then the LDAP Settings window opens, as shown in Figure 4-35. Enter the required fields in this frame.

Figure 4-35   LDAP Settings

Configure the following settings on the TS4500 tape library:

► LDAP Repository URI: This field must start with `ldap://` and end with a port number.

► Secondary LDAP Repository URI: This field must start with `ldap://` and end with a port number. If you do not have a Secondary Repository URI, leave this field blank.

► LDAP StartTLS: Enabling the LDAP StartTLS starts a normal LDAP session and initiates the TLS (Transport Layer Security) layer.

► LDAP TLS certificate: The LDAP TLS certificate is purchased from a certifying entity. It is a plain text file that contains information about the web server, and it verifies that it is what it claims to be. The TLS certificate that is stored on the TS4500 tape library enables your web browser to access the TS4500 tape library, without challenging its validity.

► Service Credentials: The service credentials include the user name and password for the LDAP administrator account. The service credentials are necessary if your LDAP server does not support anonymous access. *Anonymous access* means that any entity can access and view records without being authenticated to the LDAP server.

Note: The LDAP settings are tested when you select **Next**. If the settings are correct and communication works, you see a green check mark next to the LDAP repository URI. Then, you can continue with the next setting. If the LDAP URI is not set up or no connection exists, you cannot continue with the setup and a red cross (+) appears next to the URI.

For the lookup method, simple lookup uses group and user LDAP distinguished names (DNs) for authentication lookup. Simple lookup is set by selecting **Simple lookup** and entering the group DN and User DN, as shown in Figure 4-36. After you enter the settings, click **Next** to continue to the options for the lookup method.
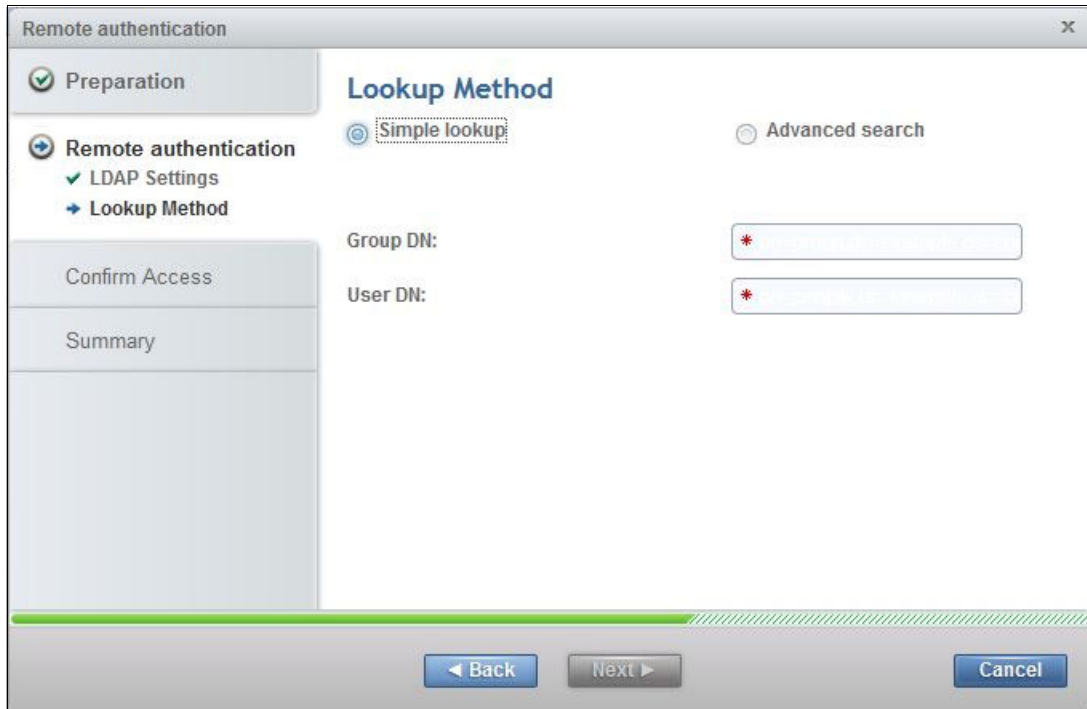

Figure 4-36   Simple lookup method

The Advanced search option provides more flexible searching and better performance. You can select the advanced search lookup method by selecting the Advanced search option, as shown in Figure 4-37.
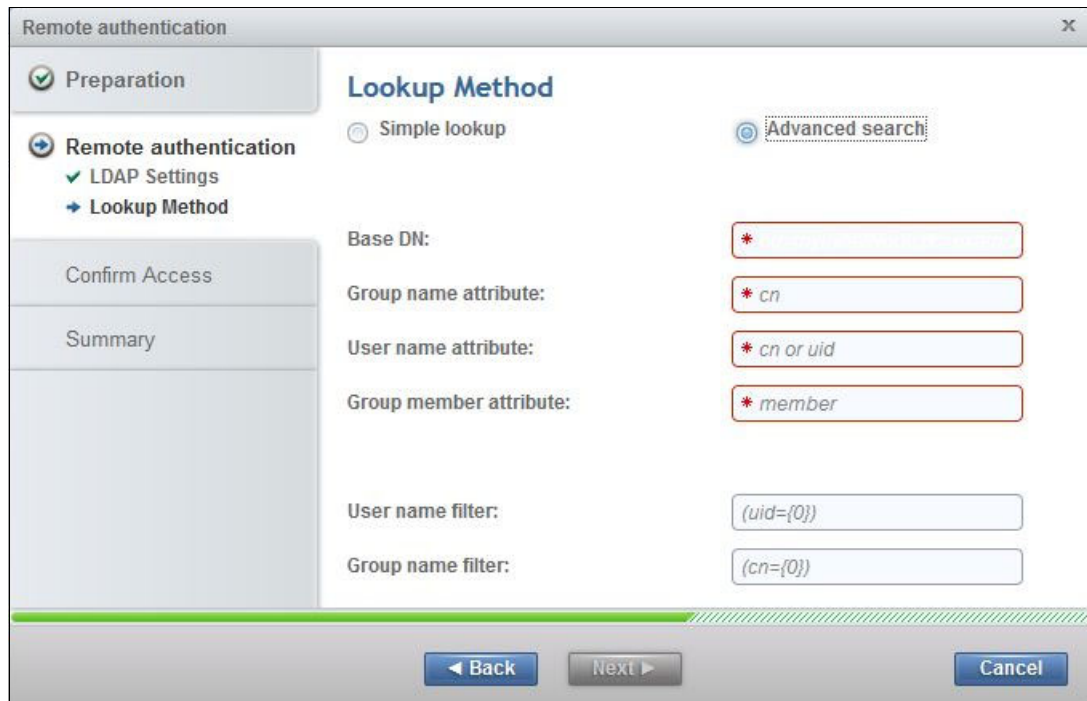

Figure 4-37   Advanced search lookup method

You can customize the following options for the advanced search method:

► Base DN: Enter the base distinguished name (DN) with which to begin your LDAP search. This search is a deep search in your LDAP tree for better performance.

► Group name attribute: Choose the group name attribute in your LDAP group accounts to associate with a TS4500 role.

► User name attribute: Use this field to customize the attribute in your LDAP user account that is used for user names.

► Group member attribute: Use this field to customize the link between your LDAP users and groups.

► User name filter (optional) and group name filter (optional): The optional user name and group name filters are useful when you want to improve your LDAP search. For example, you can create a user attribute that is called `remote` and allow remote access for all users with `remote=TS4500`.

After you enter the settings, click **Next** to continue to test that the settings are correct and to confirm the access to the servers. If all settings are correct, remote authentication is enabled.

Password and Session Policy

Figure 4-38 shows the Password and Session Policy window, which shows the current settings.

Figure 4-38   Password and Session Policy page

If the default password and session policy settings are not strict enough for your company's rules, you can customize the settings on the Password and Session Policy window by selecting **Modify**.

You can modify all of the settings that relate to the session and password policy, as shown in Figure 4-39. These settings can be set back to the default settings by selecting **Reset to Default** on this window.
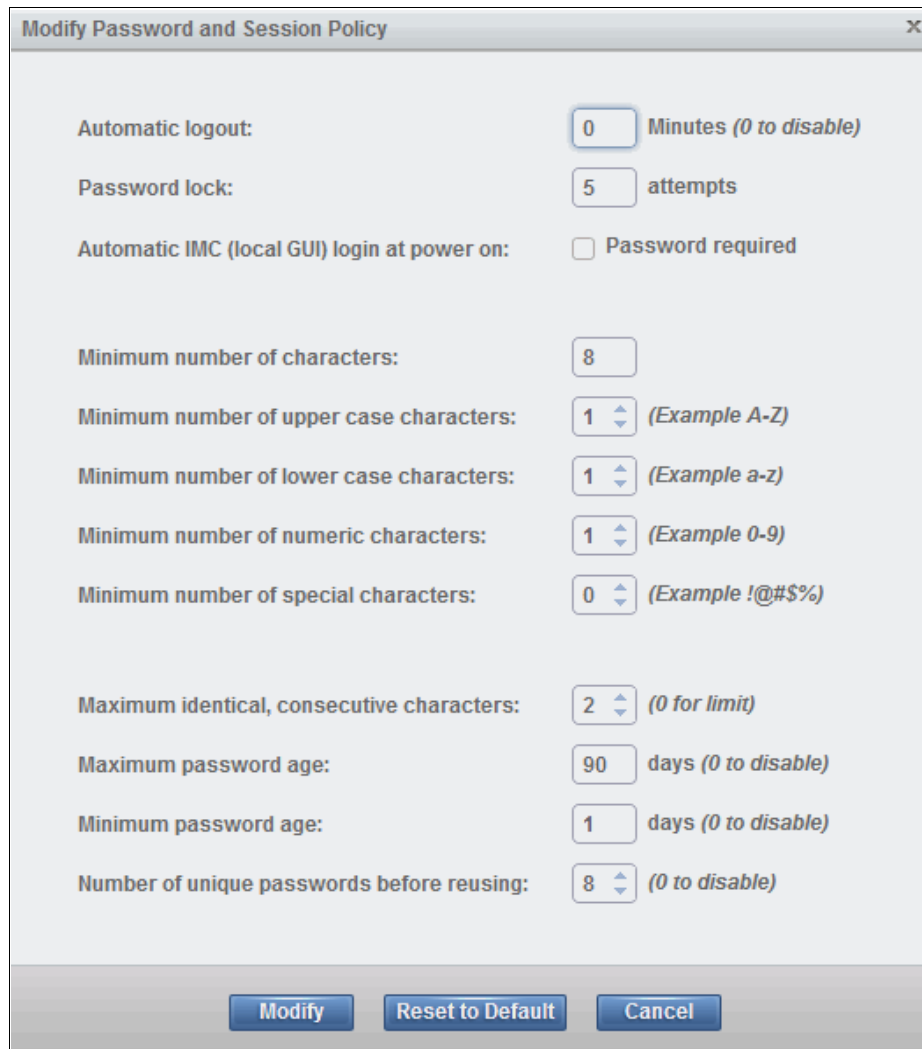
Figure 4-39   Modify Password and Session Policy window

A preset local user that is called `localGUI`, with the role of monitor, is enabled by default with the TS4500 tape library. This default allows a local user to access the integrated management console (IMC) without logging in.

However, if your company policies and procedures prohibit this type of quick access to the System Summary view, you can disable this local user login function. To disable the user login function, select **Settings** → **Security** → **Password and Session Policy**, and set the "Automatic IMC (local GUI) login at power on" setting to require a password.

Secure communications

Use this option to manage encryption settings for the GUI and command-line interface (CLI) communications with the library.

The TS4500 tape library is secured with a Secure Sockets Layer (SSL). SSL is a protocol for encrypted (secure) transmission through the internet.

Use the Secure Communications page to configure the SSL settings. See Figure 4-40.
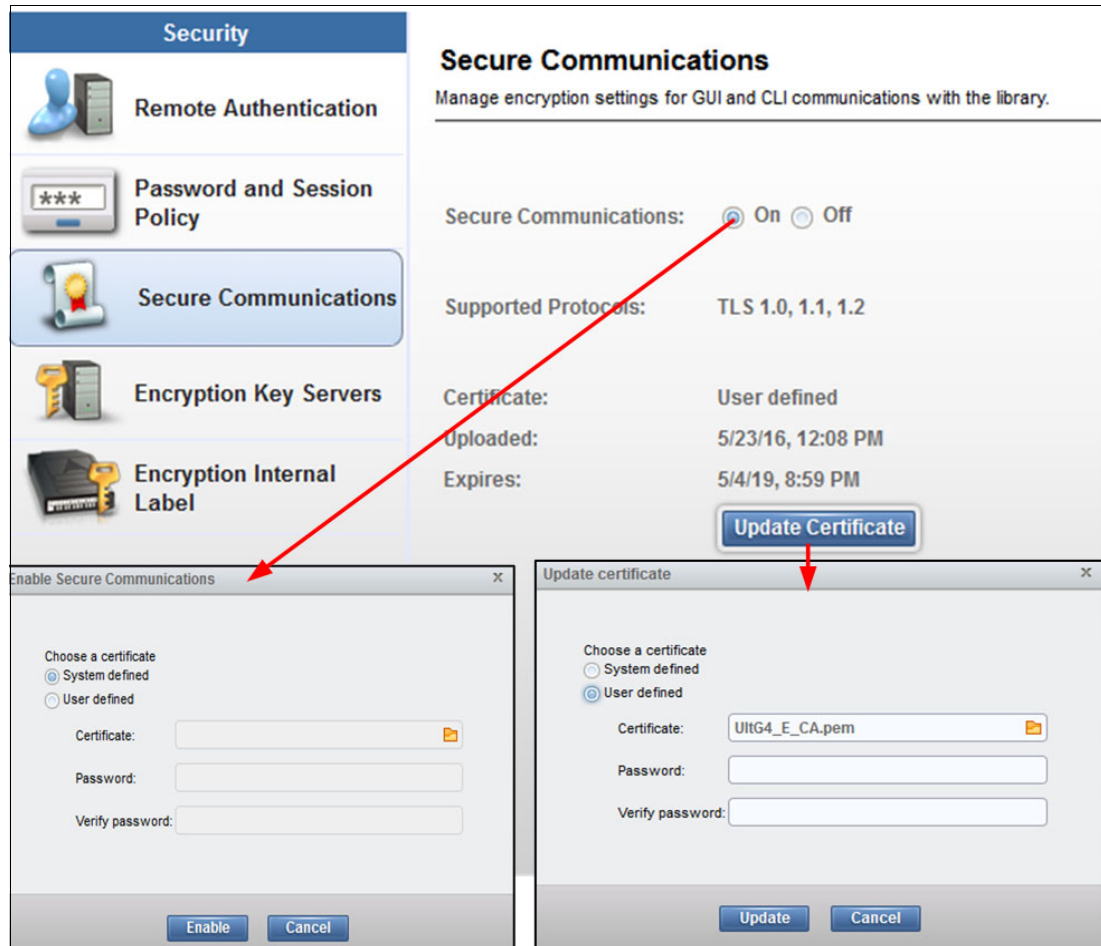
Figure 4-40   HTTPS

Use the Secure Communications window to enable or disable SSL or to update a certificate. Selecting **Enable** or **Update** provides the option to upload an SSL web certificate. This window also displays the type of certificate that is used and the upload date and expiration date.

SSL is a cryptographic security system that uses two keys to encrypt data:

▶ A public key that is known to everyone
▶ A private key that is known only to the recipient of the message

Many websites use this 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`. HTTPS stands for Hypertext Transfer Protocol Secure.

Secure communications on

When the secure communications function is on, the data that is exchanged between the TS4500 tape library and your browser or CLI is encrypted.

Secure communications off

When the secure communications function is off, your browser or CLI and the TS4500 tape library communicate with unencrypted data transmissions. Your browser uses a TLS certificate to verify the validity of the TS4500 tape library.

Update web certificate

SSL web certificates are small data files that digitally bind a cryptographic key to an organization's details. When an SSL web certificate is installed on a web server, it activates the padlock and the `https` protocol (over port `443`) and allows secure connections from a web server to a browser. This option can be used to update a certificate or replace an expired certificate.

Two options are available when you enable secure communications or update a certificate.

System-defined

The SSL cipher specification list system value is read-only. Its values are automatically modified to contain the list of cipher suites that are supported by the system SSL. If you use this option, the SSL cipher specification list system value is automatically updated with new cipher suite capabilities when you install or upgrade to a future release of the firmware system.

User-defined

If there is an existing certificate, its identifying information is displayed in the Certificate field. You can use this certificate, or click the folder icon to upload another certificate.

Certificates must be in PEM format. They may be self-signed or CA-signed, but must contain both the certificate and the private key. If the private key is encrypted, you must enter the password for the private key.

If you are using CA-signed certificates on a TS4500 tape library configured with multiple IPs, it is strongly recommended to include each IP used for web GUI access in the certificate.

Encryption key servers

Use the Encryption Key Servers page to manage the key servers that use an encryption key.

From the Add Server tab, add each encryption key server to use on the logical libraries configuration of this TS4500, as shown in Figure 4-41. This action makes the IP address of the server available when you set up library-managed encryption on the logical library.

Figure 4-41   Encryption Key Servers page

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. For more information about methods of encryption, see 4.7.2, "Create Logical Library window" on page 253 and Chapter 3, "Encryption" on page 149.

The Add Encryption Key Server window requires you to first check with an Internet Control Message Protocol (ICMP) ping to ensure that the server is available when you add the server. Click **Ping**, as shown on Figure 4-41, when you add a server to the list. Encryption key servers can also be added when you modify a logical library.

> **Note:** The TS4500 supports the configuration of four encryption key servers for each logical library.

Run Diagnostics

If you want to verify the functionality of all of the network-attached devices, you can run diagnostics on the devices. Select **Actions** → **Run Diagnostics**. Then, select the drive or select drive to test and select **Run Diagnostics**.

The diagnostics process runs for a few minutes. When the diagnostics complete, the window shows a check mark for devices that passed the test, as shown in Figure 4-42, or a red error icon for devices that failed the test.
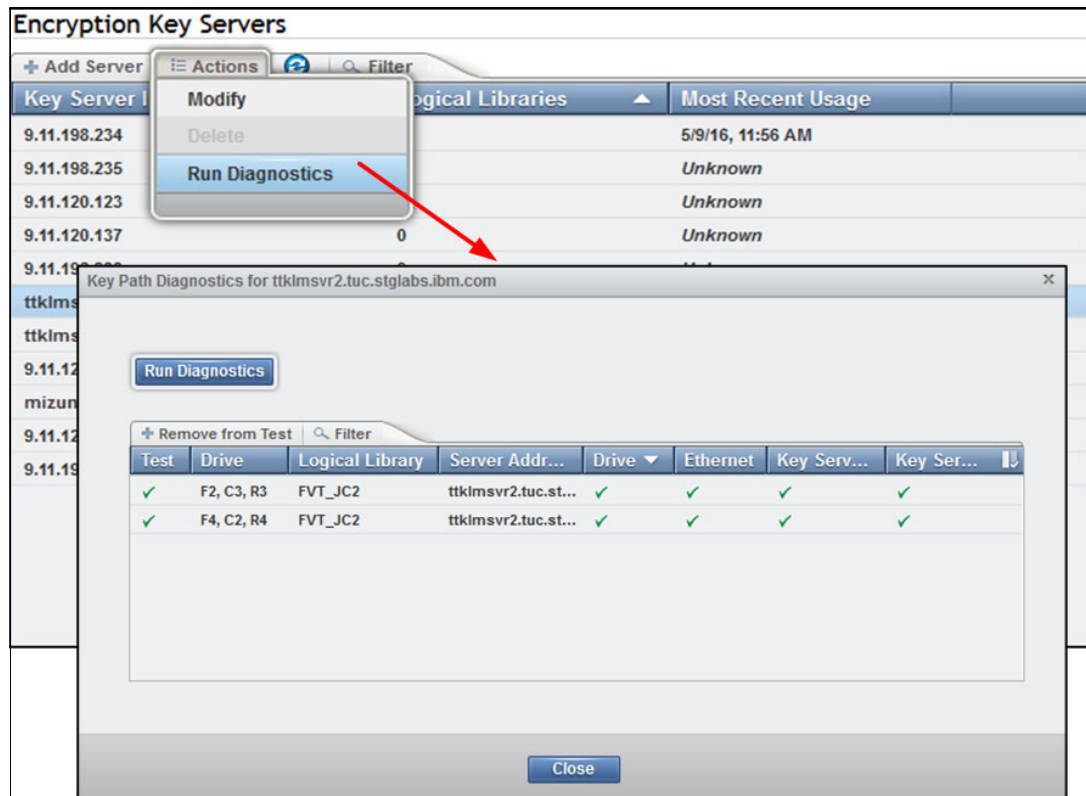

Figure 4-42   Encryption Key Servers diagnostics

Note: When you use the Run Diagnostics function, a warning icon might appear in the Ethernet column if you disabled Internet Control Message Protocol (ICMP) requests.

At least one key server IP address must be selected for the Run Diagnostics option to display on the Actions menu (or the right-click drop-down menu). If no key server IP address is added (or selected), the Run Diagnostics option does not display on the Actions menu. This server must be configured on a logical library for diagnostics to run.

ICMP requests

Internet Control Message Protocol (ICMP) is a messaging protocol (external to the TS4500 tape library) that sends error messages that a requested service is not available or that one of the network-attached devices cannot be reached. ICMP requests are disabled or enabled on the server on which the IBM Security Key Lifecycle Manager runs.

The disabled status of ICMP requests can trigger a warning in the Ethernet column when the Run Diagnostics function starts.

If ICMP requests are disabled, the server that the Encryption Key Manager runs on does not return a ping when the diagnostics are run, which triggers a warning in the Ethernet column of the Run Diagnostics table. If a warning appears in the Ethernet column, but no warning appears in the Key Server Path column, ignore the warning in the Ethernet column. If warnings appear in the Ethernet column and the Key Server Path column, the failure might be on the machine, or the network connections between the library and that machine.

Encryption Internal Label

Use the Encryption Internal Label page to create, change, or delete mappings from the cartridge key labels to the key-encrypting labels.

When the Encryption 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 TS4500 tape library. Mapping the cartridge key labels to the key-encrypting labels enables the TS4500 tape library to apply the same encryption policy for both types of labels. The Encryption Internal Label is a way for the system to share encryption policies.

For a TS4500 with only a single drive type, either Linear Tape-Open (LTO) or 3592, that is installed, only one option is shown on the Security page, as shown in Figure 4-43.

Figure 4-43   Single drive type Encryption Internal Label

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. For more information about methods of encryption, see 4.7.2, "Create Logical Library window" on page 253 and Chapter 3, "Encryption" on page 149.

The examples that are shown in the next sections show the display for a mixed drive type library.

Encryption Internal Label 3592

To configure key label mapping, select **Encryption Internal Label 3592** and select the **Create Mapping** tab, as shown in Figure 4-44. Select the method to use and then select the key labels, as required.

Figure 4-44   Add or modify key label mapping for 3592

The following values are available for the "Map to key mode" field:

► Wrapped-Default: The map to key encryption method is configured by using the Encryption Key Manager default. (This option is for 3592 cartridges only.)

► Wrapped-Clear: The externally encoded data key (EEDK) is referenced by the specified key label. (This option is for 3592 cartridges only.) The Wrapped-Clear method is typically specified when encrypted volumes are kept in-house where each keystore references the keys by using the same key labels.

► Wrapped-Hash: The EEDK is referenced by a computer value that corresponds to the public key that is referenced by the specified key label. (This option is for 3592 cartridges only.) The Wrapped-Hash method facilitates exchange with a business partner or when volumes are sent to a disaster recovery site where the key labels might differ for the same key.

Encryption Internal Label LTO

To configure key label mapping, select **Encryption Internal Label LTO** and then select the **Create Mapping** tab, as shown in Figure 4-45. Select the method to use and the key labels, as required.
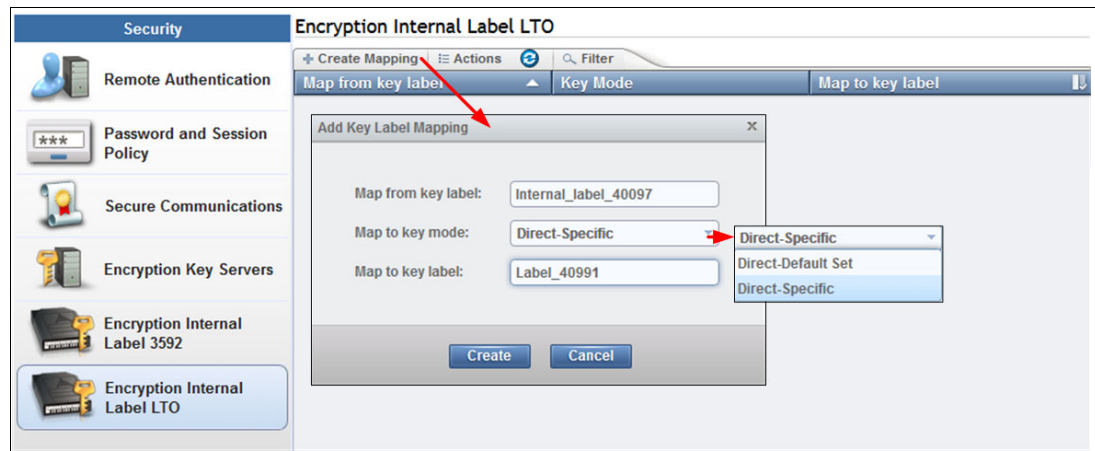
Figure 4-45   Add or modify key label mapping for LTO

The following values are available for the "Map to key mode" field:

► Direct-Default Set: The map to label is determined from the encryption key manager. The label was configured at the encryption key manager, and the key label field is left blank. (This option is for LTO cartridges only.)

► Direct-Specific: The specified key label references a symmetric data key. (This option is for LTO cartridges only.)

4.3.5 GUI Preferences

Use the GUI Preferences page to control the behavior of the navigation dock. Use the Navigation page in the TS4500 Library to enable or disable the animation of the navigation dock in the GUI. Figure 4-46 shows example of animation enabled.

Figure 4-46   Enabled navigation animation

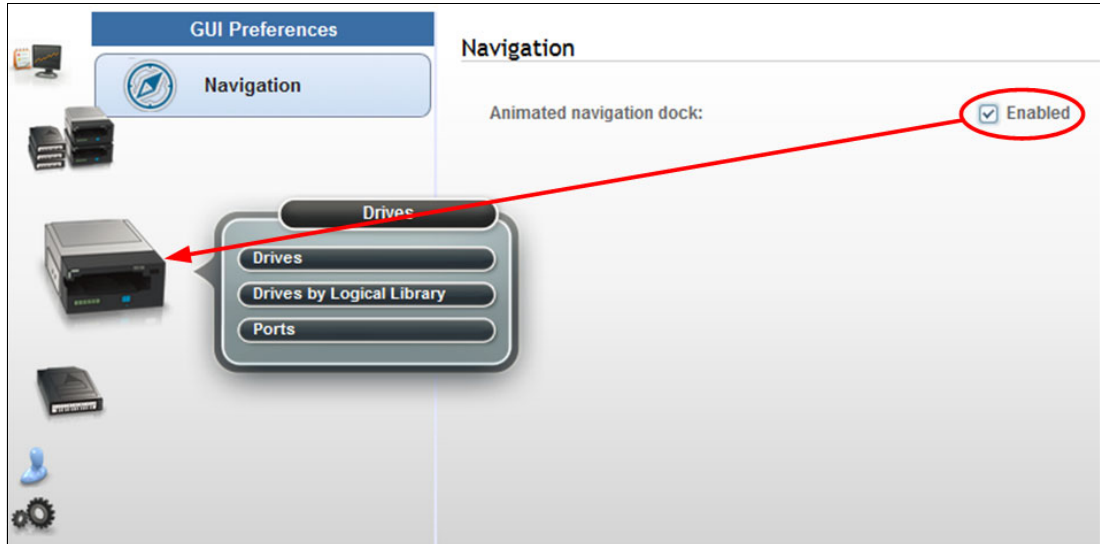You can turn off the animation if the enlarged icons obscure any information on the window. Also, turning off the navigation animation helps increase performance when you are remotely connecting to the TS4500 over a slow network connection. See Figure 4-47 shows example of animation disabled.
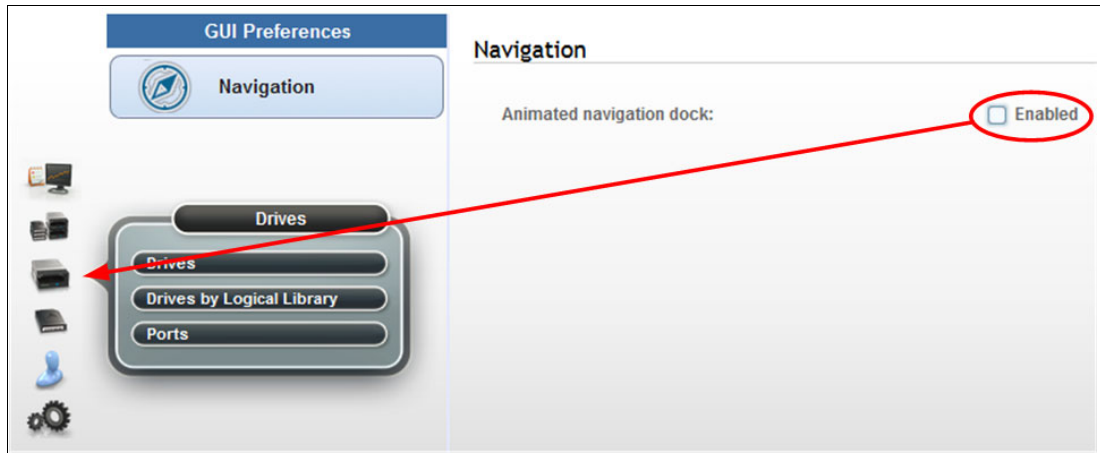
Figure 4-47   Disabled navigation animation

4.4 Access menu

Use the TS4500 management GUI pages, under the Access icon, as shown in Figure 4-48, to view, create, and assign users and their roles.

Figure 4-48   Access menu

> **Note:** The options and actions under the Access icon are available only to users with the administrator role.

4.4.1 Users

Administrators can create and manage users, map users to a role, and view which users have active sessions and how many connections they have from the Users page.

> **Note:** With the TS4500 tape library, password protection is always enabled and all users are required to sign in with a user name and password.

Selecting **Users** from the Access menu gives an overview of all configured users, as shown in Figure 4-49.

Figure 4-49   Create User tab

Table 4-4 describes the fields that are available on the Create User tab. The numbers in the table correspond to the numbers in Figure 4-49 on page 199.

Table 4-4   User window

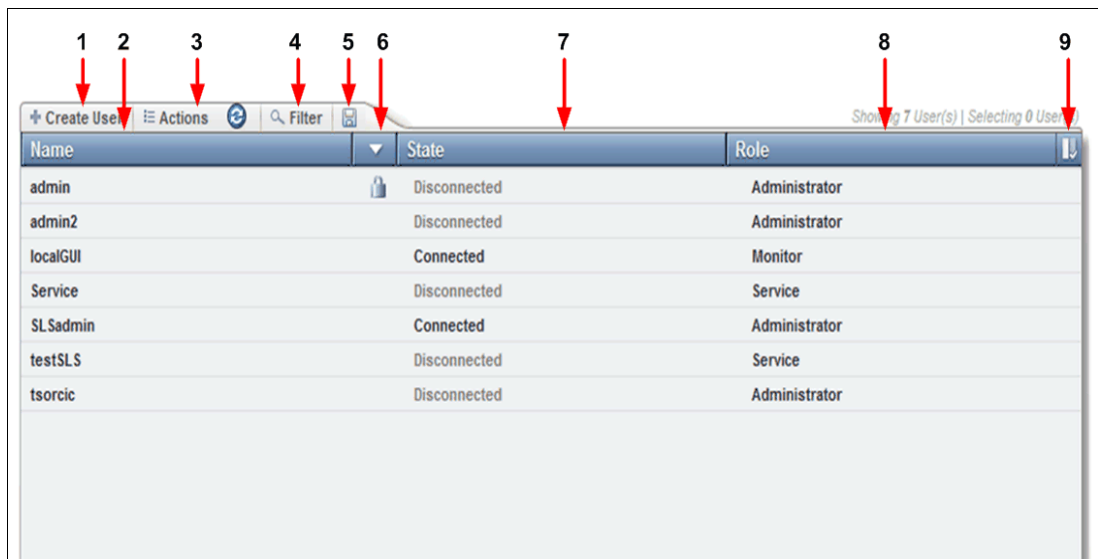| Number	Description
1	Create User tab to add a user
2	Name of user
3	Actions tab
4	Filter user or search tab
5	Save user list to file
6	Locked state of user
7	Connected state of user
8	User role
9	View menu options

The actions that are available from the Users page differ depending on whether the library is configured for local or remote authentication. For more information, see Table 4-5 for a list of available actions.

Table 4-5   Local and remote authentication actions

Actions	Local authentication	Remote authentication
Create User	X	
Map To Role	X	
Modify Email	X	
Reset Password	X	
Delete User	X	
Disconnect	X	X
Connections	X	X
Properties	X	X

Local authentication

With local authentication, each TS4500 tape library maintains a separate database of user names with corresponding passwords and roles. Therefore, user management must be performed on each library.

When local authentication is enabled, the Users page shows all users and their state (connected or disconnected). The number of active connections is displayed next to the user state. It is also possible to view and modify email addresses when local authentication is enabled.

Remote authentication

With remote authentication, security tasks are centralized and user management can be performed from a single interface, without logging in to the TS4500 tape library. This function was referred to as the Storage Authentication Service (SAS) with the TS3500 tape library.

When remote authentication is enabled, authentication requests are passed to a remote authentication server (LDAP) that verifies the user's name and password. When the user is created on the remote authentication server, the administrator assigns that user to an LDAP group. The group is then matched to a custom role on the TS4500 tape library, which specifies the access permissions for that logged-in user.

> **Important:** The name of the group on the remote authentication server must be the *same* as the name of the role on the TS4500 tape library for the group to be matched to that role.

The "create" action is disabled on the Users page when remote authentication is enabled because you must create the user on the remote authentication server first. In addition, modifying a user's email, password, and user group must be performed on the remote authentication server. Only connected users are shown on the User page, which is shown in Figure 4-49 on page 199.

To enable remote authentication, see "Remote authentication" on page 201.

IMC access by a local user

In some environments, it is possible to rely on the physical security of the data center as the default operating mode. For this scenario, the TS4500 tape library allows a local user to access the Integrated Management Console (IMC) without logging in, enabling quick access to the System Summary view of the TS4500 management GUI.

A preset local user called `localGUI`, with the role of monitor, is enabled by default with the TS4500 tape library. This is the only local user that is valid when remote authentication is enabled.

If the localGUI user is deleted, all users will be required to log in at the IMC.

To disable this local user login function and show the login window at the IMC, go to **Settings** → **Security** and select **Access Rules**.

Creating users

You can create up to 80 users, each with a unique user name and password.

Each user account is mapped to a role that defines the pages that the user can view and the actions that the user can perform. Each user can be mapped to only one role, but multiple users can be mapped to any role. To configure user roles and to read an explanation of each of the roles, see 4.4.2, "Roles" on page 205.

To create a user, select **Create User** on the Users window. The Create User window opens, as shown in Figure 4-50. Enter the user name and role. The user receives the role that is chosen from the Role drop-down list. If you do not want the user to receive a default role, ensure that the role is first set up so that it can appear on the drop-down list. To create and manage roles, see 4.4.2, "Roles" on page 205.
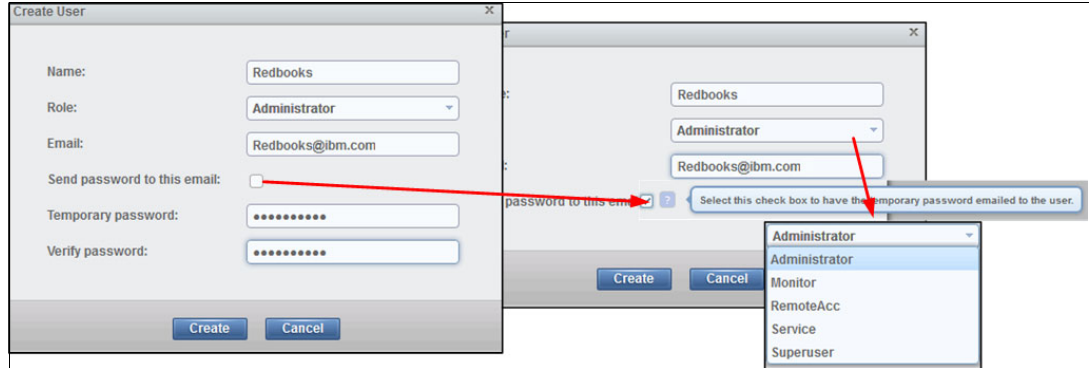

Figure 4-50   Create User

A user can receive the temporary password through one of the following methods:

► If **Send password to this email** is selected, you need to specify a valid email address for a user so that the user can receive passwords and email notifications. You must set up email notifications first. See "Email Server" on page 180. When a new user is created or when a user's password is reset, the temporary password is automatically sent to the email address of the user, rather than to an administrator. A user with a valid email address can also be selected as a recipient of email alerts from the Notifications page.

► If an email address is not specified, an administrator is responsible for generating a new password or resetting a password and informing the user.

The password that you set must conform to the rules that are defined on the Password and Session Policy window. See "Password and Session Policy" on page 190.

Important: A user's password is expired after the user is created, so a new user is prompted to reset the password the first time that the new user logs in.

After all fields are completed, select **Modify** to receive a message that confirms that the user is created and a reminder that the password is only temporary. See Figure 4-51.
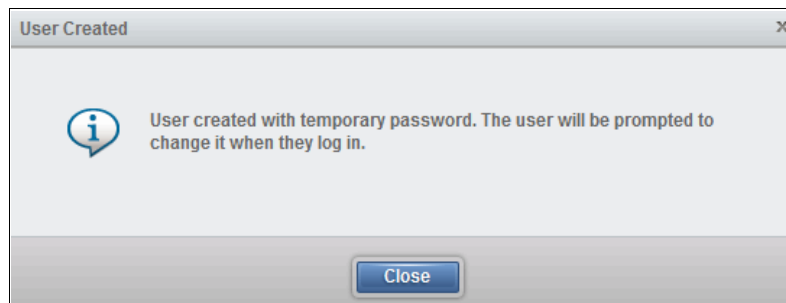
Figure 4-51   User Created

First-time login

When a user logs in for the first time, the user is presented with the login window. The user must use their user name and temporary password to start the login process, as shown in Figure 4-52.
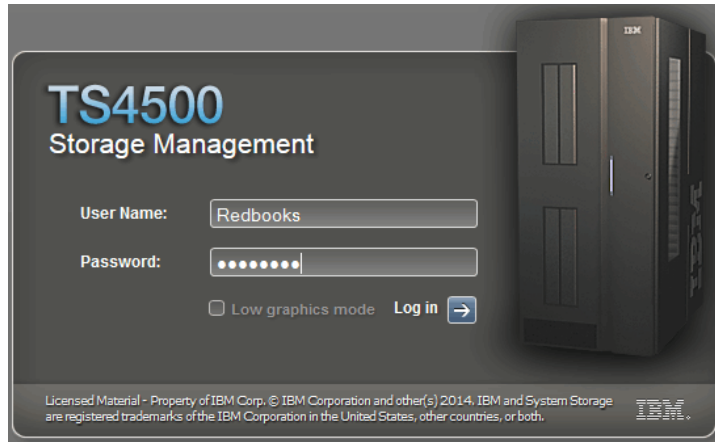
Figure 4-52   User login

The user is then presented with the change password window, as shown in Figure 4-53.

The new password must conform to the rules that were defined in the Password and Session Policy. See "Password and Session Policy" on page 190.

Note: The user name and password are case-sensitive.
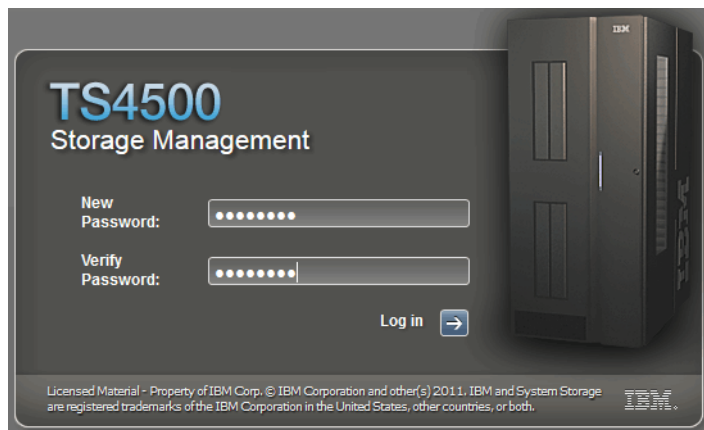
Figure 4-53   Change password

After the user sets the password, the user logs in with the new password on the initial login window, which is shown in Figure 4-52. After the user logs in with the new password, the user can access the TS4500 management GUI with access to the assigned role.

Modifying a user

An administrator can perform several actions on a user by selecting the user and then by using the Actions menu, as shown in Figure 4-54.
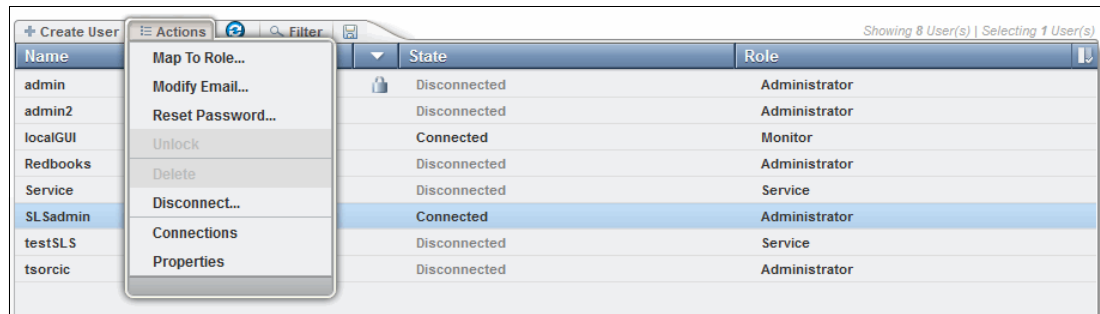
Figure 4-54   Actions

The following functions are available on the Actions menu:

► Map to Role: The administrator can map a new role to a user. If the user is logged in, this action logs out the user.

► Modify Email: The administrator can modify or add an email address to a user.

► Reset Password: The administrator can reset a user password and provide the user with a temporary password. The user must change this password to a new password by using the same procedure that is described in "First-time login" on page 203.

► Unlock: If a user is locked out because the user exceeded the maximum number of unsuccessful login attempts, an administrator can unlock the user. The locked user shows a locked icon on the user list, as shown in Figure 4-55.
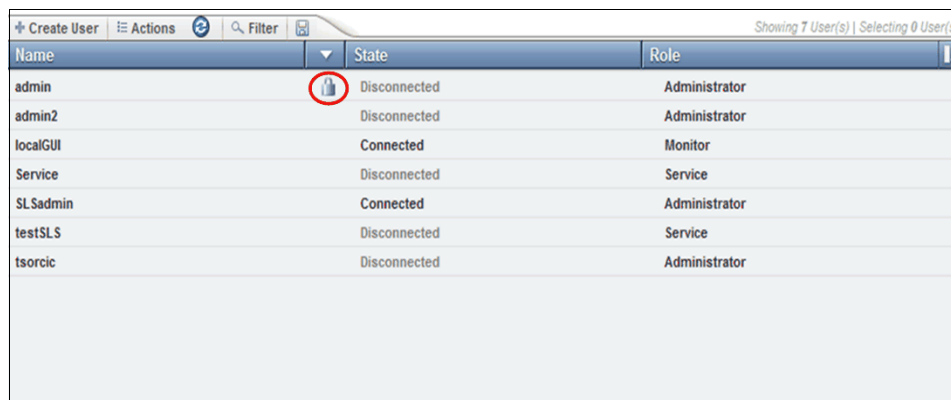
Figure 4-55   Locked user

If the user lost their password, any administrator can reset the password. If the user is locked, the administrator must unlock the user first.

► Delete: An administrator can delete a user. The user must be in a disconnected state to be deleted.

► Disconnect: An administrator can disconnect a user from the TS4500.

► Connections: This option lists the IP addresses that were used by the selected user to log in to the system. This option shows whether a user is being used multiple times and from what address.

▶ Properties: This option displays the properties of the user, the state of the user, and the user's last connection, as shown in Figure 4-56.
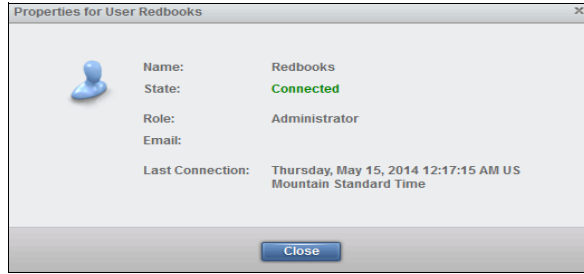
Figure 4-56   User properties

Locked out

If you are locked out of the TS4500 management GUI, you can revert to the default administrator user name and password by using the reset button at the back of the server. This button resets the user name and password to the default logon settings for 15 minutes.

Use this reset button only for emergencies, for example, if the remote authentication server is down or if the administrator loses or forgets their password and no administrators can access the system. See "Access Recovery" on page 49 for this process.

4.4.2 Roles

Roles define the pages that users can view and the actions that they can perform. Library administrators manage roles and the users that are assigned to them. Figure 4-57 shows the Role window.
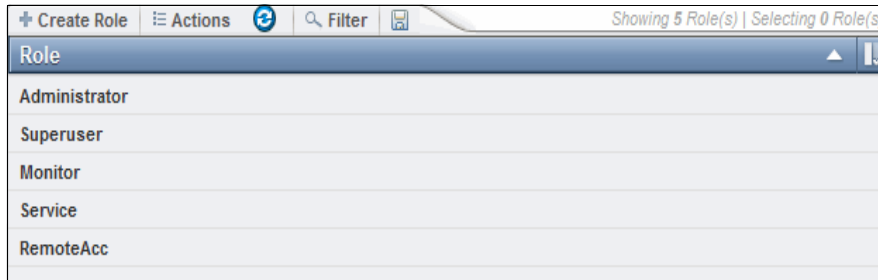
Figure 4-57   Role window

Preset roles

The TS4500 tape library has four preset roles, each with a different level of access to the TS4500 management GUI. It is also possible to create up to 16 new roles, each with a custom name and one of the preset permission levels. All roles have access to all logical libraries.

You cannot rename, delete, or modify the access permissions for any of the preset roles.

The following roles are preset default roles:

▶ Monitor: Users that are mapped to this role can view all physical and library data, but they cannot view user accounts or security settings. This role is useful for library operators.

▶ Superuser: Users that are mapped to this role can view all pages and perform library tasks, but they cannot manage users, modify security settings, or access service-related functions.

- ► Administrator: Users that are mapped to this role can perform all library tasks, including managing access and security, but they cannot access service-related functions.
- ► Service: Users that are mapped to this role can view all pages that are available to a monitor role. Additionally, this role can perform service-related functions, such as updating firmware, downloading logs, calibrating library components, and performing diagnostic tests. This role is useful for IBM service support representatives (SSRs).

  When this user logs in to the TS4500 management GUI, certain tables display additional information, and several of the available actions differ from the actions that are available for the other roles.

Custom roles

Users that are mapped to a role with a customized name can view all of the pages that are available to the selected preset permission level of the custom role.

Note: The permissions of a custom role with service-level access cannot be modified, even from the TS4500 command-line interface (CLI).

Creating or deleting a role

Name new roles and assign their permission by selecting from the preset role permission levels:

1. Create new roles by selecting **Access** → **Roles**.
2. Then, select the **Create Role** tab.
3. Enter a name for the role.

4. Then, select one of the preset role permission levels from the Duplicate permission from list box. See Figure 4-58. All roles have access to all logical libraries in the TS4500 tape library.
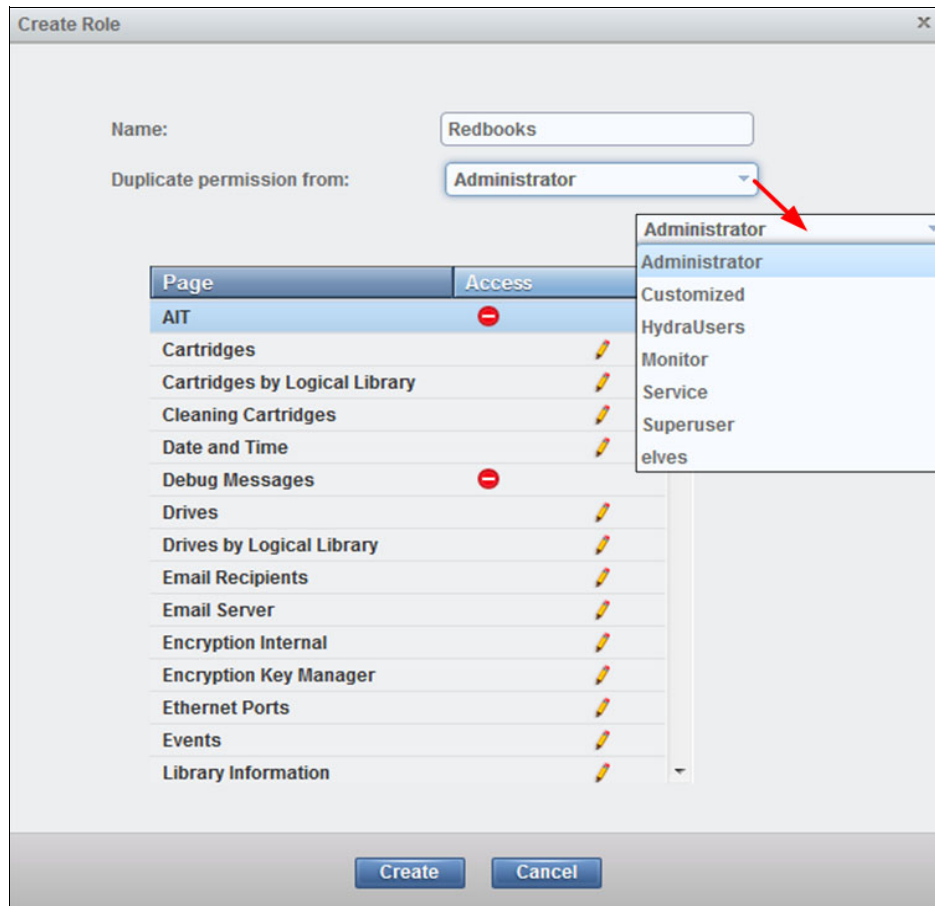
Figure 4-58   Create Role

To remove a role, select the role, then click **Access** → **Roles** → **Actions** → **Delete**. You can delete a role only if no users are assigned to the role.

You can also use the TS4500 CLI to create, modify, and delete roles, and to customize the permissions of a role.

Note: You must create a custom role before a user can be assigned to it.

Modifying the permissions of a role

You can modify customized role tasks from the TS4500 CLI only by first creating the role using "Creating or deleting a role" on page 206.

Ensure that the TS4500 CLI is installed. Open a command prompt in the same directory as the `.jar` file.

The CLI command has this format:

```
java -jar TS4500_CLI.jar "C:\[pathname_of_ts4500_cli.jar]" -ip [LCC ip] -u
[username] -p [password] --[cli_command]
```

This command is useful to gather current role permissions that you can modify.

> **Note:** If SSL is enabled on the TS4500 tape library, you need to add the `--ssl` parameter to the command after the password:
>
> ```
> java -jar TS4500CLI.jar -ip [LCC ip] -u [username] -p [password] --ssl
> --[CLI_command]
> ```

viewRolePermissions

This command displays a list of all permissions for a specified role. For example, we set up a role that is called `Redbooks`, which we want to save to a file that is called `role.txt`, as shown in Example 4-1.

Example 4-1   The viewRolePermissions command

```
C:\TS4500>java -jar TS4500CLI.jar -ip 10.1.121.99 -u Redbooks -p RedBOOks --view
RolePermissions Redbooks > role.txt
                          Action,    Access Level
                             AIT,      No Access
                      Cartridges,        Modify
    Cartridges by Logical Library,        Modify
            Cleaning Cartridges,         Modify
                  Debug Messages,      No Access
                          Drives,        Modify
       Drives by Logical Library,        Modify
            Email Notifications,         Modify
               Email Recipients,         Modify
             Encryption Internal,        Modify
          Encryption Key Manager,        Modify
                 Ethernet Ports,         Modify
                          Events,        Modify
            Library Information,         Modify
             Licensed Functions,         Modify
               Logical Libraries,        Modify
          Management GUI Behavior,        Modify
                 Master Console,      No Access
                 Password Rules,         Modify
               Position Control,      No Access
           Remote Authentication,        Modify
                           Roles,        Modify
               SNMP Destinations,        Modify
              SNMP Notifications,        Modify
                     Scan Speed,      No Access
             Secure Socket Layer,        Modify
                   Service Port,      No Access
           Syslogs Notifications,        Modify
                          System,        Modify
             System Date and Time,        Modify
                           Tasks,        Modify
                           Users,        Modify
                   VOLSER Ranges,        Modify
    VOLSER Ranges by Logical Library,     Modify
```

The output of this command is saved to our file, `role.txt`. You can now modify this file and change roles to suit your requirements. The output from this command can also be copied to another text file and modified.

The setRolePermissions command

This command sets up custom roles to the existing permissions for a specified role. First, edit the text file that was created with the **viewRolePermissions** command, and then set the new permissions with the **setRolePermissions** command, as shown in Example 4-2.

Example 4-2   setRolePermissions

```
C:\TS4500>java -jar TS4500CLI.jar -ip 10.1.121.99 -u Redbooks -p RedB00ks --set
RolePermissions rolenew.txt -role Redbooks
The permissions were updated successfully
```

To confirm that the role is changed, issue the **viewRolePermissions** command, as shown in Example 4-3.

Example 4-3   Confirm that role is changed

```
C:\TS4500>java -jar TS4500CLI.jar -ip 10.1.121.99 -u Redbooks -p RedB00ks --view
RolePermissions Redbooks > rolenew.txt
                             Action,   Access Level
                                AIT,     No Access
                         Cartridges,        Modify
         Cartridges by Logical Library,    Modify
                Cleaning Cartridges,        Modify
                     Debug Messages,     No Access
                             Drives,        Modify
          Drives by Logical Library,        Modify
                Email Notifications,     Read Only
                   Email Recipients,     Read Only
                 Encryption Internal,    Read Only
             Encryption Key Manager,        Modify
                     Ethernet Ports,        Modify
                             Events,        Modify
                Library Information,        Modify
                 Licensed Functions,        Modify
                  Logical Libraries,        Modify
             Management GUI Behavior,       Modify
                     Master Console,     No Access
                     Password Rules,        Modify
                   Position Control,     No Access
             Remote Authentication,        Modify
                              Roles,        Modify
                  SNMP Destinations,        Modify
                 SNMP Notifications,        Modify
                         Scan Speed,     No Access
                Secure Socket Layer,        Modify
                       Service Port,     No Access
                Syslogs Notifications,      Modify
                             System,        Modify
                System Date and Time,        Modify
                              Tasks,        Modify
                              Users,        Modify
                      VOLSER Ranges,        Modify
     VOLSER Ranges by Logical Library,       Modify
```

For more information about the TS4500, see Chapter 5, "Command-line interface (CLI)" on page 293.

4.5 Cartridges menu

Use the TS4500 management GUI pages under the Cartridges icon to view all cartridges, view cartridges by logical library, assign and move cartridges, and modify logical libraries, as shown in Figure 4-59.
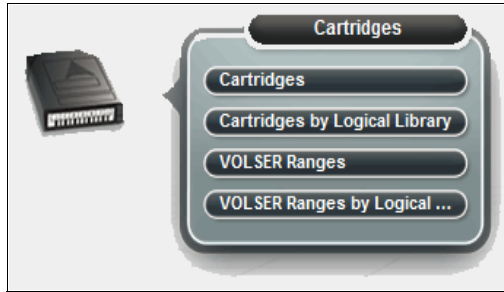

Figure 4-59   Cartridges menu

4.5.1 Cartridges

Use the Cartridges page to move cartridges to a different location, remove cartridges to an I/O station, assign cartridges to a logical library, or unassign cartridges from a logical library.

The Cartridges menu has the following functions:

- ► Searching for cartridges
- ► Viewing cleaning cartridge status
- ► Viewing cartridge states
- ► Assigning or unassigning cartridges
- ► Fixing a tape with an unknown volume serial number (VOLSER)
- ► Selecting priority for media verification
- ► Moving cartridges
- ► Exporting the mount history
- ► Performing other cartridge tasks from the CLI

Figure 4-60 shows the main Cartridges window or table.

Figure 4-60 Cartridges

Searching for cartridges

You can use the Cartridges table to find specific cartridges and view their state (slot, I/O slot, drive, or gripper). Sort the table to locate specific tape cartridges. You can sort by VOLSER, state, location, logical library, element address, or most recent use. Go to the Cartridges by Logical Library page to see the cartridges, which are displayed by their logical library.

Search for specific cartridges by using the filter. Click **Filter** and enter a value in the search field or click the **Advanced Filter** icon to the right of the search field to enter extended search criteria, as shown in Figure 4-61. Enter substrings if the entire value is unknown. Wildcard characters are not supported. Instead of wildcard characters, you can add more substrings to the search by clicking the plus sign (**+**) at the end of each criterion. Search values are not case-sensitive.
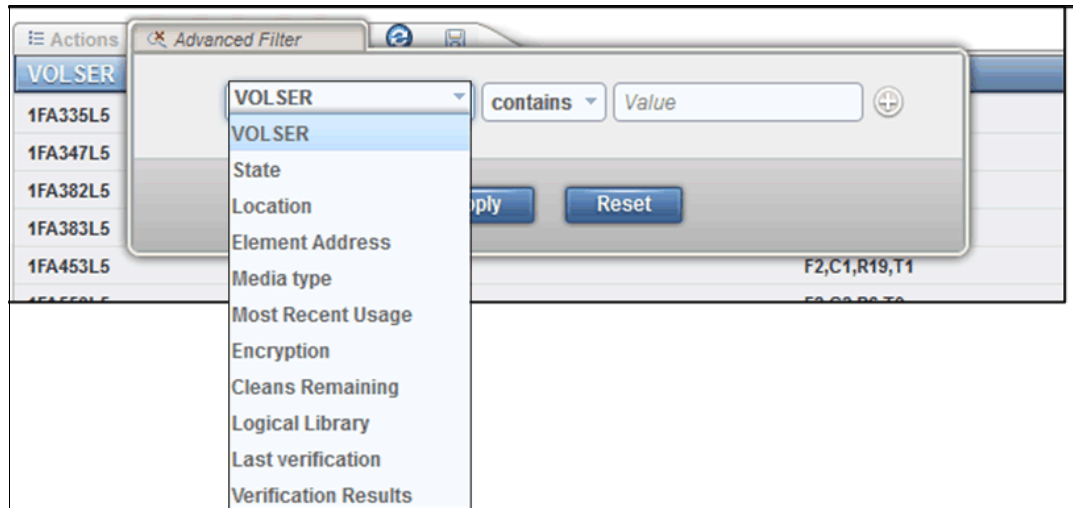

Figure 4-61 Advanced Filter option

The Cartridge database can be saved to a `.csv` file from the save option. It is also possible to save the list of cartridges that results from a search. To export the cartridge data, select the **Export Data** or **Save** icon (diskette), and then, select **Export Table Data**, as shown in Figure 4-62.
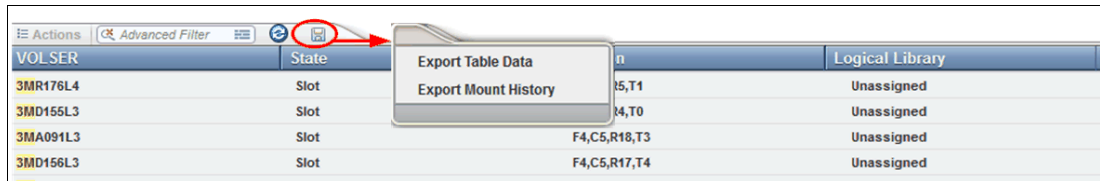
Figure 4-62   Save list

Viewing cleaning cartridge status

IBM supplies a cleaning cartridge with the first frame of each media type in a library. The library uses the cleaning cartridge to automatically clean tape drives, as needed, to maintain the efficiency of the tape drives. Each cleaning cartridge can be used up to 50 times.

This option is used to view how many cleanings remain on a cleaning cartridge. The number of remaining cleanings is displayed in the Cleans Remaining column of the Cartridges table. This column is hidden, by default.

Right-click the table header to select the Cleans Remaining column. To see all cleaning media in the TS4500, sort the column by Cleans Remaining by using the arrow, as shown in Figure 4-63.

You can also view how many cleaning cycles remain on all cleaning cartridges in a logical library on the Cartridges by Logical Library page.

Figure 4-63   Remaining cleanings

You can optionally eject expired cleaning cartridges automatically. To enable this feature, see "Cartridges and Accessors" on page 168.

Note: Cleaning cartridges are shared among logical libraries.

Cartridge states

The State column in the Cartridges table lists the current state for each cartridge. The following states are possible:
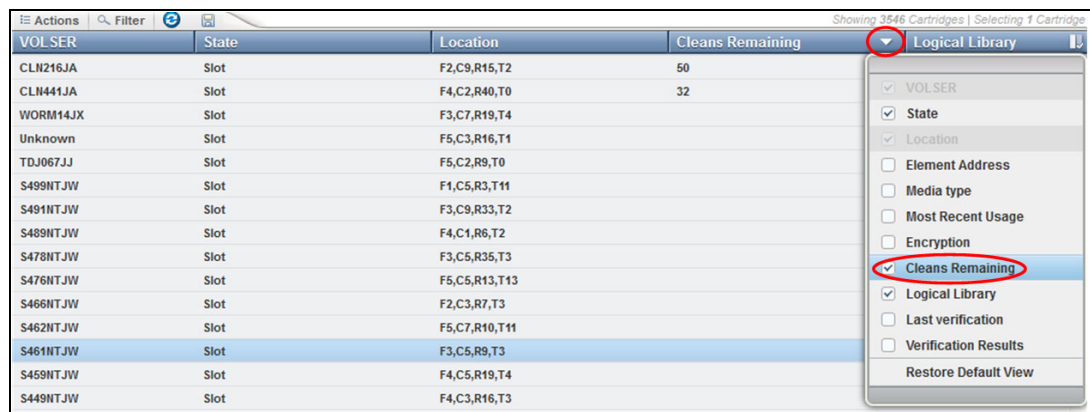
► Drive: This state means that a tape cartridge is in a tape drive.

► Gripper: This state means that a tape cartridge is in the gripper of the cartridge accessor.

► I/O Slot (Import Queued): This state means that a tape cartridge is in an I/O slot, but it is queued to move to a storage slot.

► I/O Slot: This state means that a tape cartridge was moved to the I/O station. This state is cleared if the cartridge is moved by the operator to any other location, including a different I/O station slot.

► Slot: This state means that a tape cartridge is in a storage slot.

► Slot (Assignment Pending): This state means that a tape cartridge is in the Unassigned logical library because an empty import/export element (IEE) address is not currently available for assignment.

► Slot (Export Queued): This state means that a tape cartridge was queued to move from a slot to the I/O station by one of the following methods:

  – The host issues a `move` command from the storage element to the IEE.
  – An operator selects a Move To I/O Slot operation from the management GUI.

► Slot (Virtual I/O): This state means that a tape cartridge was imported (physically moved) into the slot, but it is still in the virtual I/O (VIO) element address space and it is not queued for export.

Assigning or unassigning cartridges

A bar code label with a volume serial (VOLSER) number is affixed to each cartridge. Cartridges are assigned to a logical library with VOLSER ranges that are defined when the logical library is created. If the VOLSER range that is assigned to a logical library matches the VOLSER of a cartridge, that cartridge is assigned to the logical library. If the VOLSER of a newly inserted cartridge does not match the VOLSER range of a logical library, the cartridge is available to import into any logical library of the same media type.

The assignment is then determined by the first application to import the cartridge. VOLSER ranges were called the *Cartridge Assignment Policy* with the TS3500 tape library.

You can modify the cartridges that are assigned to a logical library by modifying the VOLSER range of the logical library from the VOLSER Ranges by Logical Library page.

Assigning a cartridge

If an individual cartridge is outside of a VOLSER range, you can use the Assign action to assign that cartridge to a specific logical library. However, creating VOLSER ranges is the preferred method for assigning cartridges to logical libraries.

To assign or reassign cartridges to a logical library, highlight one or more cartridges from the same logical library and then select **Actions** → **Assign**, as shown in Figure 4-64.
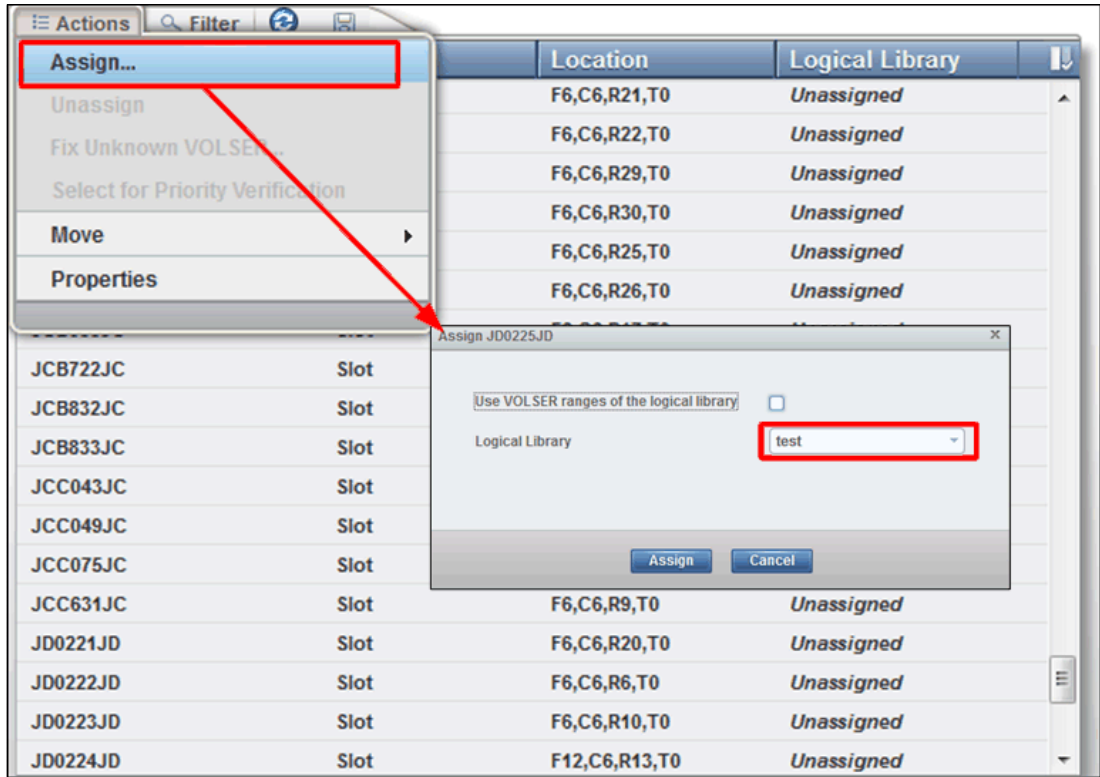
Figure 4-64   Assign selection

You can bulk assign all available or unassigned cartridges from the Cartridges by Logical Library page by highlighting the Available or Unassigned cartridge rows and selecting **Actions** → **Assign All Cartridges**.

Note: If the new cartridge assignments exceed the maximum number of cartridges that is allowed by a logical library, any additional cartridges are unassigned. Go to the Logical Libraries page to modify the maximum number of cartridges that is allowed, and then try the cartridge assignment again.

Unassigning cartridges

To unassign one or more cartridges, select the cartridge, and use the Actions menu to select **Unassign**. Select **Yes** on the next panel, as shown in Figure 4-65. However, as shown in the warning message, this action might result in synchronization problems with the application. To avoid this scenario, the preferred method is to use the application to eject cartridges.
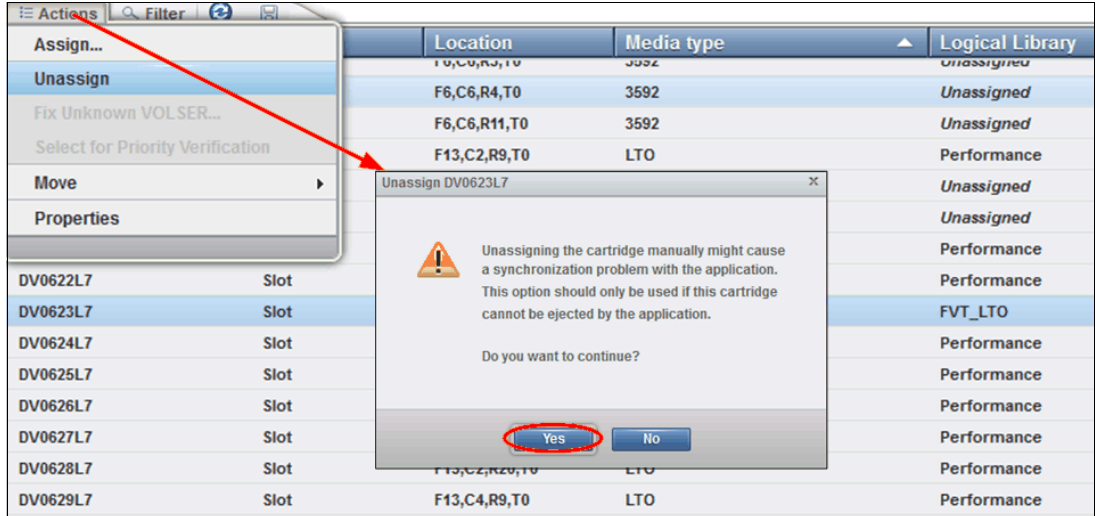
Figure 4-65   Unassign

Fixing a tape with an unknown VOLSER

Many tape management applications use Standard Label tape processing. The VOLSER number on the bar code label must match the VOLSER that is written to the tape to maintain compatibility with this type of processing. If a tape's VOLSER is unknown, you cannot use it until a VOLSER is established.

If a tape has an unknown VOLSER, select **Actions** → **Fix Unknown VOLSER** to apply a new VOLSER number to the tape. Enter the first 6 characters of the volume serial number and then add the last 2 characters that specify the cartridge type, taking note of the warning message, as shown in Figure 4-66.
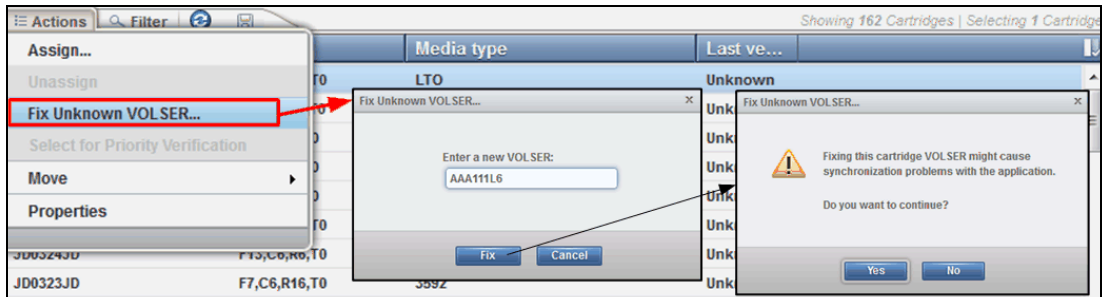
Figure 4-66   Fix Unknown VOLSER

Table 4-6 shows the possible cartridge type values.

Table 4-6   Cartridge types

Media	Cartridge type
LTO media	L8, LY, L7, LX, L6, LW, L5, LV, L4, LU, L3, and LT
3592 media	JD, JZ, JL, JC, JY, JB, JX, and JK

Click **Fix** to automatically assign the cartridge to the logical library that includes the VOLSER range that contains the VOLSER of the fixed cartridge.

Note: This action might result in synchronization problems with the application. An audit type of action for your application might be required.

Select for Priority Verification

After you set up the verification function, you can select one tape volume to verify. Select the media from the Cartridges menu and select the VOLSER to verify. On the Actions menu, click **Select for Priority Verification**, as shown in Figure 4-67. For information about media verification, see "Media verification" on page 229.
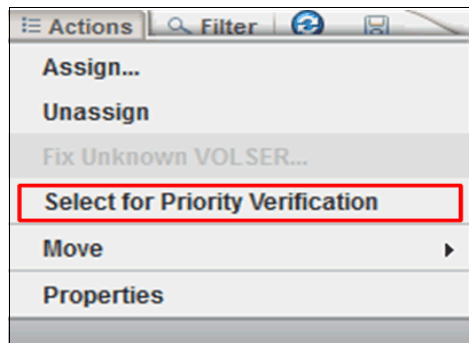
Figure 4-67   Select for Priority Verification

Moving cartridges

At times, you might want to instruct the library to move a specific tape cartridge. For example, if a single host controls the library and the host fails during an operation, you can use the Actions menu on the Cartridges page to move one or more cartridges to continue the operation, as shown in Figure 4-68.
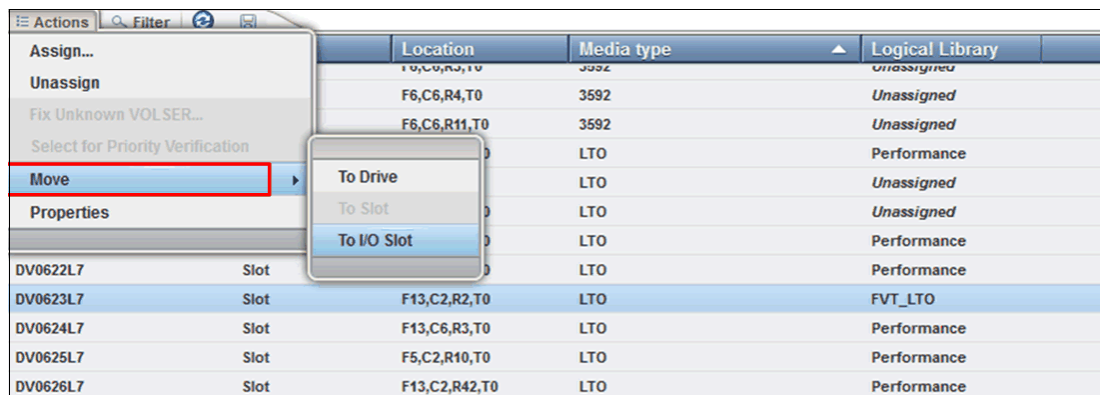
Figure 4-68   Move cartridge

You can select **Actions** → **Move** → **To Drive**, **Actions** → **Move** → **To Slot**, or **Actions** → **Move** → **To I/O Slot**, depending on where you want to move the cartridge.

Note: The use of the Cartridges page to move cartridges might result in synchronization problems with the application. To avoid this scenario, the preferred method is to use the application to move cartridges.

Exporting the mount history

Click the **Save** icon (which is shown on Figure 4-62 on page 212) and click **Export Mount History** to download the Mount History report. This report is a comma-separated value (.csv) file that contains a history of the last 250 unmounted cartridges and information about the tape drives. An example of a portion of this file is shown in Figure 4-69.

|	A	B	C	D	E	F	G	H	I	J	K	L	M	N
1	Mount History													
2							Mount	>>>	>>>	>>>	>>>	>>>	Life	>>>
3							Media	>>>	Host	>>>	Drive	Tape Alert	Mounts	WRetries
4							Write	Read	Write	Read	Residency	Media	Media	Media
5	Date and Time	VolSer	Frame	Drive	LogLib	EAddr	MBs	MBs	MBs	MBs	Minutes	_1-64	Count	Count
6	2014 05 15 18:56	_D040NTJR	3	11	_LL4Beta	258	0	0	0	0	0	0	0	0
7	2014 05 15 18:56	_JJS249JJ	2	14	_LL4Beta	259	0	0	0	0	0	0	0	0
8	2014 05 15 18:57	_9T0028JA	3	10	_LL4Beta	257	0	0	0	0	0	0	0	0
9	2014 05 15 18:59	_9T0028JA	2	14	_LL4Beta	259	0	0	0	0	0	0	0	0
10	2014 05 15 20:01	_D040NTJR	3	10	_LL4Beta	257	0	0	0	0	0	0	0	0
11	2014 05 15 20:01	_JJS249JJ	3	11	_LL4Beta	258	0	0	0	0	0	0	0	0
12	2014 05 15 21:06	_A00008	3	10	_LL4Beta	257	0	0	0	0	0	0	0	0
13	2014 05 15 21:07	_D040NTJR	3	10	_LL4Beta	257	0	0	0	0	0	0	0	0
14	2014 05 12 16:23	_313034JB	3	15	_FVT1_Tal	257	0	0	0	0	0	0	0	0
15	2014 05 12 16:26	_313005JB	3	15	_FVT1_Tal	257	0	0	0	0	0	0	0	0
16	2014 05 12 16:33	_313099JB	3	15	_FVT1_Tal	257	0	0	0	0	0	0	0	0
17	2014 05 12 17:14	_313034JB	3	15	_FVT1_Tal	257	0	0	0	0	0	0	0	0
18	2014 05 12 17:21	_313099JB	3	15	_FVT1_Tal	257	0	0	0	0	0	0	0	0
19	2014 05 12 17:32	_313034JB	3	15	_FVT1_Tal	257	0	0	0	0	0	0	0	0
20	2014 05 12 17:33	_313005JB	3	15	_FVT1_Tal	257	0	0	0	0	0	0	0	0
21	2014 05 12 17:36	_313034JB	3	15	_FVT1_Tal	257	0	0	0	0	0	0	0	0
22	2014 05 12 17:37	_313099JB	3	15	_FVT1_Tal	257	0	0	0	0	0	0	0	0
23	2014 05 12 17:41	_313005JB	3	15	_FVT1_Tal	257	0	0	0	0	0	0	0	0

Figure 4-69   Mount History

The file name includes the date that the file was downloaded and the library name (*LIBNAME_YYYYMMDD*_mount_history.csv).

The following information is included in the mount history report:

▶ Date and Time: The date and time that the cartridge was mounted in the drive. The format is *yyyy mm dd hh:nn.ss*, where *yyyy* equals the year, *mm* equals the month, *dd* equals the day, *hh* equals the hour, *nn* equals the minute, and *ss* equals the second.

▶ VolSer: The volume serial number of the cartridge (also known as the $VOLSER$). The VOLSER is a unique identifier. Ignore the underscore that precedes the VOLSER.

▶ Frame: The number of the library frame from which the cartridge was unmounted. Beginning with the base frame, frames are numbered 1 - 4, from left to right.

▶ Drive: The number of the drive from which the cartridge was unmounted. Drives are numbered 1 - 16.

▶ LogLib: The name of the logical library to which the cartridge was assigned.

▶ EAddr: The element address from which the cartridge was unmounted.

▶ Mount Tape Alert Media: The number of the most recent TapeAlert flag that was received by this drive and that referred to this cartridge.

▶ Life Mounts Media: The number of times that the cartridge was mounted to a drive since it was manufactured.

▶ Life WRetries Media: During the life of the cartridge, the number of errors that occurred when drives tried write operations again.

▶ Life WPerms Media: During the life of the cartridge, the number of permanent, unrecoverable errors that occurred when drives performed write operations.

▶ Life RRetries Media: During the life of the cartridge, the number of errors that occurred when drives tried read operations again.

▶ Life RPerms Media: During the life of the cartridge, the number of permanent, unrecoverable errors that occurred when drives performed read operations.

- ► Mount Rating Drive: The overall measure of the condition of the drive. `X'00'` is unknown. The value ranges from `X'01'` (best) to `X'FF'` (worst). This rating is the efficiency of the drive.

- ► Mount Rating Media: The overall measure of the condition of the cartridge that is mounted. `X'00'` is unknown. The value ranges from `X'01'` (best) to `X'FF'` (worst). This rating is the efficiency of the cartridge.

- ► Mount Rating Ports: The overall measure of the condition of the interface to the host server. `X'00'` is unknown. The value ranges from `X'01'` (best) to `X'FF'` (worst). This rating is the efficiency of the interface.

- ► Mount Rating Port0: The overall measure of the condition of the Port 0 interface to the host server. `X'00'` is unknown. The value ranges from `X'01'` (best) to `X'FF'` (worst). This rating is the efficiency of the Port 0 interface.

- ► Mount Rating Port1: The overall measure of the condition of the Port 1 interface to the host server. `X'00'` is unknown. The value ranges from `X'01'` (best) to `X'FF'` (worst). This rating is the efficiency of the Port 1 interface.

- ► Mount Rating Rsvd: Reserved for the library interface.

- ► Mount Write Perf: The ratio of performance write commands in relation to all write-type commands. This value is a measure of the efficiency of write performance. The value is given as a percentage. A high percentage is better and a low percentage is worse.

- ► Mount Write ERPs: The measure of how the data rate performance affects the error-recovery procedures (ERPs) on write operations. The value is given as a percentage. A high percentage is better and a low percentage is worse.

- ► Mount Write Burst: For write operations, the measure of the comparison between the window tape buffer rate to the average rate. The *window rate* is the amount of data that is moved divided by the time when the data is ready in the mode (when data can be moved, but it is not). The average rate is the amount of data that is moved divided by the overall time in the mode (including setup, overhead, and so on). The value is given as a percentage. A high percentage is better and a low percentage is worse.

- ► Mount Write Buffer: The average tape-buffer efficiency on write operations. This value is the *streaming write efficiency*. The value is given as a percentage. A high percentage is better and a low percentage is worse.

- ► Mount Read Perf: The ratio of performance read commands in relation to all read-type commands. The value is given as a percentage. A high percentage is better and a low percentage is worse.

- ► Mount Read ERPs: The measure of how the data rate performance affects the error-recovery procedures (ERPs) on read operations. The value is given as a percentage. A high percentage is better and a low percentage is worse.

- ► Mount Read Burst: For read operations, the measure of the comparison between the window tape buffer rate to the average rate. The window rate is the amount of data that is moved divided by the time when it is ready in the mode (when data can be moved, but it is not). The average rate is the amount of data that is moved divided by the overall time in the mode (including setup, overhead, and so on). The value is given as a percentage. A high percentage is better and a low percentage is worse.

- ► Mount Read Buffer: The average tape-buffer efficiency on read operations. This value is the *streaming read efficiency*. The value is given as a percentage. A high percentage is better and a low percentage is worse.

- ► Mount Capacity Total: The measure of the efficiency of static capacity. This total can be viewed as the percentage of recorded media that fits into the currently recorded area in

relation to how much data can ideally fit in that area. The lower the percentage, the less capacity is available (due to recording error recovery, media defects, and so on).

► Mount Capacity Writes: The measure of the efficiency of active capacity on write commands. This value can be viewed as the sum of efficiency for write operations on this mount. The value is given as a percentage. A high percentage is better and a low percentage is worse.

► Mount Capacity Control: The measure of the efficiency of active capacity on all other operations. The value is given as a percentage. A high percentage is best and a low percentage is worst.

► Crypto Status: Whether a cartridge is encrypted. Values are 1 (media contains encrypted data), 0 (media does not contain encrypted data), or a blank space if the drive was unable to determine whether the media contains encrypted data.

► Crypto Rekey: Whether a cartridge was rekeyed. Values are 1 (cartridge was rekeyed during the last mount) or 0 (cartridge was not rekeyed during the last mount).

► Mount Host Write: The number of megabytes (MB) that was written during a mount.

► Mount Host Read: The number of megabytes (MB) that was read during the mount.

► Mount Drive Residency: The number of minutes that the tape cartridge remained in the tape drive during the mount.

4.5.2 Cartridges by Logical Library

Use the Cartridges by Logical Library page to create and manage logical libraries, and assign, unassign, or move cartridges.

The Cartridges by Logical Library window has the following functions:

► Searching for cartridges
► Viewing cleaning cartridge status
► Assigning or unassigning cartridges
► Moving cartridges
► Creating and managing logical libraries

Figure 4-70 shows the main window for Cartridges by Logical Library and the available selections for the default columns that you want to view.
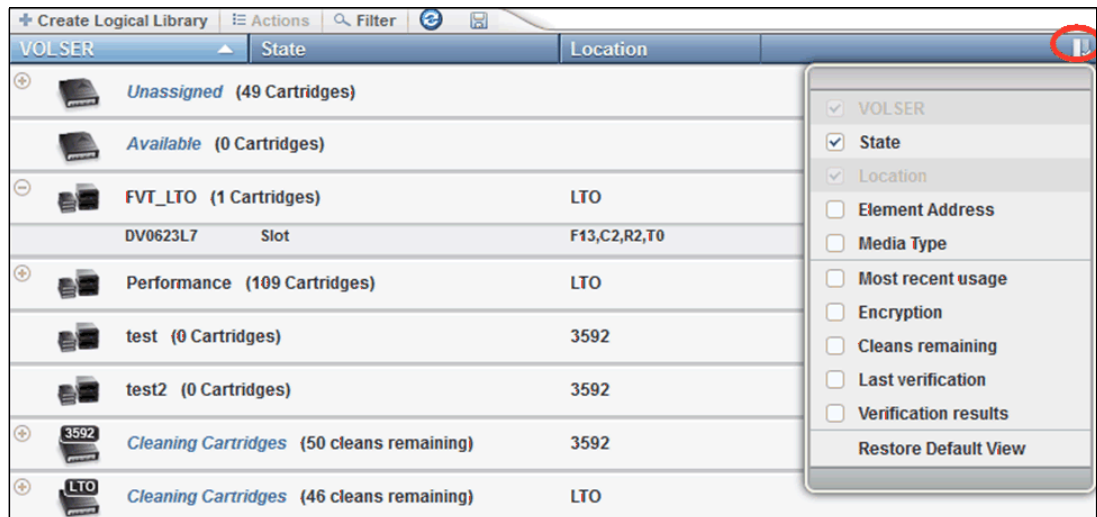

Figure 4-70   Cartridges by Logical Library

Searching for cartridges

Sort the table on the Cartridges by Logical Library page to locate specific tape cartridges within a specific logical library. You can sort by VOLSER, state, location, element address, most recent use, last verification, or verification results.

Search for specific cartridges by using the filter. Select **Filter** and enter a value in the search field. Enter substrings if the entire value is unknown. Wildcard characters are not supported. Instead of wildcard characters, you can add more substrings to the search by clicking the plus sign (**+**) icon at the end of each criterion. Search values are not case-sensitive.

Viewing cleaning cartridge status

IBM supplies a cleaning cartridge with the first frame of each media type in a library. The library uses the cleaning cartridge to automatically clean tape drives, as needed, to maintain the efficiency of the tape drives. Each cleaning cartridge can be used 50 times. The cleaning cartridge is shared with all logical libraries that are configured, and it is not assigned to any logical library.

View how many cleanings remain on all cleaning cartridges in a logical library on the Cartridges by Logical Library table. You can also view how many cleanings remain on a specific cleaning cartridge in the Cleans Remaining column on the Cartridges page, as shown in Figure 4-71.

You can optionally automatically eject expired cleaning cartridges. To enable this feature, select **Settings** → **Library** → **Cartridges**, and select **Automatically**, as shown in Figure 4-12 on page 168.

Figure 4-71   Cleaning cartridges

> **Remember:** Cleaning cartridges are shared among logical libraries.

Assigning or unassigning cartridges

A bar code label with a volume serial (VOLSER) number is affixed to each cartridge. Cartridges are assigned to a logical library with VOLSER ranges that are defined when the logical library is created. If the VOLSER range that is assigned to a logical library matches the VOLSER of a cartridge, that cartridge is assigned to the logical library.

If the VOLSER of a newly inserted cartridge does not match the VOLSER range of a logical library, the cartridge is available to import into any logical library of the same media type. The assignment is then determined by the first application to import the cartridge.

You can modify the cartridges that are assigned to a logical library by modifying the VOLSER range of the logical library from the VOLSER Ranges by Logical Library page.

Assigning

If an individual cartridge is outside of a defined VOLSER range, you can use the Assign action to assign that cartridge to a specific logical library. However, creating VOLSER ranges is the preferred method for assigning cartridges to logical libraries.

To assign or reassign cartridges to a logical library, highlight one or more cartridges from the same logical library, and then select **Actions** → **Assign**, as shown in Figure 4-72.
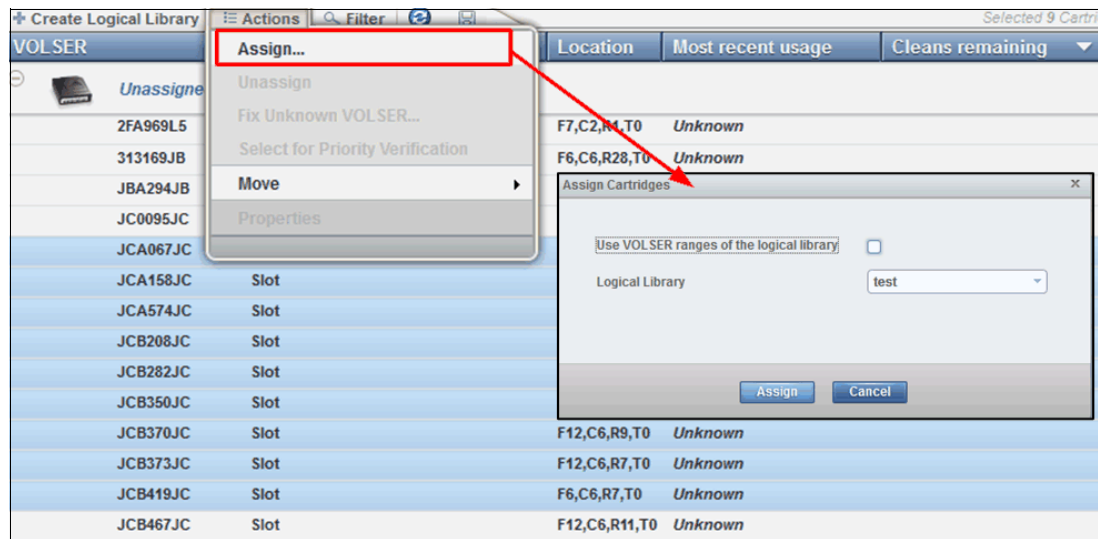
Figure 4-72   Assign Cartridges to a logical library

Note: If the new cartridge assignments exceed the maximum number of cartridges that is allowed by a logical library, any additional cartridges are unassigned. Go to the Logical Libraries page to modify the maximum number of cartridges that is allowed and try the cartridge assignment again.

Unassigning cartridges

Select **Actions** → **Unassign** to unassign one or more cartridges. See Figure 4-73. However, this action might result in synchronization problems with the application. To avoid this scenario, the preferred method is to use the application to eject cartridges.
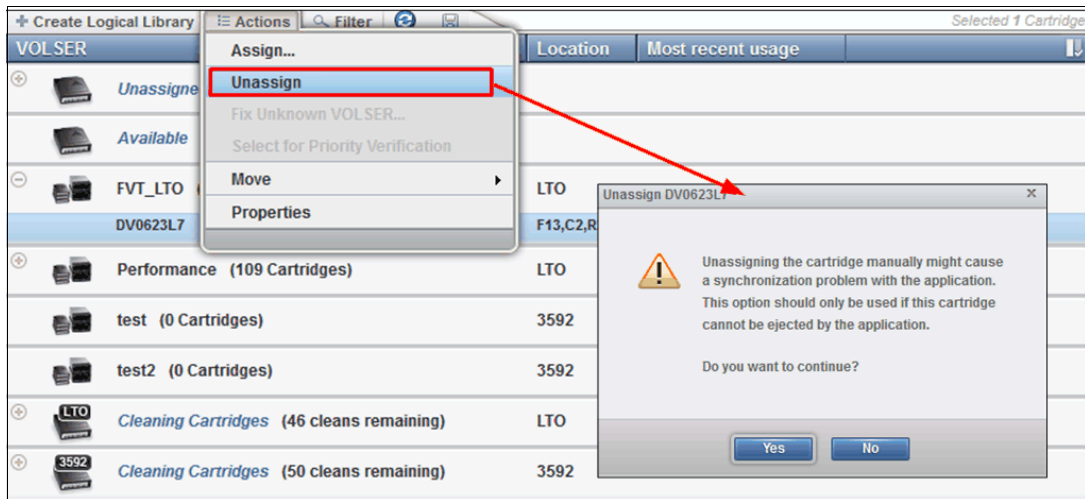
Figure 4-73   Unassigning cartridges manually

Moving cartridges

At times, you might want to instruct the library to move a specific tape cartridge. For example, if a single host controls the library and the host fails during an operation, you can use the Actions menu on the Cartridges page to move one or more cartridges to continue the operation, as shown in Figure 4-74.

Figure 4-74   Move cartridge from the Cartridges page

You can select **Actions** → **Move** → **To Drive**, or **Actions** → **Move** → **To Slot**, or **Actions** → **Move** → **To I/O Slot**, depending on where you want to move the cartridge.

Note: The use of the Cartridges page to move cartridges might result in synchronization problems with the application. To avoid this scenario, the preferred method is to use the application to move cartridges.
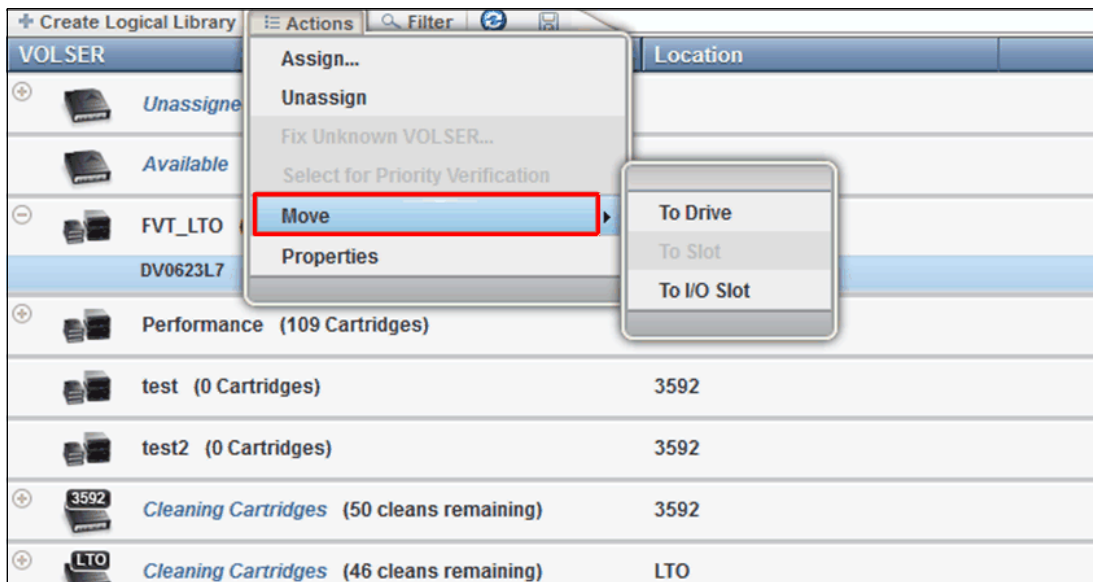
Creating and managing logical libraries

For information about creating and managing logical libraries, including setting or modifying the method of encryption that is used by logical libraries, see 4.7.2, "Create Logical Library window" on page 253.

4.5.3 VOLSER ranges

Volume serial (VOLSER) ranges are used to assign cartridges to specific logical libraries. You can view a list of all VOLSER ranges in the library, search for VOLSERs, and create, modify, and delete VOLSER ranges on the VOLSER Range page, as shown in Figure 4-75.

The following information is presented on this window:

► Using VOLSER ranges
► Creating and managing logical libraries
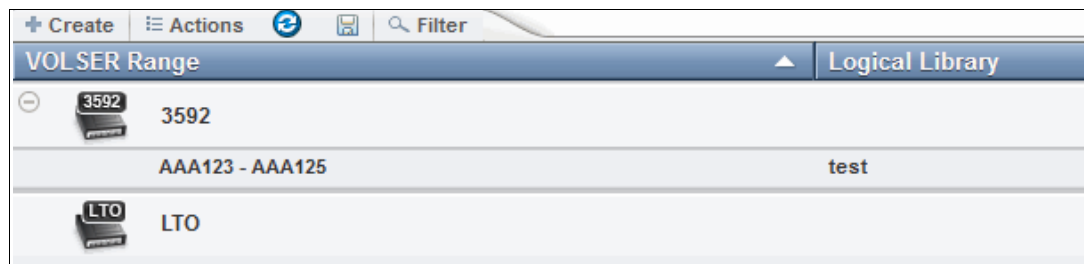
Figure 4-75   Create VOLSER Range window

When you insert a cartridge into the library and its VOLSER is within a range that is assigned to a certain logical library, the cartridge is assigned to that logical library automatically. The cartridge must be of the same media type as that logical library. For example, if you create a logical library that is called `LogicalLibrary1` for VOLSERs that range from `ABC000` to `ABC999` (a library of LTO drives) and then you insert a cartridge with VOLSER `ABC123`, the library recognizes that the VOLSER belongs in the range and assigns it to `LogicalLibrary1`.

If you insert a cartridge that is outside of any VOLSER ranges, it is available to import 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 among all logical libraries.

Creating or modifying a VOLSER range

To create a VOLSER range, highlight a logical library and select **Actions → Create VOLSER Range**. To modify an existing range, select **Actions → Modify VOLSER Range**. Enter the start and end VOLSERs for the range and click **Create** or **Modify**. See Figure 4-76. Any cartridges that belong to that VOLSER range are automatically assigned, except cartridges that are being exported. If the reassignment exceeds the maximum cartridge capacity of the new or modified logical library, any excess cartridges are automatically unassigned.

Figure 4-76   Create or modify the VOLSER range

Reassigning a VOLSER range

You can reassign a VOLSER range to a different logical library of the same media type by highlighting the range (or ranges) and by selecting **Actions → Reassign VOLSER Range** to display the Reassign window that is shown in Figure 4-77. Any cartridges that belong to that VOLSER range are automatically reassigned. If the reassignment exceeds the maximum cartridge capacity of the new logical library, any excess cartridges are automatically unassigned.

Figure 4-77   Reassign VOLSER range

Delete a VOLSER range

To delete a VOLSER range, highlight the range and select **Actions → Delete VOLSER Range**. If any cartridges are assigned to the range, they are automatically unassigned.

> **Note:** Any action that causes cartridge assignments to change can result in application synchronization problems. To avoid this scenario, first use the application to eject any cartridges that are assigned to the selected VOLSER range.

4.5.4 VOLSER Range by Logical Library

Volume serial (VOLSER) ranges are used to automatically assign cartridges to specific logical libraries. You can create the ranges when you create your logical libraries or you can create, modify, and reassign the ranges on the VOLSER Range by Logical Library page. The following information is presented for using VOLSER ranges:

► Creating and managing logical libraries
► Creating, modifying, or deleting VOLSER ranges

Figure 4-78 shows the VOLSER Range by Logical Library window.
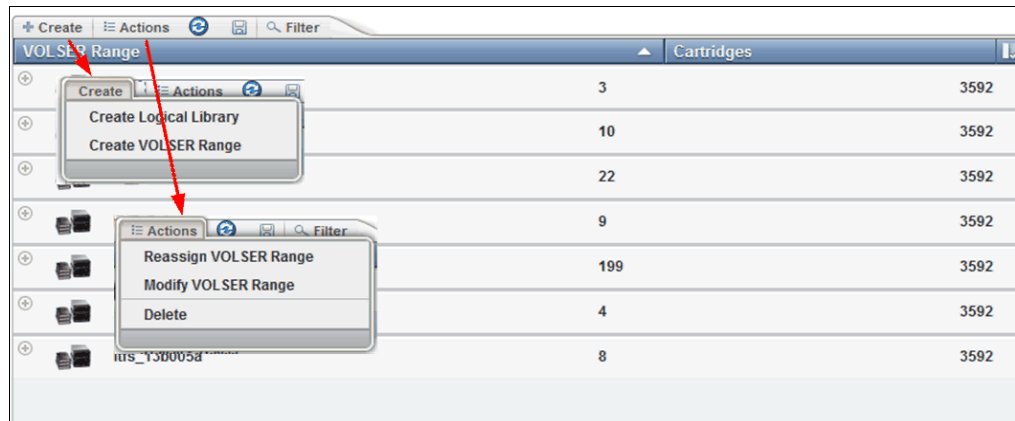
Figure 4-78   Volser Range by Logical Library window

Using VOLSER ranges

When you insert a cartridge into the library and its VOLSER is within a range that is assigned to a certain logical library, the cartridge is assigned to that logical library. The cartridge must be of the same media type as that logical library. For example, if you create a logical library that is called `LogicalLibrary1` for VOLSERs that range from `ABC000` to `ABC999` (a library of LTO drives) and then you insert a cartridge with VOLSER `ABC123`, the library recognizes that VOLSER as belonging to the range and assigns it to `LogicalLibrary1`.

If you insert a cartridge that is outside of any VOLSER ranges, it is available to import 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 among all logical libraries.

Creating or modifying a VOLSER range

To create or modify a VOLSER range, highlight a logical library and select **Actions** → **Create VOLSER Range** or **Actions** → **Modify VOLSER Range**. Enter the start and end VOLSERs for the range and click **Create** or **Modify**. Any cartridges that belong to that VOLSER range are automatically assigned, except cartridges that are being exported. If the reassignment exceeds the maximum cartridge capacity of the new or modified logical library, any excess cartridges are automatically unassigned.
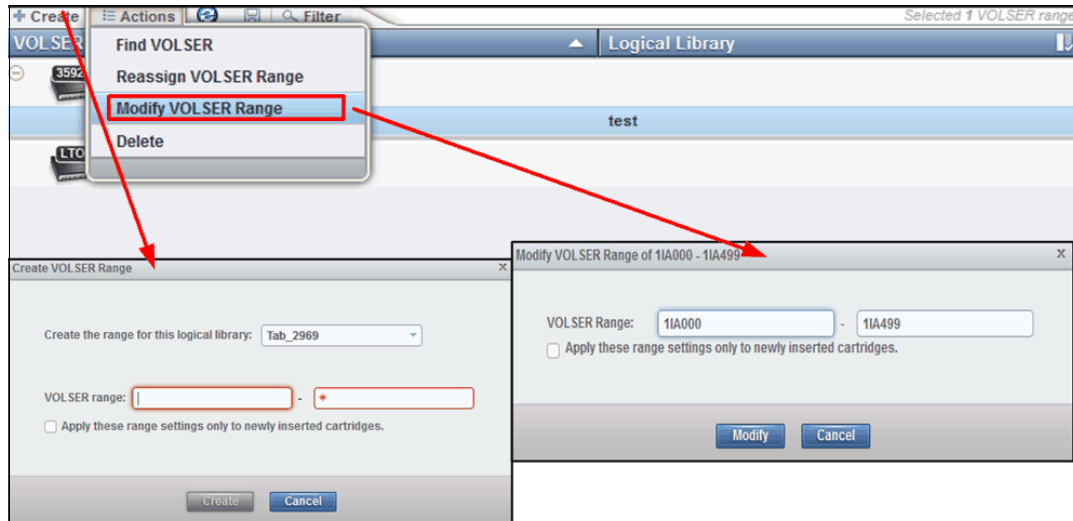
Reassign a VOLSER range

You can reassign a VOLSER range to a different logical library of the same media type by highlighting the range (or ranges) and selecting **Actions** → **Reassign VOLSER Range**. Any cartridges that belong to that VOLSER range are automatically reassigned. If the reassignment exceeds the maximum cartridge capacity of the new logical library, any excess cartridges are automatically unassigned.
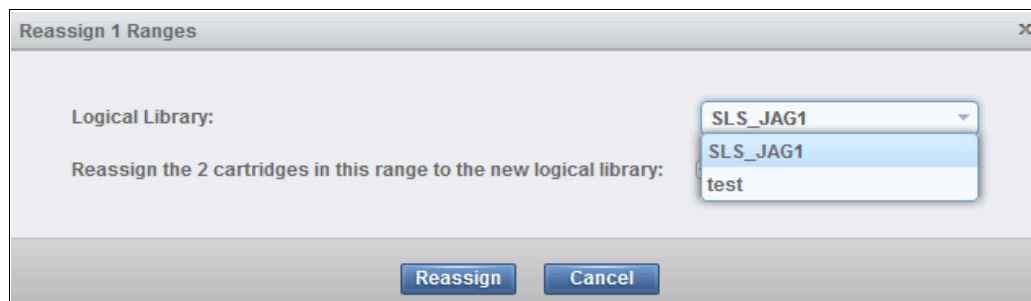
Delete a VOLSER range

To delete a VOLSER range, highlight the range and select **Actions** → **Delete VOLSER Range**. If any cartridges are assigned to the range, they are automatically unassigned.

> **Note:** Any action that causes cartridge assignments to change can result in application synchronization problems. To avoid this scenario, first use the application to eject any cartridges that are assigned to the selected VOLSER range.

4.6 Drives menu

Use the TS4500 management GUI pages under the Drives icon, as shown in Figure 4-79, to view all drives in the library, view drives by logical library, view drive port status and perform tasks, such as assigning drives, enabling control paths, configuring drives for verification, and setting drive port configuration.
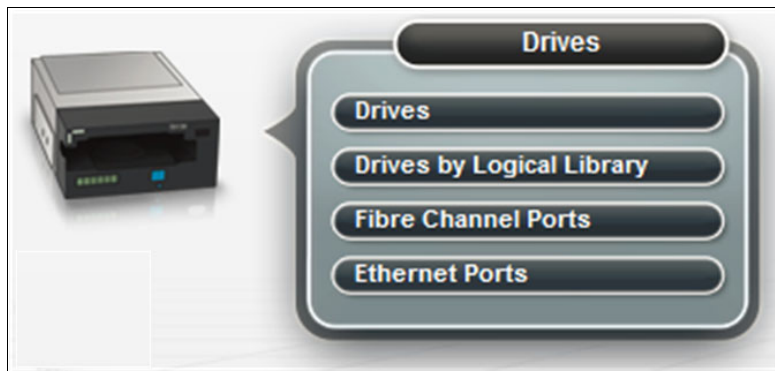
Figure 4-79   Drives menu

4.6.1 Drives

Use the Drives page to view the location and state of all drives in the library, and to enable or disable control paths, eject cartridges, reset or clean drives, or update drive firmware.

You can use the view options and display additional drive status options on the Drives page, such as port status, drive serial numbers (S/Ns), and worldwide node name (WWNN), as shown in Figure 4-80.
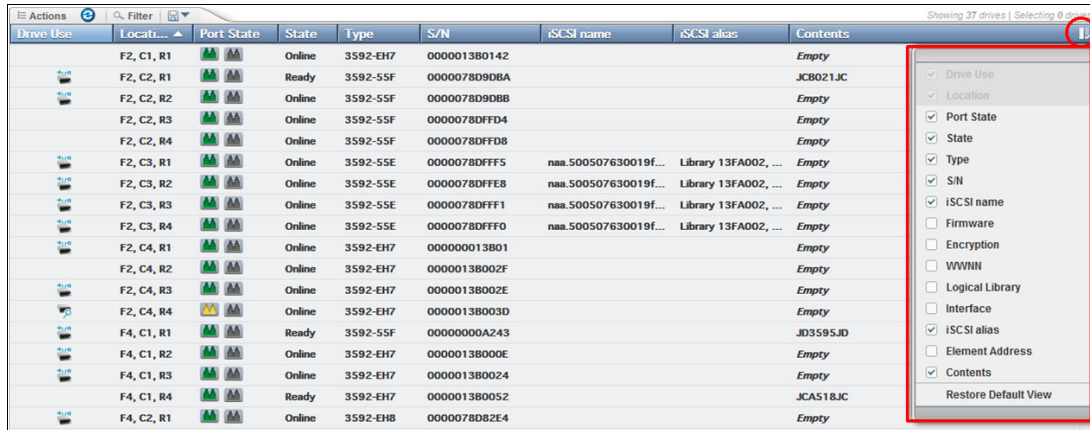
Figure 4-80   Drives page

The Drives page and the Actions menu options are shown on Figure 4-81. Depending on whether the selected drive is assigned or unassigned, you optionally can reassign or assign the drive.
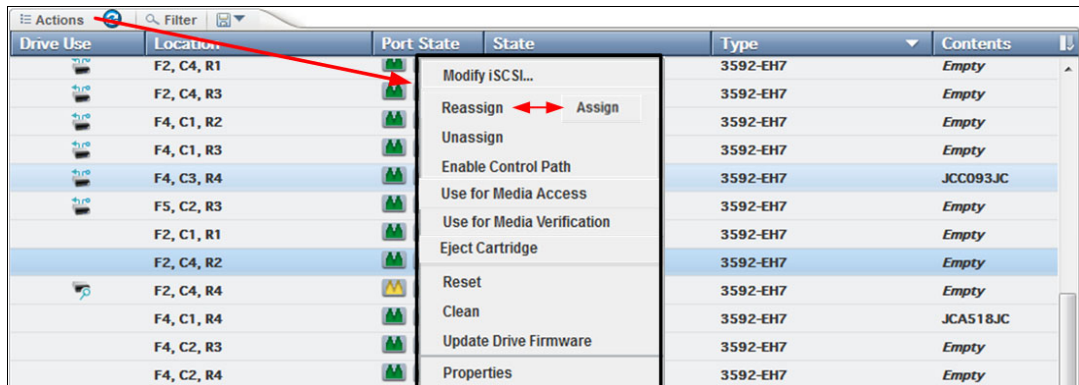
Figure 4-81   Drives page Actions menu options

Adding or removing tape drives

A tape drive is unassigned after it is installed in the tape library. All unassigned drives are assigned when a logical library is created by using the logical library presets. Or, you can use the Drives by Logical Library page to assign a tape drive to a logical library. For details about the logical library configuration, see 4.7.2, "Create Logical Library window" on page 253.

Reassigning a drive

You can reassign a drive from one logical library to another logical library by using the Reassign drive option. First, ensure that the drive is not a control path drive, then use the Drives by Logical Library page to reassign the drive, as shown in Figure 4-82.
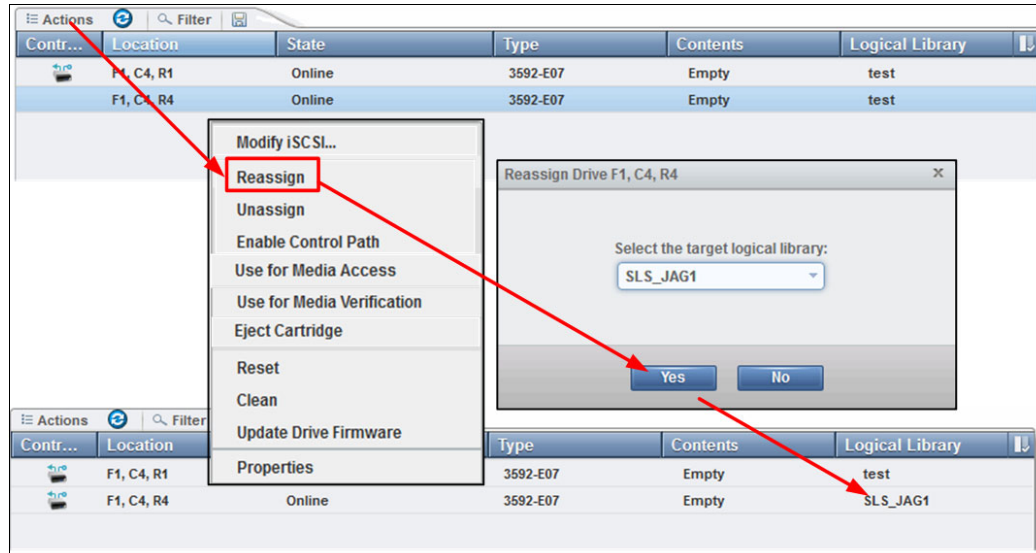
Figure 4-82   Reassign a drive

You assign a drive by using the **Assign** option, which is the same as reassigning the drive.

Unassigning a drive

Before a drive is physically removed from the tape library, it must be empty and unassigned. Use the Drives page to eject the cartridge and use the Drives by Logical Library page to unassign the drive, as shown in Figure 4-83.
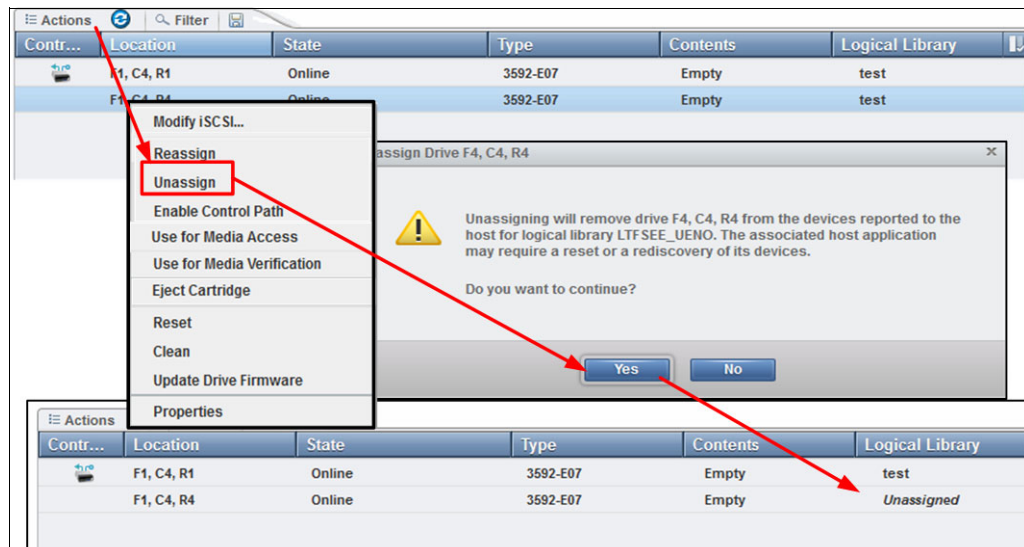
Figure 4-83   Unassign a drive

Media verification

The TS4500 supports media verification, which is fully controlled by the TS4500 at a logical library level. It is transparent to any software application that controls the library.

Use this feature to verify any media for the ability to read all of the data on the selected media within a logical library. Media verification is set up to run automatically on a set schedule.

You can set a recurring schedule for verification by days, months, or years. After you set up the media verification, you can verify a single medium before the set schedule, if required.

Cartridges that are being verified are still available to use. 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.

Media verification requires that you configure dedicated drives in the logical library for this function. We recommend that you dedicate at least two drives for this task. These drives are not available to use for media access, and they are not visible to hosts.

> **Important:** Assigning drives within a logical library as media verification drives is disruptive because these drives are taken offline to any application that configured them.

For a library with multiple logical libraries, these drives can be reassigned to a different logical library to use for media verification, but this reassignment can remove the logical library verification setup.

After media verification is enabled on a logical library for the first time, all cartridges are due for verification on the same date, but because the policy period is not a deadline, it merely establishes a queue of media verification activity. The initial queue of media verification can take time, even months if a library is large.

This time depends on the number of cartridges, how full they are, and the number of media verification drives. Each cartridge has a unique last verification date, which means that all cartridges are not due for media verification at the same time.

> **Note:** We recommend that at least two drives are assigned for verification. The number of drives needs to be sized based on the number of cartridges in the logical library and how full they are.

After you run media verification on a cartridge, the next verification will be based on the last verification date, plus the configured policy period of the logical library.

> **Note:** The last verification date is stored in the cartridge memory (CM) so that the policy is still applied even if a cartridge is exported and imported to the same or a different logical library (LL). The policy period is based on the logical library settings of the logical library to which the cartridge is imported.

Media verification setup

The first step is to configure a drive for media verification. Two methods are available:

- ▶ Configure an unassigned drive as the verification drive.
- ▶ Configure an assigned drive as the verification drive.

Configuring an unassigned drive as the verification drive

To configure an unassigned drive for media verification, from the main menu, select **Drives** → **Drives by Logical Library**, select **Unassigned drives**, and select the drive from the list to use as a verification drive.

A warning message appears to inform you that this drive will not be available for media access and it will not be visible to hosts. This drive can be used for media verification only, as shown in Figure 4-84. Repeat this task for all drives that you configure for media verification.
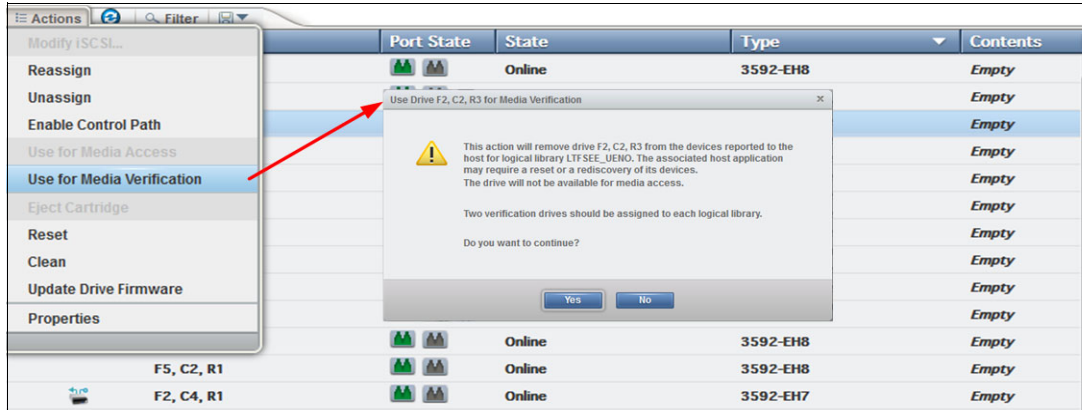
Figure 4-84   Drive configuration for media verification

After all of the required drives are set, the drives display as verification drives, as shown in Figure 4-85.
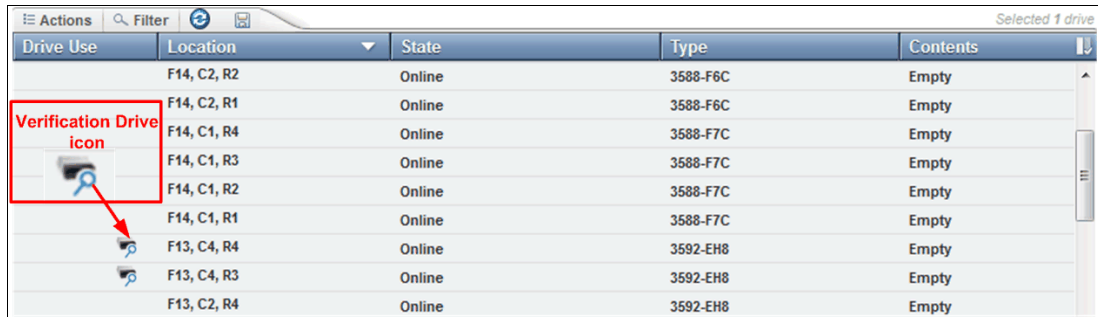
Figure 4-85   Verification drives

You can now assign these drives to a logical library which has been set up for media verification. Select the drive, and then click **Actions** → **Assign** to assign them to the logical library that is required, as shown in Figure 4-86. Repeat this task for all drives that are required to verify media.
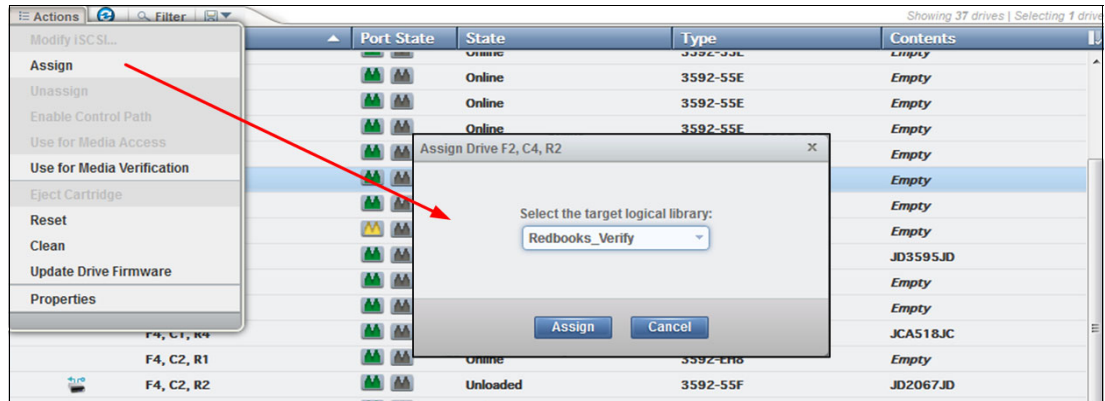
Figure 4-86   Assign verify drive

These drives are now assigned to the required logical library. They can be seen from the Drives by Logical Library menu, as shown in Figure 4-87.
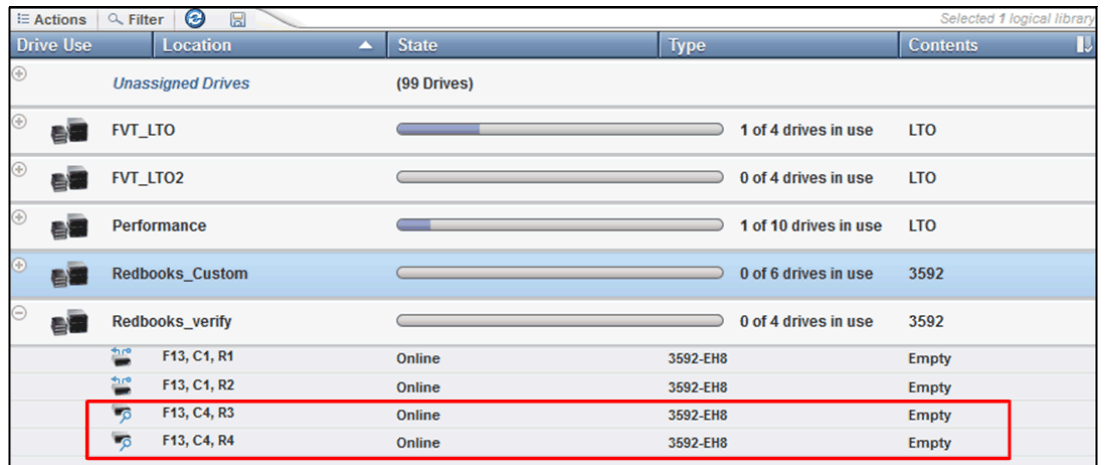
Figure 4-87   Verify media drives that are assigned to a logical library

Configure an assigned drive as a media verification drive

From the Drives by Logical Library menu, select the logical library. Then, select the drive that you want to use for media verification. Then, click **Actions** → **Use for Media Verification**. Repeat this task for all drives that are required for media verification. Display the drives in the logical library, and you can see that these drives are now configured for verification, as shown in Figure 4-88.

Figure 4-88   Media verification drives by logical library

Configuring media verification on a logical library

After the drives are assigned to the logical library for media verification, you can configure the logical library for media verification. Select the logical library. Then, click **Actions** → **Modify Media Verification**.

From the pop-up menu, enable **Automatic media verification** and select the frequency, first verification date, and media verification drive options to suit your requirements. You can set a recurring schedule for verification by days, months, or years.

You can select the date to start the first verification, and you can set the verification drives, as shown in Figure 4-89.
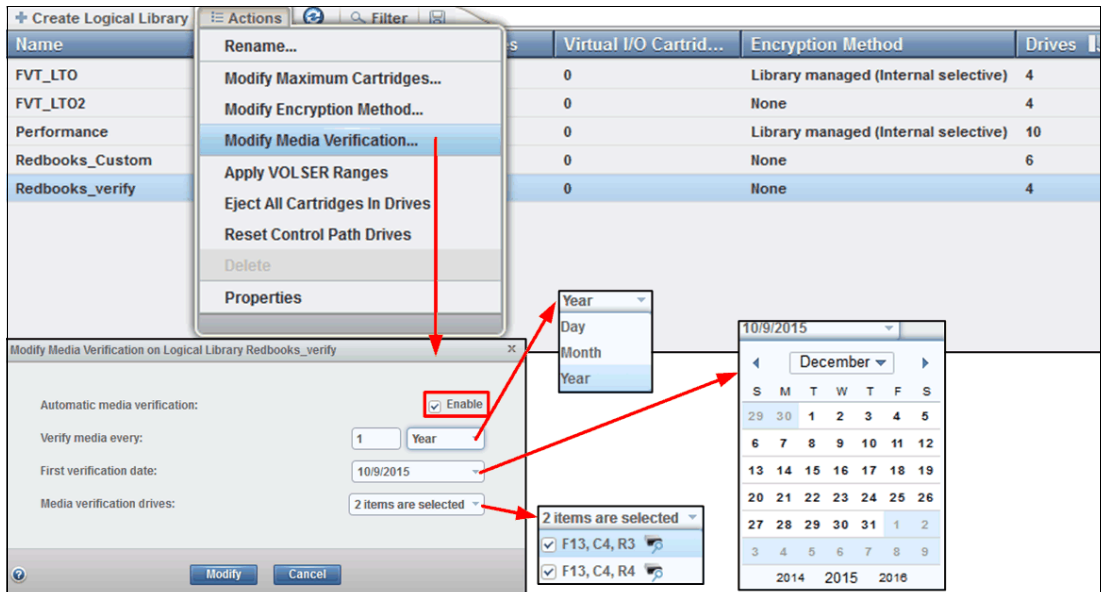
Figure 4-89   Configure media verification

This action enables media verification for the selected logical library. The verification occurs based on the policy that you set.

Verify a single tape volume

After the verification policy is set, you can select one tape volume to verify. Select the media from the Cartridges menu, and select the VOLSER to verify. Then, click **Actions** → **Select for Priority Verification**, as shown in Figure 4-90.
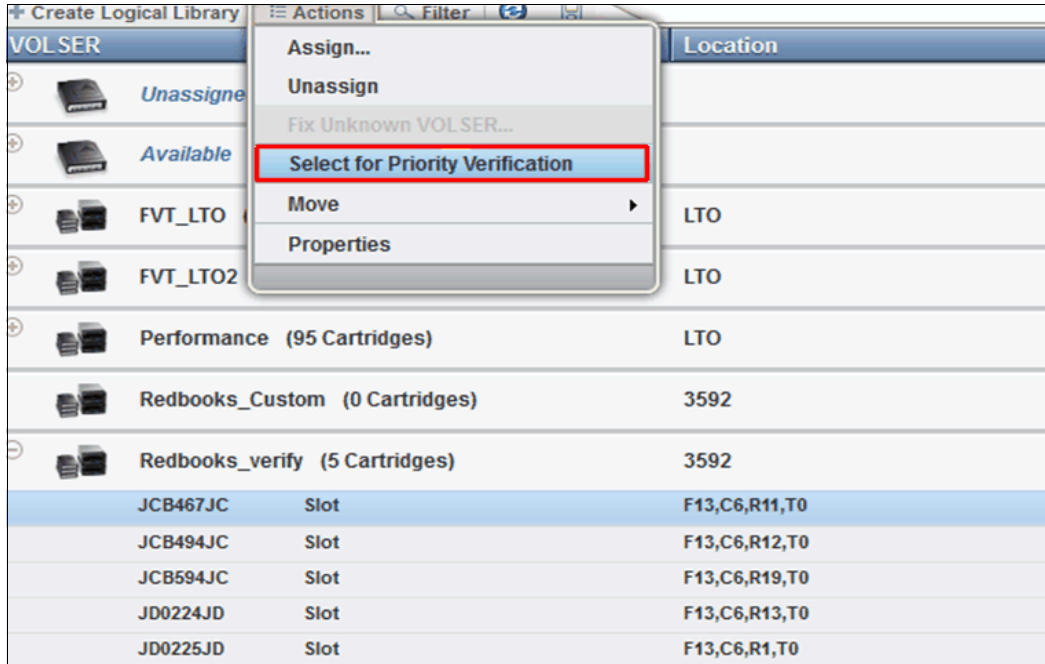
Figure 4-90   Select for Priority Verification

This selection places this tape volume next in the queue for verification. By using the Tasks menu, you can monitor and display the status of the media verification, as shown in Figure 4-91.
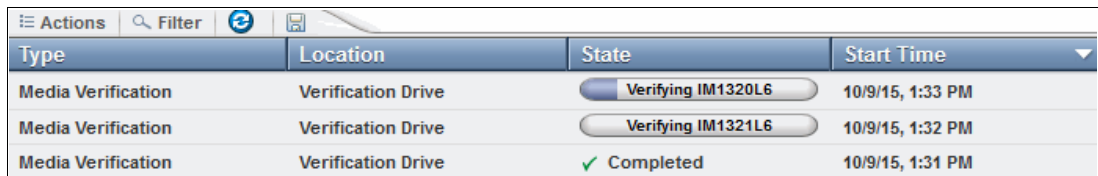
Figure 4-91   Tasks menu

You can display the status of each tape volume by selecting the tape volume and displaying its properties, as shown in Figure 4-92. The properties show the last verification date, verification result (for example, passed), and the next verification date.
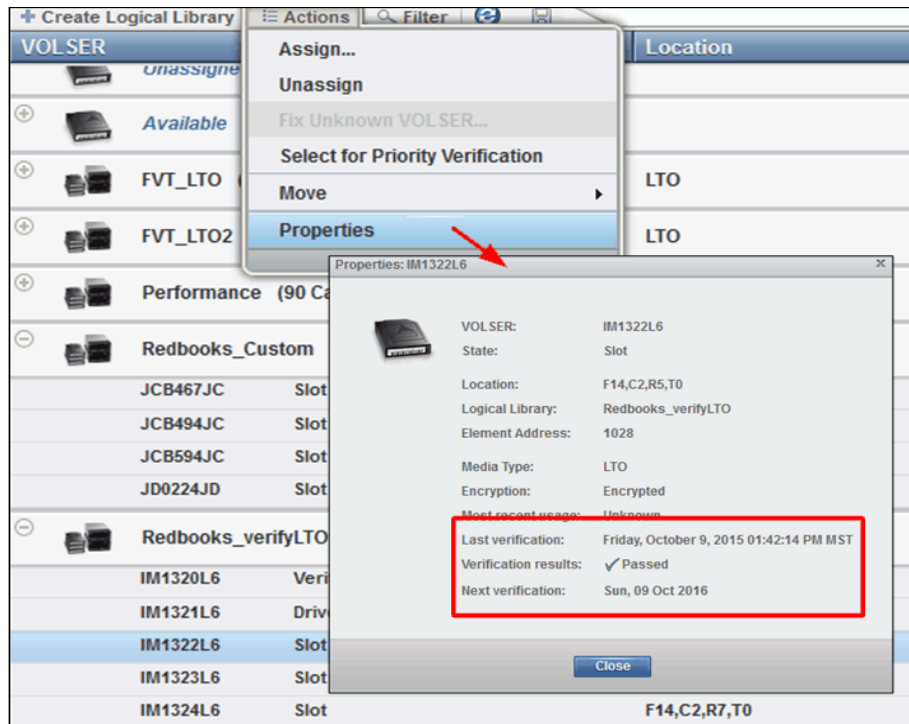
Figure 4-92   Media properties

Also, you can use the Cartridges menu to obtain the last verification date by clicking **Export Table Data** to export the table data to a spreadsheet, as shown in Figure 4-93.
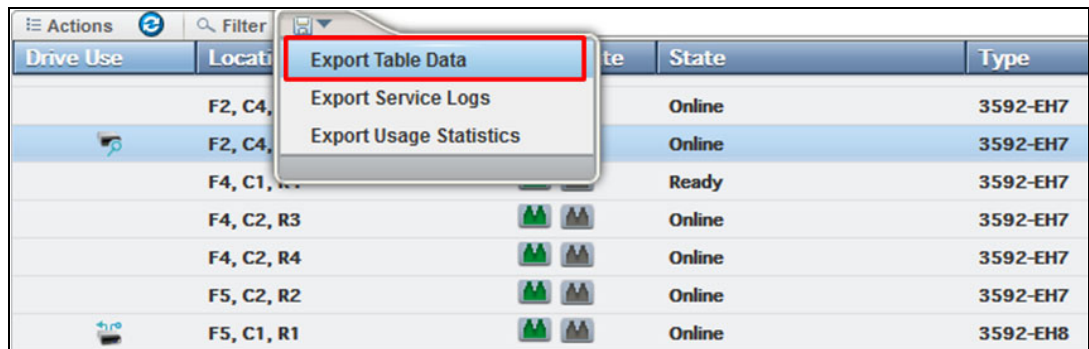
Figure 4-93   Export Table Data option

To change a drive that is assigned for media verification, select the drive in the logical library. Click **Actions** → **Use for Media Access** to set the drive for normal media access. Now, the drive is available for normal data use, as shown in Figure 4-94.
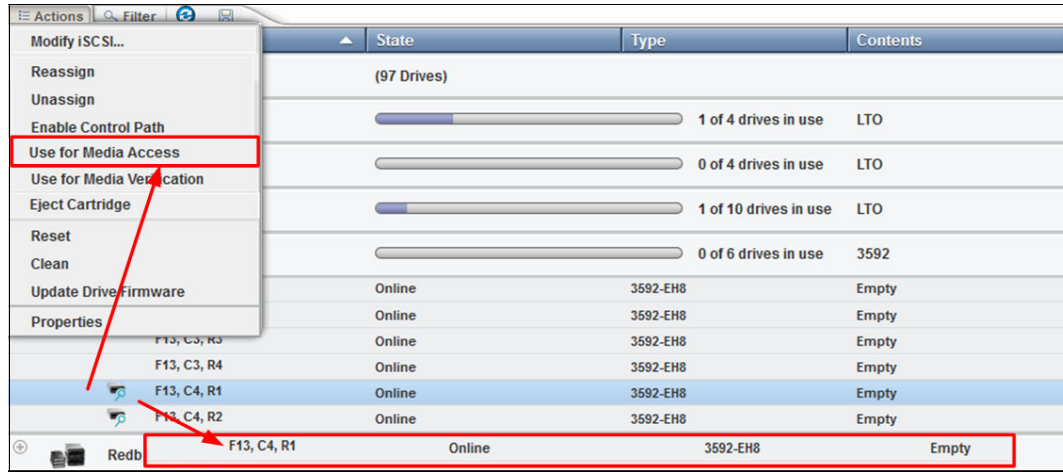
Figure 4-94   Change a verification drive to a media access drive

Control path drives

A *control path* is a logical path to the TS4500 tape library. A control path is the path for Small Computer System Interface (SCSI) Medium Changer commands that are 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.

Any drives that are enabled as control paths are identified with the icon that is shown in Figure 4-95.

Figure 4-95   Control path drive icon

To enable a control path, select the drive or drives that are to be configured, then select **Actions** → **Enable Control Path** to designate one or more drives as control path drives, as shown in Figure 4-96.
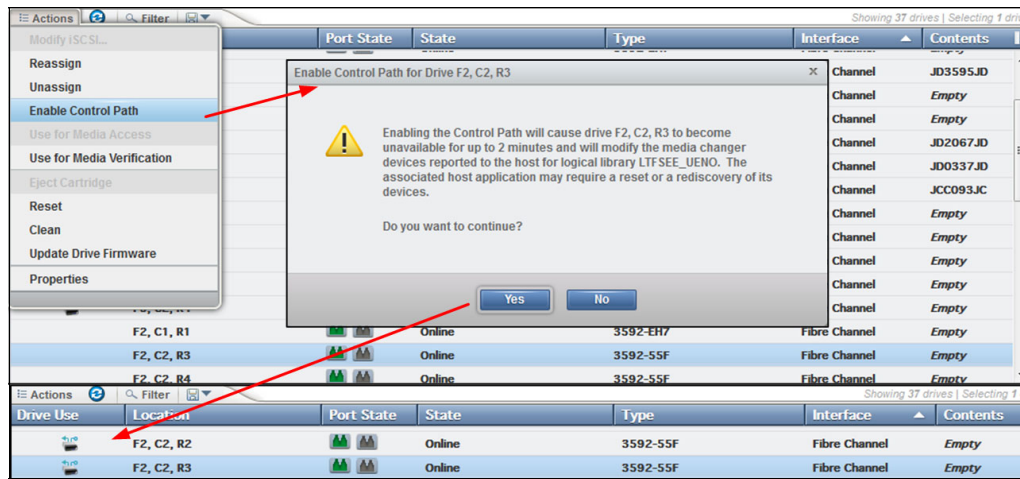
Figure 4-96   Enable Control Path

It is possible for a logical library to have no control path drives. To disable a control path, use the same method as shown in Figure 4-96, but select **Actions** → **Disable Control Path**, as shown in Figure 4-97.
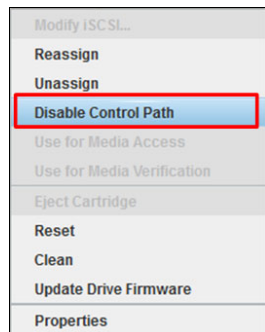
Figure 4-97   Disable Control Path

The use of multiple control paths for any single, configured logical library provides the following benefits:

► Allows access to the logical library by multiple servers
► Provides communication failover so that if one control path fails, host communication for the entire library is not lost

Note: Use the Path Failover feature (Feature Code 1682) to enable the host device driver to send a command again to an alternate control path for the same logical library.

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.

Control path drives cannot be removed from a logical library that is performing jobs. If the logical library is not actively in use, control path drives can be removed from a logical library only after all non-control path drives are removed or a different control path drive is assigned.

iSCSI drive configuration

To configure a TS1155 model 55E drive, select the drive or drives that are to be configured, then select **Actions** → **Modify iSCSI** and the configuration entry window will display, as shown in Figure 4-98.
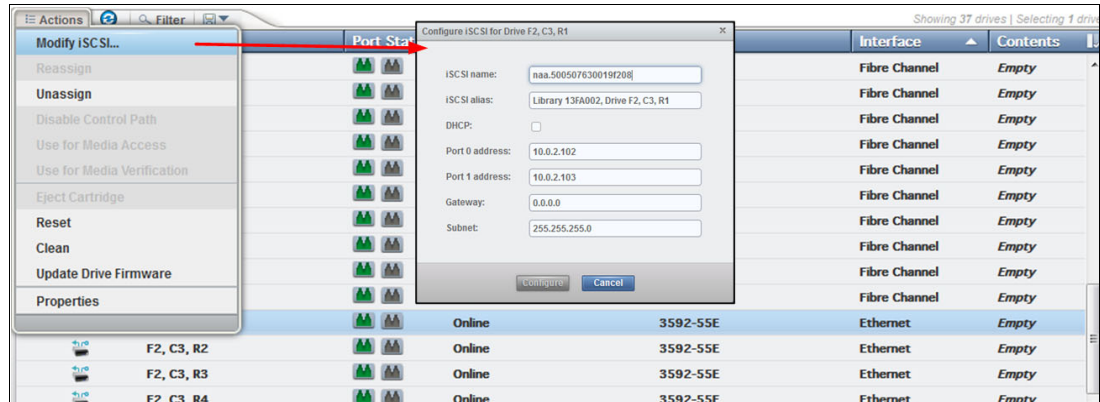
Figure 4-98   Ethernet drive configuration

A window is displayed where you can modify or add fields, such as:

► Modify the iSCSI name for this drive, this is a unique name such as an iSCSI qualified name (IQN) for each drive. The target iSCSI name has a maximum of 223 chars and has a default of naa,driveWWNN.

► Modify the iSCSI alias, which is a name given to the drive and associated to the iSCSI name and is used to give a user defined name to the drive such as library serial number and drive position. This field makes managing the drive easier.

► DHCP or static IP address can be used. If DHCP is used then the IP address does not need to be added.

► Static IP address, gateway, and network mask can be added for each drive, or for a range of drives.

To configure all drives IP address information at the same time, select all drives that are to be configured, then select **Actions** → **Modify iSCSI.** The window, shown in Figure 4-99 will display and you can enter the starting IP address for the drive port and all drives will be configured starting at this address.
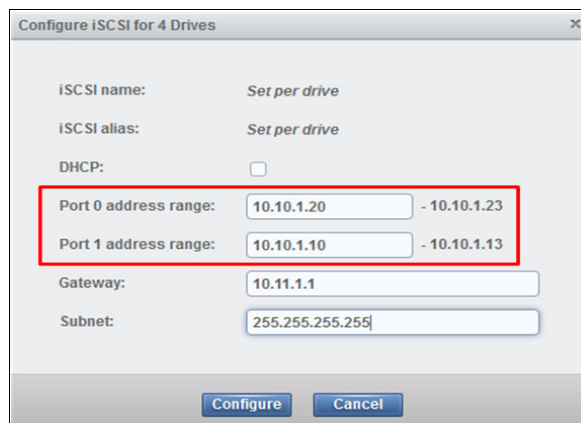
Figure 4-99   Setting range of SCSI address on TS1155 55E

CHAP can be configured for secure communications on these ports, as shown in section "iSCSI" on page 174.

To display the current drive settings, select the drive then **Actions** → **Properties,** the current drive settings and properties will be displayed, as shown in Figure 4-100.
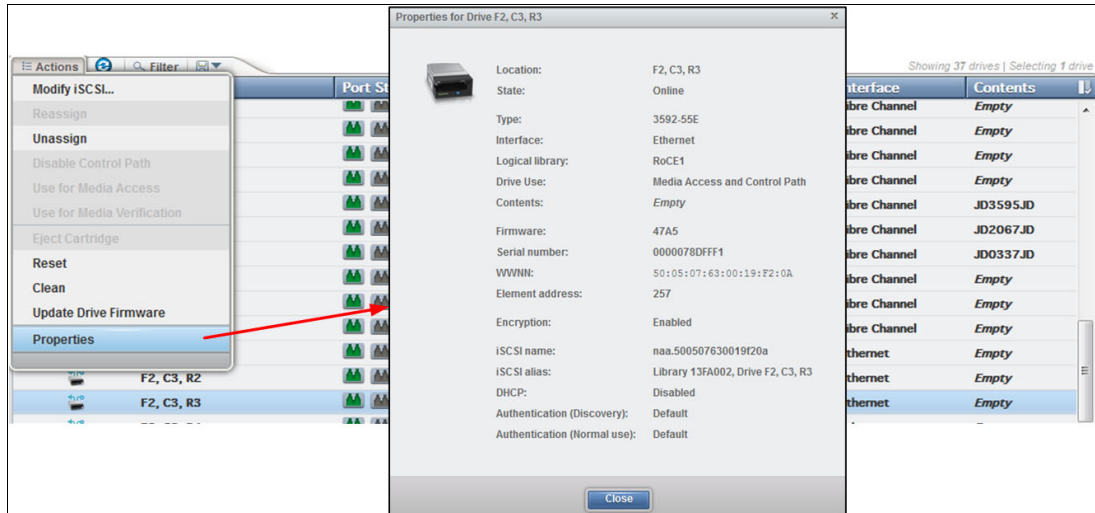
Figure 4-100   Ethernet drive property display

Resetting a tape drive

You can reset a drive by using the Drives by Logical Library page. Select the drive. Then, select **Actions** → **Reset**, as shown in Figure 4-101. The drive is unavailable for up to 4 minutes.
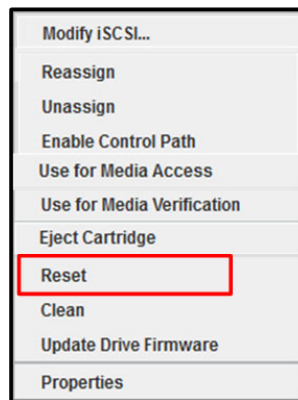
Figure 4-101   Reset the drive

Cleaning tape drives

The TS4500 tape library automatically cleans tape drives, as needed. However, you also can initiate a manual cleaning from the Drives page (Figure 4-102). Select **Actions** → **Clean**.

Figure 4-102   Clean a drive

A valid cleaning cartridge is required for cleaning drives. Monitor cleaning cartridge usage from the Cartridges page. See "Viewing cleaning cartridge status" on page 220.

Updating drive firmware

When you use this action, as shown in Figure 4-103, you can select one drive to update or you can update multiple drives of the same media type simultaneously with the firmware level that was uploaded. A drive is updated even if it is running a firmware level that is later than the version of drive code that was uploaded.
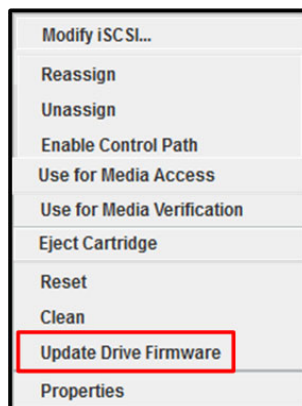
Figure 4-103   Update Drive Firmware

You can update drive firmware on one drive or multiple drives at one time. Any drives that are selected on the Drives page are updated with the firmware level that was uploaded. It is possible to install firmware levels that are earlier than the version that the drive is running.

To avoid disrupting the host, control path drives are updated when they are reset. All other drives are updated when the drive is unloaded. Control path drives must be manually reset to use the uploaded firmware level.

Procedure to update drive firmware

Obtain the drive firmware package on your workstation from IBM Fix Central:

http://www.ibm.com/support/fixcentral/

From the Drives page of the TS4500 management GUI, select one or more drives, and then, click **Actions** → **Update Drive Firmware**, as shown in Figure 4-103 on page 239. The File Upload window opens. Browse to the drive firmware image and click **Open**.

> **Note:** The LTO 8, 7, 6, and 5 drive firmware image file is named `LTOZ_xxxx.fcp_fh.ro` where *Z* is the drive type and *xxxx* is the firmware level. The TS1100 drive firmware image file is named `xxxx_xxx.fcp_fj_D.fmrz` where *xxxx_xxx* is the drive firmware level.

Monitor the status of the update in the State column and the Firmware column of the Drives table.

Select the control path drives with a state of "Reset Required" and select **Actions** → **Reset** to reset the drives.

Exporting data, logs, and statistics

Click the **Save** icon (diskette) to see the Export Data menu to export data from the Drives table, export service logs, or export drive usage statistics. This window is shown in Figure 4-104.

Co... ▲	Location	S		Contents	Firmware	
	F1, C2, R4	O	**Export Table Data**	Empty	E4J0	
	F1, C3, R4	O	**Export Service Logs**	Empty	E4J0	
	F1, C4, R4	R	**Export Usage Statistics**	1FA314L5	E4J0	
	F2, C1, R1	Online	LTO 6	Empty	E4J0	
	F2, C2, R1	Online	LTO 6	Empty	E4J0	
	F2, C4, R2	Online	LTO 5	Empty	E4J0	
	F2, C4, R3	Online	LTO 6	Empty	E4J0	
	F2, C4, R4	Online	LTO 5	Empty	E4J0	
	F4, C2, R4	Online	LTO 6	Empty	E4J0	
	F4, C3, R1	Online	LTO 6	Empty	E4J0	
	F2, C1, R2	Online	LTO 5	Empty	E4J0	
	F3, C1, R4	Online	LTO 5	Empty	E4J0	
	F4, C1, R4	Online	LTO 6	Empty	E4J0	

Figure 4-104   Exporting data, logs, or statistics

When you export drive usage statistics, a `LIBNAME_YYYYMMDD_drive_statistics.csv` file for all of the drives is exported. This file presents the number of loads, number of megabytes read and written, and number of cleanings for each drive location.

You can use this window to export service logs from a drive to send to IBM Support, if needed. Select the drive for which you want to export the logs, and then, select **Export Service Logs** from the Export Data menu.

4.6.2 Drives by Logical Library

Use the Drives by Logical Library page to view drive assignment and usage among all logical libraries, view cleaning cartridge status, assign drives, and manage the logical libraries and their settings. This window gives you a view of the drives from a Logical Library view, as shown in Figure 4-105.

Figure 4-105   Drives by Logical Library

Monitoring drive usage

The drive usage bar indicates the current drive usage for the logical library. The number on the right of the bar is the total number of drives that is assigned to the logical library. The bar fills as a percentage of the number of drives that is in use, as shown in Figure 4-106.

Figure 4-106   Monitor drive usage
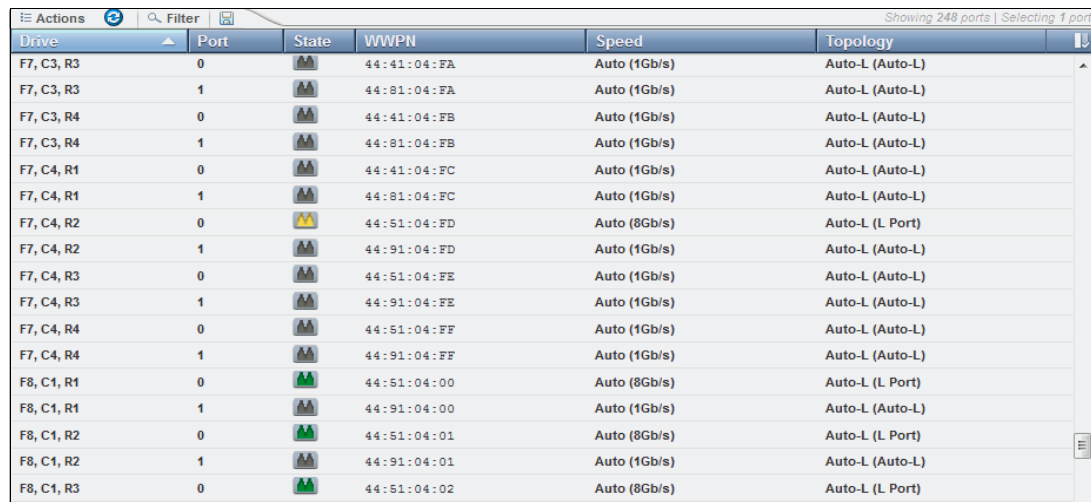
The bar turns red if all of the drives in the logical library are being used. If all of the drives are being used frequently, the logical library might be over-allocated and you need to consider adding more drives to the logical library.

The same actions can be performed on this panel as on the Drives menu. All of these functions are described in detail in 4.6.1, "Drives" on page 226.

4.6.3 Fibre Channel Ports

Use the Fibre Channel Ports option on the Drives menu, shown in Figure 4-79 on page 226, to view all of the Fibre Channel port information about drives in the library. You can view drive port status, and perform tasks, such as setting the port link speed and topology.

The selection of the Ports option on the Drives menu opens a summary page of all drives and their port status, as shown in Figure 4-107.

Drive	Port	State	WWPN	Speed	Topology	
F7, C3, R3	0		44:41:04:FA	Auto (1Gb/s)	Auto-L (Auto-L)	
F7, C3, R3	1		44:81:04:FA	Auto (1Gb/s)	Auto-L (Auto-L)	
F7, C3, R4	0		44:41:04:FB	Auto (1Gb/s)	Auto-L (Auto-L)	
F7, C3, R4	1		44:81:04:FB	Auto (1Gb/s)	Auto-L (Auto-L)	
F7, C4, R1	0		44:41:04:FC	Auto (1Gb/s)	Auto-L (Auto-L)	
F7, C4, R1	1		44:81:04:FC	Auto (1Gb/s)	Auto-L (Auto-L)	
F7, C4, R2	0		44:51:04:FD	Auto (8Gb/s)	Auto-L (L Port)	
F7, C4, R2	1		44:91:04:FD	Auto (1Gb/s)	Auto-L (Auto-L)	
F7, C4, R3	0		44:51:04:FE	Auto (1Gb/s)	Auto-L (Auto-L)	
F7, C4, R3	1		44:91:04:FE	Auto (1Gb/s)	Auto-L (Auto-L)	
F7, C4, R4	0		44:51:04:FF	Auto (1Gb/s)	Auto-L (Auto-L)	
F7, C4, R4	1		44:91:04:FF	Auto (1Gb/s)	Auto-L (Auto-L)	
F8, C1, R1	0		44:51:04:00	Auto (8Gb/s)	Auto-L (L Port)	
F8, C1, R1	1		44:91:04:00	Auto (1Gb/s)	Auto-L (Auto-L)	
F8, C1, R2	0		44:51:04:01	Auto (8Gb/s)	Auto-L (L Port)	
F8, C1, R2	1		44:91:04:01	Auto (1Gb/s)	Auto-L (Auto-L)	
F8, C1, R3	0		44:51:04:02	Auto (8Gb/s)	Auto-L (L Port)	

Figure 4-107   Ports summary

The port State column is sorted by state color (green, yellow, or gray).

The gray port status icon is shown in Figure 4-108.

Figure 4-108   Gray port status icon

The gray port status icon indicates that no light is detected at the drive's Fibre Channel port. One of the following conditions is true:

► A Fibre Channel cable is unplugged at the drive or at the nearest Fibre Channel device (host bus adapter, switch, or hub).

► A Fibre Channel cable is broken between the drive and the nearest Fibre Channel device (host bus adapter, switch, or hub).

► The drive or the nearest Fibre Channel device (host bus adapter, switch, or hub) is powered off or has a hardware problem.

The yellow port status icon is shown in Figure 4-109.

Figure 4-109   Yellow port status icon

The yellow port status icon indicates that the Fibre Channel connections between the drive and the Fibre Channel device to which it is connected (host bus adapter, switch, or hub) are good, but communication is not established and device is unable to log into the fabric or HBA, possible issues include the port on the switch is disabled or not configured correctly.

The green port status icon is shown in Figure 4-110.

Figure 4-110   Green port status icon

The green port status icon indicates that the Fibre Channel connections are good and communication is established.

The summary display shows the Speed and Topology columns, which include both the setting and the actual value in the following format: `setting (actual)`.

To modify a port setting, select the port or ports that you want to modify and select **Actions** → **Modify Speed** or **Modify Topology** from the Ports view, as shown in Figure 4-111.
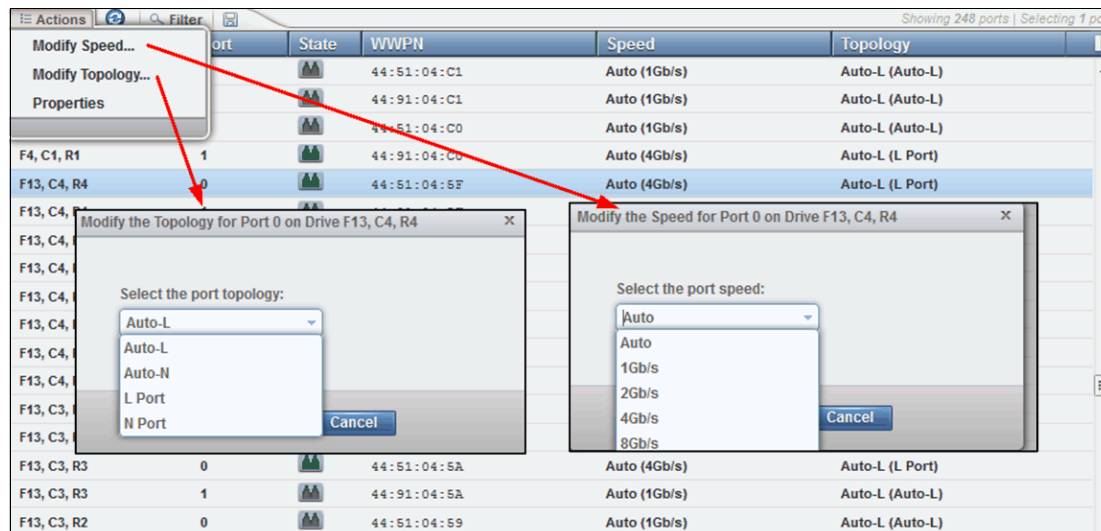
Figure 4-111   Modifying the topology and speed in the Ports view

The following setting values are valid for the topology:

► Auto-L (The drive tries Loop port (L) mode first.)
► Auto-N (The drive tries Node port (N) mode first.)
► L Port (NL)
► N Port

> **Note:** The recommended setting for topology if you are connecting to an FC switch is to use either the Auto-N or N port setting.

The following setting values are valid for the port link speed:

► Auto
► 1 Gbps
► 2 Gbps
► 4 Gbps
► 8 Gbps

From the Actions menu, you can display the properties of a port, as shown in Figure 4-112.
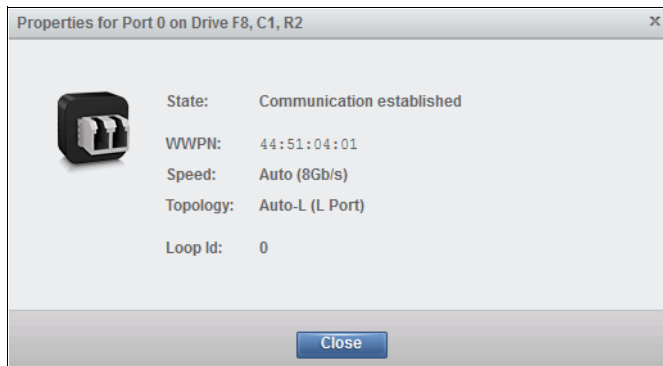
Figure 4-112   Port properties

4.6.4 Ethernet ports

Use the Ethernet Ports option on the Drives menu, which is shown in Figure 4-113, to view all of the TS1155 model 55E Ethernet port information for the drives in the library. The window shows a summary of all Ethernet drives, such as state, IP address, iSCSI details, MAC address, and speed of connection, and it cannot modify any settings.

Figure 4-113   Ethernet ports

The port State column is sorted by state color (green, yellow, or gray).

The gray port status icon is shown in Figure 4-114.

Figure 4-114   Gray port status icon

The gray port status icon indicates that no light is detected at the drive's Ethernet port. One of the following conditions is true:

► A Ethernet cable is unplugged at the drive or at the nearest Ethernet device (host bus adapter, switch, or hub).

► A Ethernet cable is broken between the drive and the nearest Ethernet device (host bus adapter, switch, or hub).

► The drive or the nearest Ethernet device (host bus adapter, switch, or hub) is powered off or has a hardware problem.

The green port status icon is shown in Figure 4-115.

Figure 4-115   Green port status icon

The green port status icon indicates that the Ethernet connections are good and communication is established.

The summary display shows information on all Ethernet drives, such as state, IP address, iSCSI details, MAC address and speed of connection.

From the Actions menu, you can display the properties of a port, as shown in Figure 4-116.

Properties for Port 0 on Drive F2, C3, R1   ✕

Drive:	F2, C3, R1
Port:	0
State:	Port initialization complete
IP address:	10.0.2.102
DHCP:	Disabled
iSCSI Name:	naa.500507630019f208
iSCSI Alias:	Library 13FA002, Drive F2, C3, R1
Gateway:	0.0.0.0
Subnet:	255.255.255.0
MAC Address:	00-1a-64-ea-04-83
Speed:	10 Gbps
Authentication (Discovery):	Disabled
Authentication (Normal use):	Disabled

Close

Figure 4-116   Ethernet port properties

4.7 Library menu

Use the TS4500 management GUI page under the Library icon to view or manage the logical libraries, as shown in Figure 4-117.

Figure 4-117   Library menu

> **Note:** The Slots option is only available if the user logged in by using the service user ID or if the user has service-level access.

4.7.1 Advanced Library Management System

Advanced Library Management System (ALMS) is an extension of the IBM patented Multi-Path Architecture. With ALMS, the TS4500 tape library can virtualize the locations of cartridges (called *SCSI element addresses*) while it maintains the native storage area network (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 to assign 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 affecting host applications.

ALMS offers the dynamic management of cartridges, cartridge storage slots, tape drives, and logical libraries. It enables the TS4500 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 the logical drive allocation.

ALMS provides the following capabilities:

► Dynamic partitioning (storage slot pooling and flexible drive assignment)
► Transparent capability to add or remove storage capacity to any host application
► Capability to configure drives or 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 TS4500 tape library complies with the SCSI Medium Changer standard. ALMS is not apparent to the application. The SCSI Medium Changer can be thought of as a "location-centric" interface. The application that is controlling a SCSI Medium Changer device specifies a source and destination location for each request to move a cartridge. The traditional SCSI library does not have control of the cartridge locations. Instead, the SCSI library acts on behalf of the server.

Functional description

This section provides a functional description of the ALMS features.

Storage slot virtualization

The host view of a cartridge location is known as the *SCSI storage element address*. Without ALMS, the storage element address maps directly to a specific storage slot after the library is configured. With ALMS enabled, a specific storage element address is no longer associated with a specific storage slot. Instead, storage slots are virtualized by dynamically associating them with element addresses, as required.

An element address is associated with a storage slot that is selected by the library, as cartridges are moved and inventoried. If a storage element is empty because of a move, that source element address becomes unsolicited. The association of storage element addresses occurs in a way that is transparent to the application software.

You can select the number of storage element addresses for a logical library (as reported to the host application software) by changing the Maximum Number of Cartridges setting for that logical library with the TS4500 management GUI. For each logical library, the default value for this setting is the number of addressable storage slots that is installed in the library for that cartridge type when ALMS is first enabled or after ALMS is enabled when the logical library is created.

You can change the Maximum Number of Cartridges setting for each logical library, but the value must always be greater than or equal to the number of cartridges that is assigned to that logical library. The Maximum Number of Cartridges can be set to a value that is higher than the number of addressable storage slots that is installed at the time to allow future library capacity expansion to not be apparent to the host application software. However, application performance might degrade slightly because of the greater number of addresses. Be careful to not exceed the license limitations of the host application software.

Drive assignment

By using the ALMS flexible drive assignment capability, any drive in any position within any frame can be assigned to any logical library without creating any gaps in drive addresses. Drive (data transfer) element addresses are still mapped to specific drive locations when the drive is assigned. Any drive location can be assigned to any logical library by using the TS4500 management GUI. Each drive that is added to a logical library is assigned to the lowest available element address, regardless of the drive location.

> **Note:** The intermix of models is supported within the same logical library, but only for drives of the same type. LTO drives cannot be mixed with 3592 drives, and 3592 drives cannot be mixed with LTO drives.

ALMS is enabled by default on the TS4500, and the data terminal equipment (DTE) addresses for any newly installed and assigned drives do not depend on the positions of the drives. The DTE address for any newly installed or assigned drive is determined by the sequence in which the drive is assigned to each logical library. With ALMS, drives are assigned to logical libraries by using the Drives by Logical Library page to assign a tape drive to a logical library on the Management Interface (MI).

With this interface, the DTE address for the first drive that is assigned to a new logical library is 256 (x'101'), as shown in Figure 4-118. The DTE address for any other drive that is assigned to a logical library is based on the next available DTE address in that particular logical library. The next available DTE address is the lowest-available DTE address after the starting DTE address. This address fills any gaps that are created when drives are unassigned and removed from a logical library.

When a drive is unassigned from a logical library by using the web interface, only that DTE address is made available for future usage. No other DTE addresses are affected.
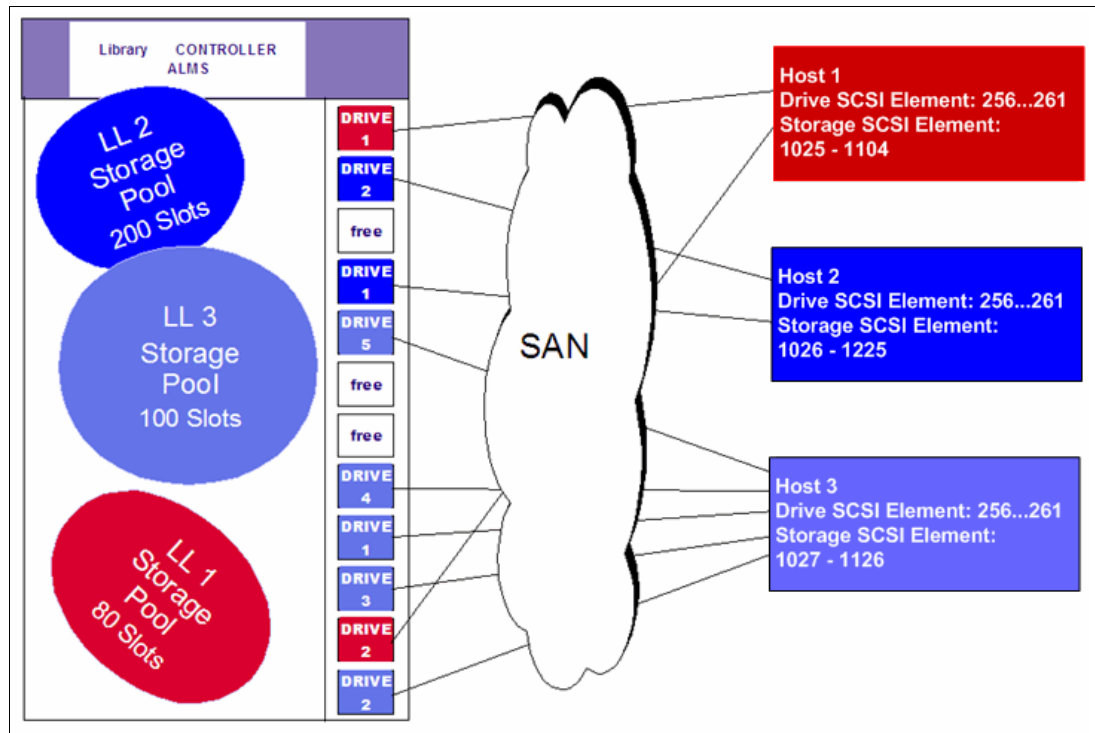
Figure 4-118   TS4500 tape library with ALMS

Storage slot pooling

ALMS allows logical libraries to be added or deleted without disrupting operations. 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 so that changes to the capacity allocation for each logical library can occur without downtime or administrator involvement.

The minimum logical library has a name only and it can be thought of as a file folder that has no contents. Drives are assigned to the logical library from the Drives page of the TS4500 management GUI. Cartridges are assigned to the logical library based on their VOLSERs and by using one of the following methods, which are listed in priority order:

► VOLSER ranges
► Software application moves 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 the VOLSER assignment and physical location of cartridges are stored in *nonvolatile random access memory* (NVRAM).

Assigning VOLSER ranges

You can assign specific cartridges to each logical library based on their VOLSERs. With the TS3500 tape library, this function was known as the *Cartridge Assignment Policy*.

All cartridge assignments are displayed on the VOLSER range bar. As you create logical libraries and assign VOLSER ranges, any cartridges that are not part of those ranges remain unassigned. View or assign unassigned cartridges on the Cartridges page.

When you insert a cartridge into the library and its VOLSER is within a range that is assigned to a certain logical library, the cartridge is assigned to that logical library. The cartridge must be of the same media type as that logical library. For example, if you create `Logical Library 1` for VOLSERs that range from `ABC000` to `ABC999` (a library of LTO drives) and then you insert a cartridge with VOLSER `ABC123`, the library recognizes that VOLSER as belonging to the range and assigns it to `Logical Library 1`.

If you insert a cartridge that is outside of any VOLSER ranges, it is available to import into any logical library of the same media type. The assignment is then determined by the first application to import the cartridge.

You can view all of the VOLSER ranges if you select **Actions** → **View VOLSER ranges**. You can also view all VOLSER ranges that are assigned to each logical library on the VOLSER Ranges by Logical Library page.

Virtual I/O

With ALMS, virtual I/O slots enhance the import and export capabilities of the library. With the TS4500 tape 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 so that you can 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, enhancing import and export performance, while also decoupling physical cartridge movement from the application, increasing operator efficiency.

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.

The VIEE temporarily takes on the attributes of an IEE until a host moves the cartridge into a *storage element* (StE). When the host move occurs, if the cartridge is in a storage slot, no physical move is needed and the element changes from a VIEE to an StE. Similarly, when a host exports a cartridge from an StE, the physical storage slot is reported as a VIEE without moving the cartridge to the I/O station. The library monitors when free space is available in the I/O station and moves exported cartridges when it is convenient for the library.

If a cartridge cannot be assigned, this situation is reported as `Assignment Pending`. This situation can occur if the assigned logical library does not have any available VIEE slots, or if all of the logical libraries do not have a common VIEE to share. To resolve this situation, free VIEE addresses so that they are available in all libraries or make a specific assignment of this cartridge to a logical library.

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. However, often it is advantageous to be able to share a single library between heterogeneous or homogeneous applications. Certain applications (and certain servers) do not allow sharing a library between systems.

With the TS4500 tape library, 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. With the TS4500 tape library, you can also create configurations that enable the library to process commands from multiple *homogeneous* applications, for example, the same application that is run by several System p servers.

Use the TS4500 management GUI to perform the following actions.

Separate libraries to separate applications

Configure the library so that it is partitioned into separate logical libraries that independently communicate with separate applications through separate control paths. This configuration (example 1 in Figure 4-119) requires no special capabilities from the server or application.
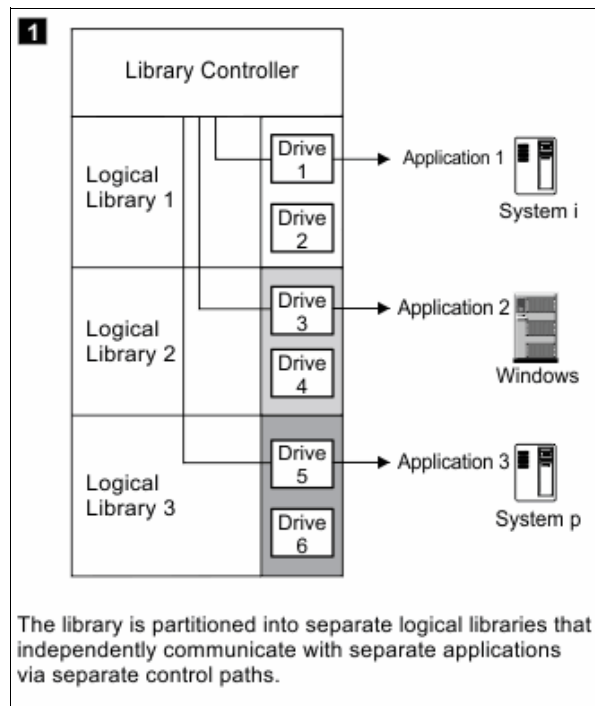
Figure 4-119   Separate libraries to separate applications

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, several ways exist to set up this type of configuration. The following methods are typical examples:

► One server to a single control path
► All servers to a single control path
► Multiple servers through multiple control paths

One server to a single control path

Configure 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 (example 2 in Figure 4-120). This configuration is used by IBM Spectrum Protect.
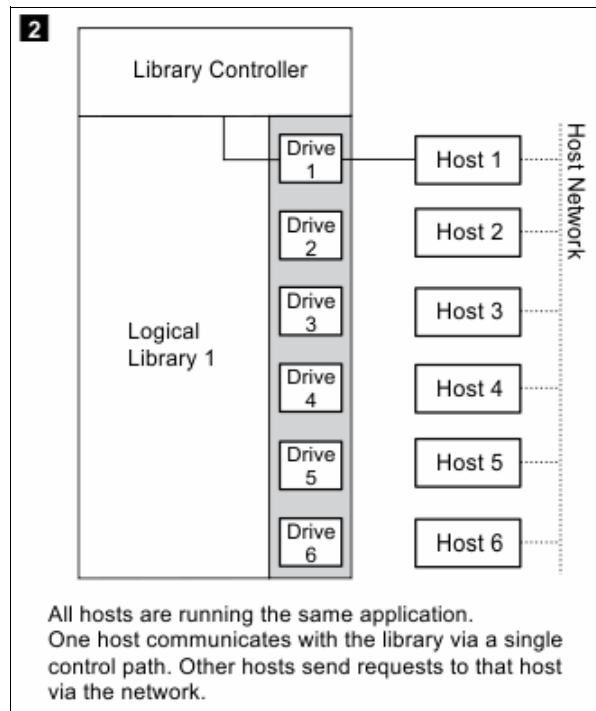
Figure 4-120   Separate libraries to separate applications

All servers to a single control path

Configure all of the servers to communicate with the library through a single, common control path (example 3 in Figure 4-121). This configuration is used in high-availability environments, such as IBM High Availability Cluster Multi-Processing (IBM 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 vendor.
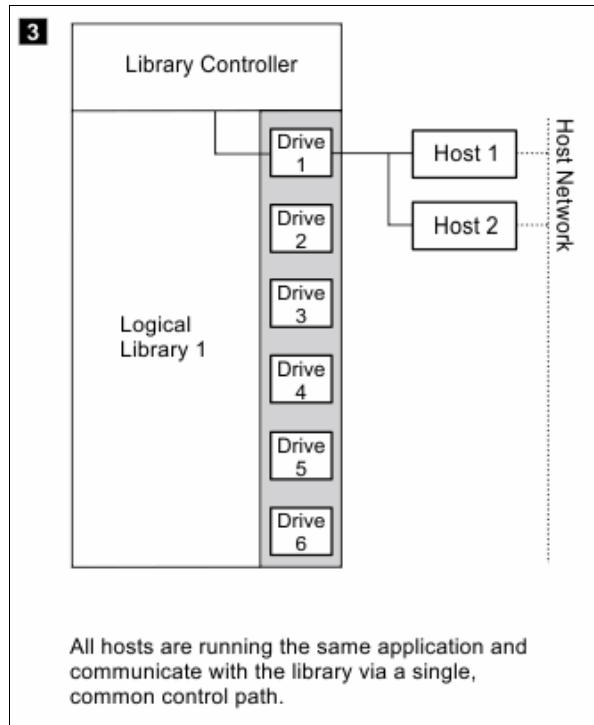
Figure 4-121   Separate libraries to separate applications

Multiple servers through multiple control paths

Configure multiple logical libraries to communicate with multiple servers through multiple control paths. This configuration (Figure 4-122) requires that you add multiple logical libraries, and it is used by separate Backup, Recovery, and Media Services.
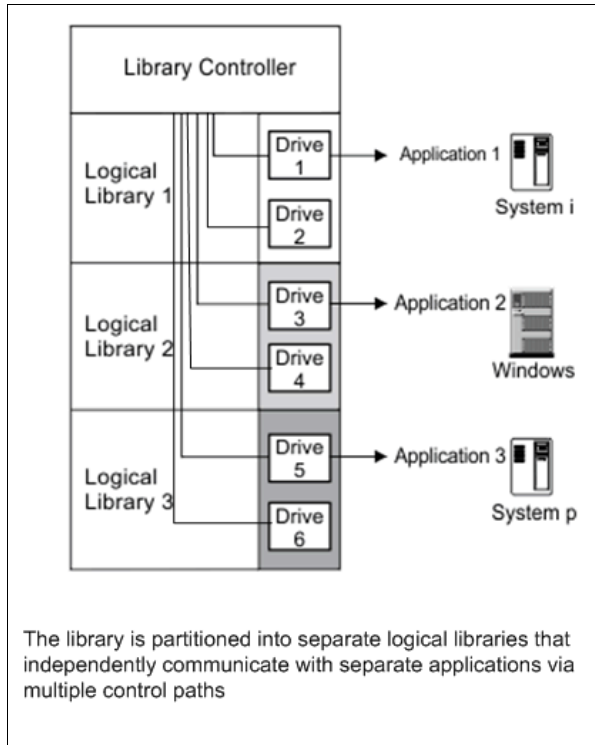
Figure 4-122   Separate libraries to separate applications

Your library configuration is not limited to these examples. Many configurations are possible and you can design them according to your business needs.

4.7.2 Create Logical Library window

Use this page to manage and reconfigure logical libraries, including modifying the method of encryption that is used on the logical library. Figure 4-123 shows a list of already configured libraries and the window that is used to set the columns of information to display.
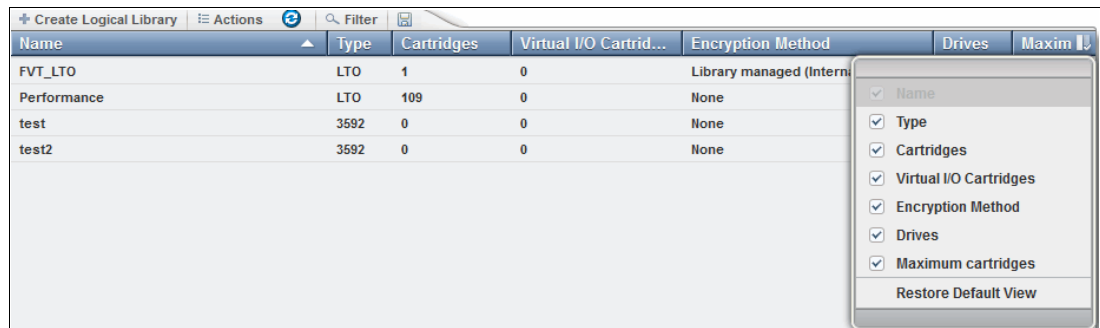
Figure 4-123   Logical Library main window

Using 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 these components:

► 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 drives, 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.

Note: When you name logical libraries, develop an enterprise-wide standard or convention for naming libraries for easier management of the libraries.

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

You can create multiple logical libraries by partitioning the physical library's tape drives and tape cartridges into two or more logical libraries. Each logical library can contain only one media type.

Creating logical libraries

Create logical libraries by using presets that have the preferred drive and encryption configurations for their specific use. Select the **Create Logical Library** tab to see a selection of default logical library options, including a custom option, as shown in Figure 4-124.

Figure 4-124   Create Logical Library

Spectrum Protect

Use this option if you manage your library with Spectrum Protect.

When you select this option, between two and four of the drives that are assigned to the logical library are designated as control path drives. When possible, two consecutive drives are assigned as control paths in two separate frames. This selection configures all unassigned drives to this logical library.

To configure a logical library by using the Spectrum Protect option, select the **Spectrum Protect** icon, then define a name, select the media drive type (LTO or 3592), and select the encryption method to use. If necessary, enter the VOLSER range to use with this logical library in the Identifier field, and select **Create**, as shown in Figure 4-125.
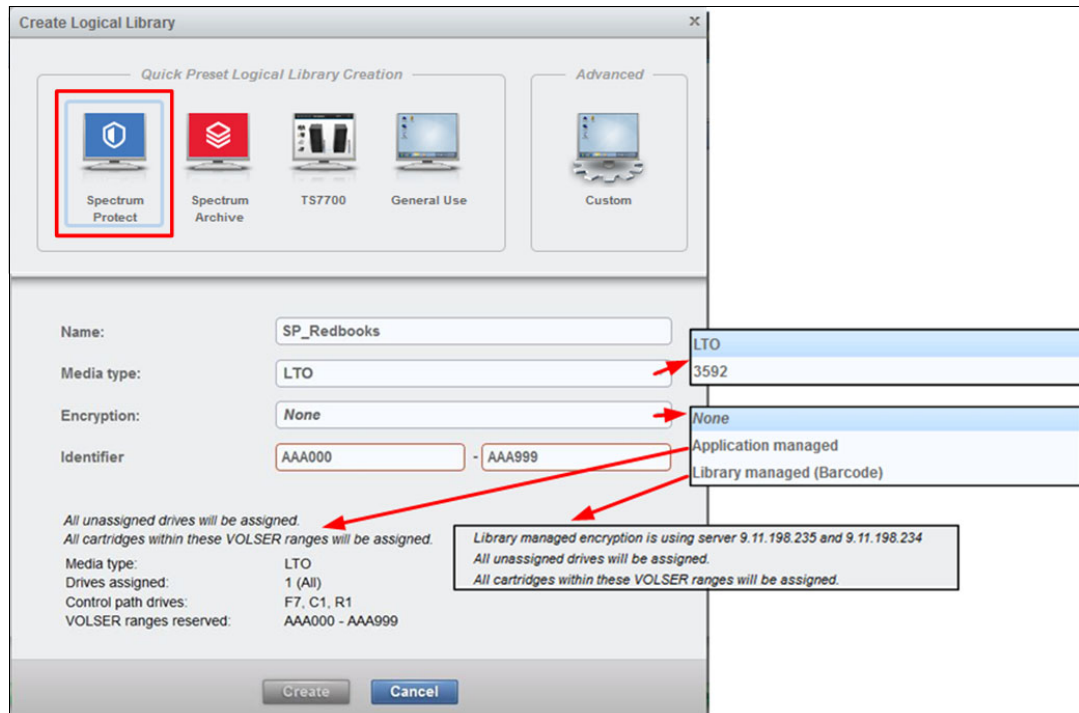
Figure 4-125   Logical library with Spectrum Protect

If library-managed encryption is used, the key server can be set up in the security option that is described in "Encryption key servers" on page 194. And, the key server can be added by using the Modify Encryption Method option from the Actions menu, as shown in "Modify Encryption Method" on page 262.

To change drive assignments or control paths, see 4.6.1, "Drives" on page 226.

IBM Spectrum Archive

Use this option if you plan to use IBM Spectrum Archive, incorporating the Linear Tape File System (LTFS) format standard for reading, writing, and exchanging descriptive metadata on formatted tape cartridges.

When you select this option, between two and four of the drives that are assigned to the logical library are designated as control path drives. When possible, two consecutive drives are assigned as control paths in two separate frames. This selection configures all unassigned drives to this logical library.

To configure a logical library by using the Spectrum Archive option, select the **Spectrum Archive** icon, then define a name, select the media drive type (LTO or 3592), and select the encryption method to use, if needed. Insert the VOLSER range to use for this logical library in the Identifier field and select **Create**, as shown in Figure 4-126.
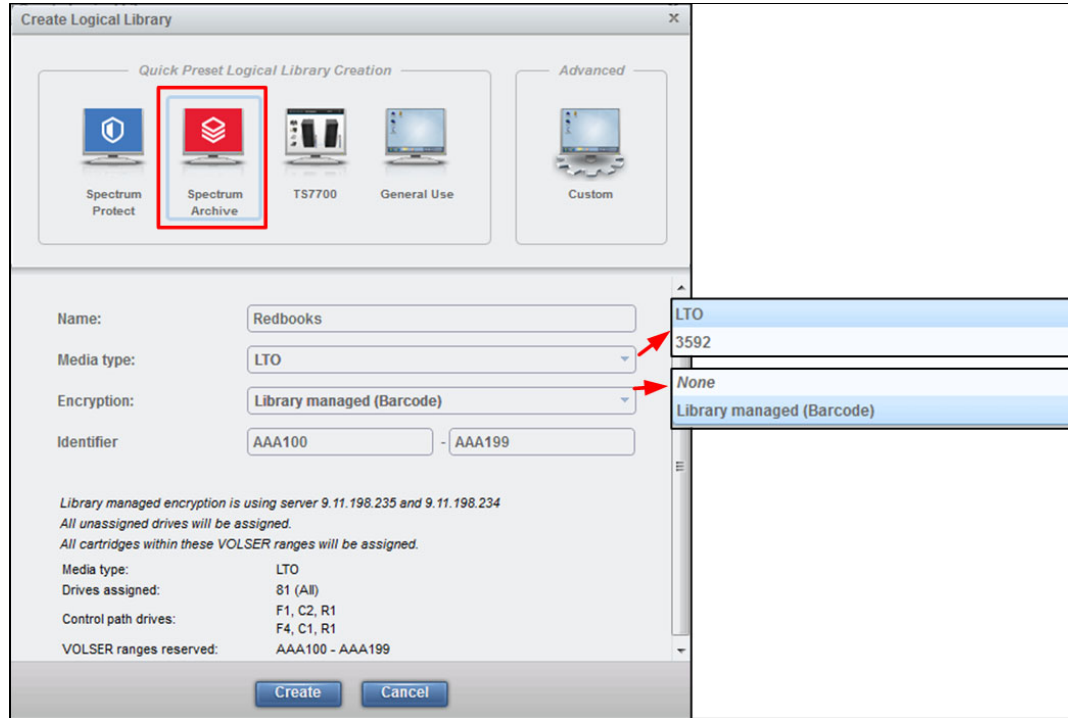
Figure 4-126   Logical library with IBM Spectrum Archive

If library-managed encryption is used, the key server can be set up in the security option that is described in "Encryption key servers" on page 194. The key server can be added by using the **Modify Encryption Method** option from the **Actions** menu, as shown in "Modify Encryption Method" on page 262.

To change drive assignments or control paths, see 4.6.1, "Drives" on page 226.

TS7700

Use this option to create a logical library for the IBM Virtualization Engine TS7700 by using all unassigned 3592 tape drives. When you select this option, up to four of the drives that are assigned to the logical library are designated as control path drives. When possible, drives are assigned as control paths in two separate frames for redundancy. The TS7700 option is shown on Figure 4-127.
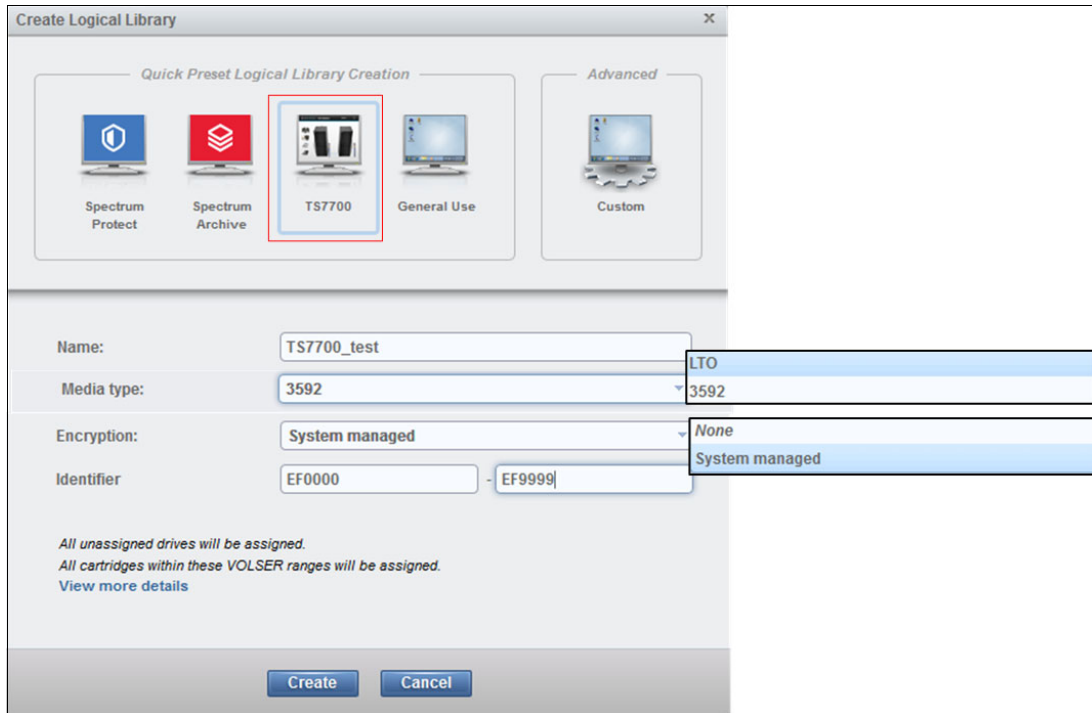
Figure 4-127 Logical Library for TS7700

Note: The TS7700 is only supported by 3592 drive types, and the encryption method must be set to **System managed**. The TS7700 must run R4.0 or higher microcode.

General Use

Use the **General Use** option if you have another application to manage your TS4500 tape library and you want to use the default options.

When you select this option, one of the drives that is assigned to the logical library is designated as a control path drive. This selection will configure all unassigned drives to this logical library.

To configure a logical library by using the General Use option, select the **General Use** icon, then define a name, select the media drive type (LTO or 3592), and select the encryption method to use, if needed. Insert the VOLSER range to use for this logical library in the Identifier field and select **Create**, as shown in Figure 4-128.
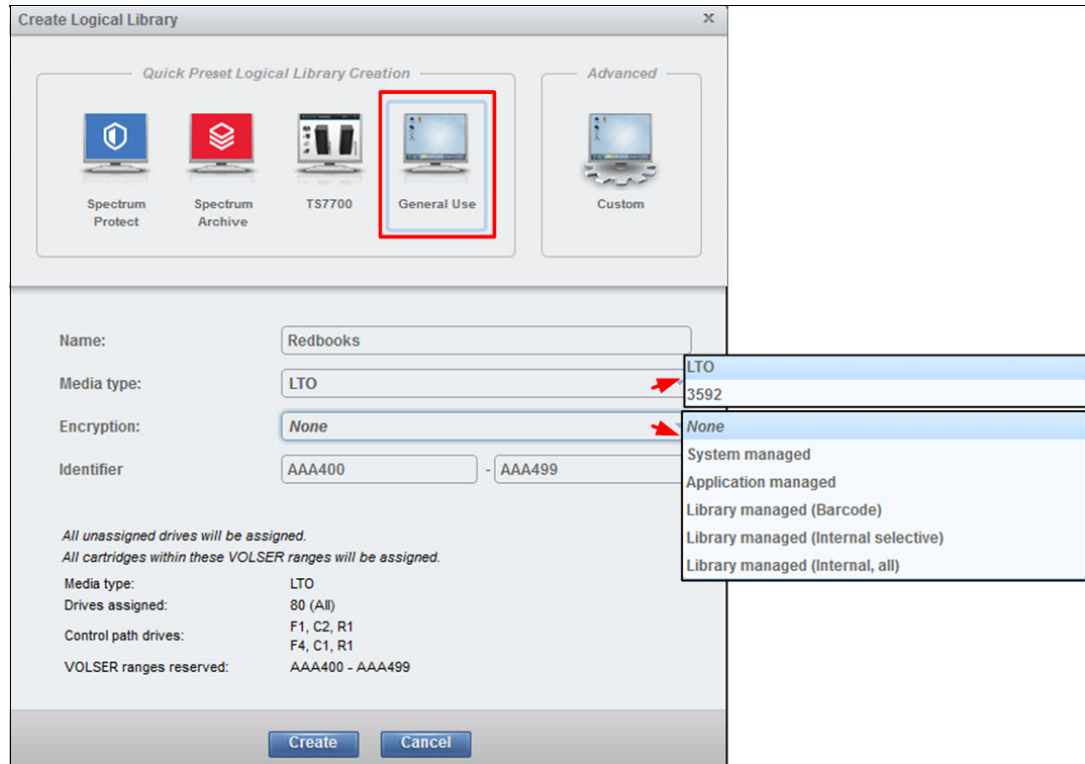
Figure 4-128   Logical library with General Use option

Custom

Use this option for a complete customization when you create a logical library if the presets do not fit your requirements. Use the Custom option to set library information and select the drives, VOLSER range, and maximum number of cartridges. Use this option if you are setting up multiple logical libraries.

Follow these steps to use the Custom option:

1. Select the number of drives and slots to use for the logical library that you are configuring. Figure 4-129 shows the initial menu after you select **Custom**. Additionally, you can select the drive assignments, VOLSER range, maximum cartridges, and summary.
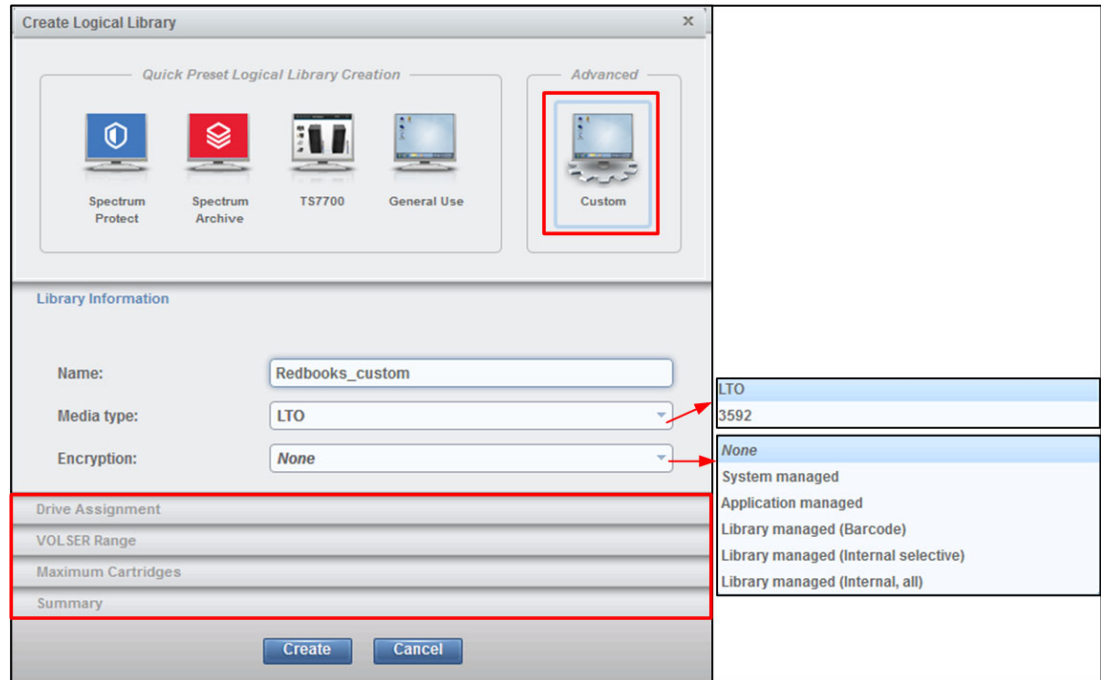
Figure 4-129   Custom logical library

2. Use the first window to define a name, select the media drive type (LTO or 3592), and select the encryption method to use, if required.

3. Use the Drive Assignment page to configure drives for the logical library, as shown in Figure 4-130. You can select all unassigned drives or select only the drives that you need. Only the unassigned drives of the type that was selected (LTO or 3592) are displayed.
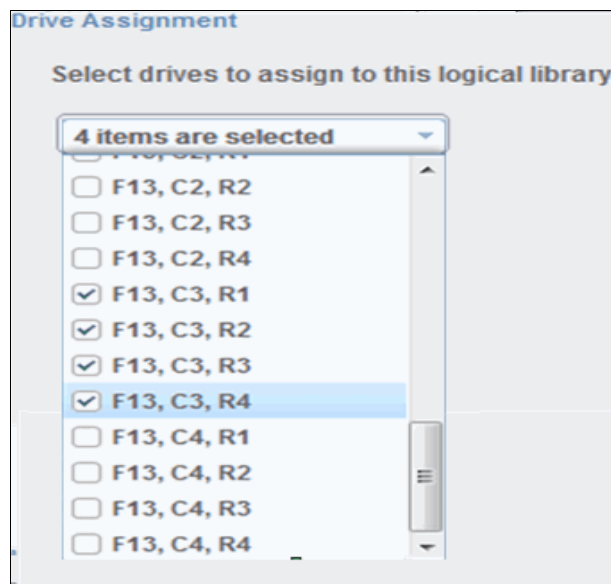
Figure 4-130   Custom drive settings

4. Use the VOLSER Range page to set up a VOLSER's range and select whether these range settings apply to only newly inserted cartridges, as shown in Figure 4-131.

Figure 4-131   Custom VOLSER range

5. Use the Maximum Cartridges page to set the number of cartridge slots that is assigned to this logical library. Also, you can use this page to configure the number of slots by using the system default, as shown in Table 4-132. The system default is the total number of slots that is licensed in the library.

Figure 4-132   Custom maximum cartridges

6. Use the Summary page to display all of your settings, as shown in Figure 4-133.

Figure 4-133   Summary

Assigning tape drives to a logical library

Each logical library requires at least one tape drive as a control path drive. Assign additional tape drives, as needed, to improve performance. Enable or disable control path drives on the Drives page, as described in "Adding or removing tape drives" on page 227.

Drives are assigned to logical libraries when the logical libraries are created. You can modify the drives that are assigned to a logical library on the Drives by Logical Library page, as shown in "Reassigning a drive" on page 228.

Note: A tape drive can be used only by the logical library to which it is assigned. Drives cannot be shared between logical libraries.

Assigning cartridges to a logical library

Cartridges are assigned to logical libraries based on the VOLSER range that is assigned to the logical library when it is created. For more information, see "Assigning VOLSER ranges". You can modify the cartridges that are assigned to a logical library by modifying the VOLSER range in "Creating or modifying a VOLSER range" on page 224.

Note: Cleaning cartridges are shared among the logical libraries.

Assigning VOLSER ranges

You can assign specific cartridges to each logical library based on their volume serial (VOLSER) numbers. With the TS3500 tape library, this function was known as the *Cartridge Assignment Policy.*

All cartridge assignments are displayed on the VOLSER range bar. As you create logical libraries and assign VOLSER ranges, any cartridges that are not part of those ranges remain unassigned. View or assign unassigned cartridges on the Cartridges page, which is described in 4.5.1, "Cartridges" on page 210.

When you insert a cartridge into the library and its VOLSER is within a range that is assigned to a certain logical library, the cartridge is assigned to that logical library. The cartridge must be the same media type as the media type of that logical library. For example, if you create `Logical Library 1` for VOLSERs that range from `ABC000` to `ABC999` (a library of LTO drives), and then you insert a cartridge with VOLSER `ABC123`, the library recognizes that VOLSER as belonging to the range and assigns it to `Logical Library 1`.

If you insert a cartridge that is outside of any VOLSER ranges, the cartridge is available to import into any logical library of the same media type. The assignment is then determined by the first application to import the cartridge.

You can view all of the VOLSER ranges by selecting **Actions** → **View VOLSER ranges**. You can also view all VOLSER ranges that are assigned to each logical library on the VOLSER Ranges by Logical Library page, as shown in 4.5.2, "Cartridges by Logical Library" on page 219.

Create Logical Library Actions menu

After a logical library is configured, you can use the **Actions** menu to select a configured logical library and modify it. Figure 4-134 shows this menu.
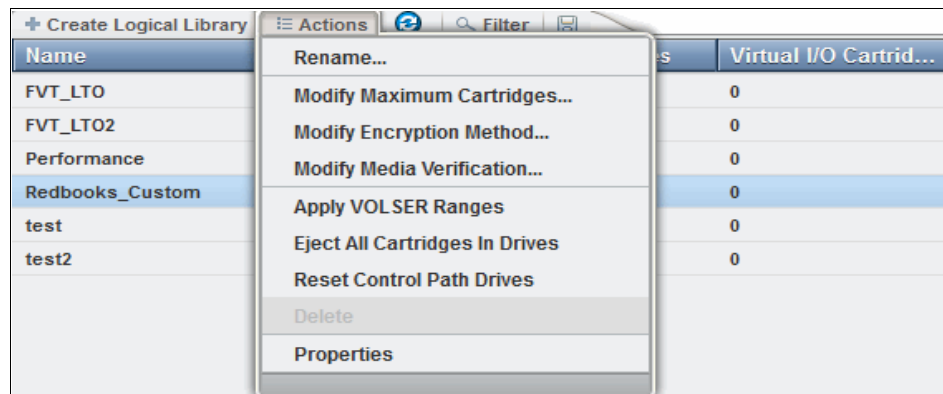
Figure 4-134   Logical Library Actions menu

Rename

Use the **Rename** option on the **Actions** menu to rename a logical library.

Select the logical library. Click **Actions** → **Rename**. The Rename window opens and you can enter a new logical library name.

Modify Maximum Cartridges

Use the Modify Maximum Cartridges option on the Actions menu to modify the maximum number of cartridges that is configured in a logical library. If a logical library ran out of storage capacity or new frames were added, this option can be used to increase or decrease the logical library cartridge capacity.

Select the logical library and click **Actions** → **Modify Maximum Cartridges**. The Modify Maximum Cartridges window opens and you can modify the number of cartridge slots for the logical library. If you added a storage frame, you can also use the "Reset to system default" option, which automatically enters the full licensed capacity of all slots in the physical library.

Modify Encryption Method

Use the Modify Encryption Method option on the Actions menu to modify the encryption method and to configure the EKM servers to use on a logical library.

Select the logical library, and click **Actions** → **Modify Encryption Method**. The Modify Encryption Method window opens so that you can set up or remove encryption from the logical library. With library-managed encryption, you can use the Modify Encryption Method page to set the EKM server IP address to use on this logical library. A drop-down list shows all of the already configured EKM servers.

You can add up to four servers to the logical library, as shown on Figure 4-135. You can use this page to add a new unlisted EKM server IP address and to test it by clicking **Ping**.
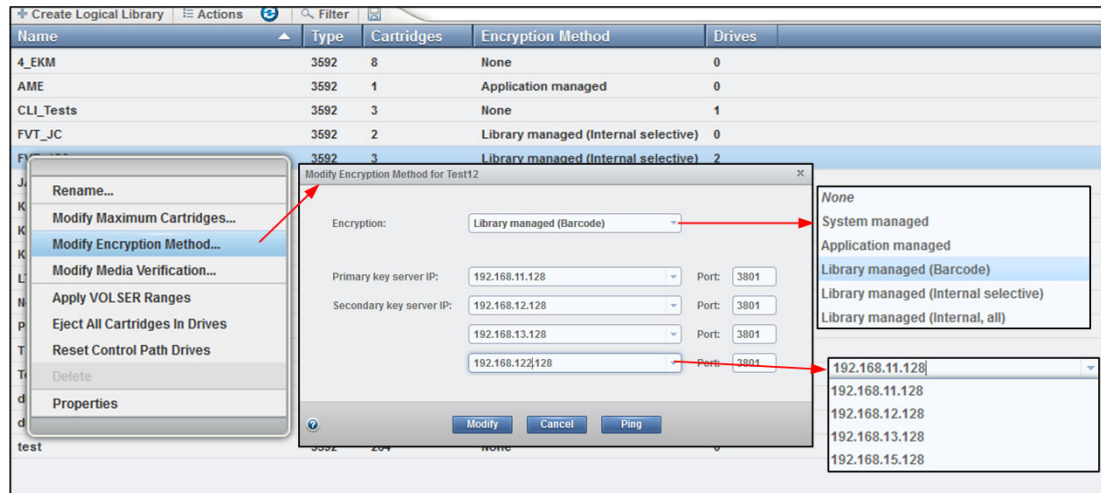
Figure 4-135   Modifying the encryption method

Apply VOLSER Ranges

Use the Apply VOLSER Ranges option on the Actions menu to reassign all cartridges based on VOLSER ranges. This action can be useful in the following scenarios:

► If cartridges with old policies that do not match the current assignments are in the library

► If a VOLSER range was moved to a different logical library, or the range was resized and the option to reassign cartridges was not selected

► If a cartridge was manually assigned outside of a VOLSER range

Cartridges are reassigned to existing logical libraries. If the maximum number of cartridges is met for a logical library, any additional cartridges that were assigned to that logical library are unassigned.

Eject All Cartridges in Drives

Use the **Eject All Cartridges in Drives** option on the **Actions** menu to eject all cartridges from all drives in a logical library. Use this option only if the cartridges cannot be ejected by the application.

Reset Control Path Drives

Use the **Reset Control Path Drives** option on the **Actions** menu to reset all control path drives that are configured on a logical library.

This option removes all paths on the selected logical library to the TS4500 for the time that it takes to reset the control path drives.

Delete

Use the Delete option on the Actions menu to delete the logical library.

To delete a logical library, you must perform these functions:

► Unassign all drives (See "Unassigning a drive" on page 228)
► Delete all VOLSER ranges (See "Delete a VOLSER range" on page 224)
► Unassign any cartridges that are assigned (See "Assigning or unassigning cartridges" on page 220)

After you complete these actions, select the logical library to delete. Click **Actions** → **Delete** and follow the instructions on the window.

Properties

Click **Actions** → **Properties** to display detailed properties about the selected logical library, as shown in Figure 4-136.
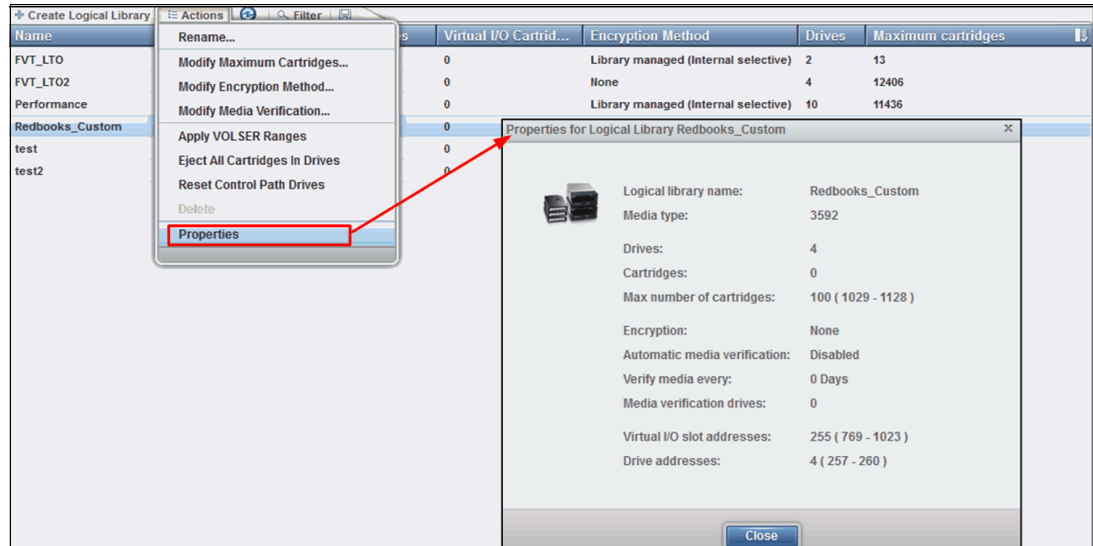
Figure 4-136   Properties

4.7.3 Slots

The Slots option is available for a user with service-level access. Use the Slots option to set storage slots online or offline.

This option is normally used by the IBM service support representative (SSR) for setting slots offline and then online during a service action. This option can also be used to set any slot online and offline for problem determination.

To set slots offline or online, select the frame, row, and slot number from the menu, as shown in Figure 4-137, and then select either the Set Online action or the **Set Offline** action.

Single or multiple slots can be selected and the number that was selected is displayed in the upper-right corner of the menu.
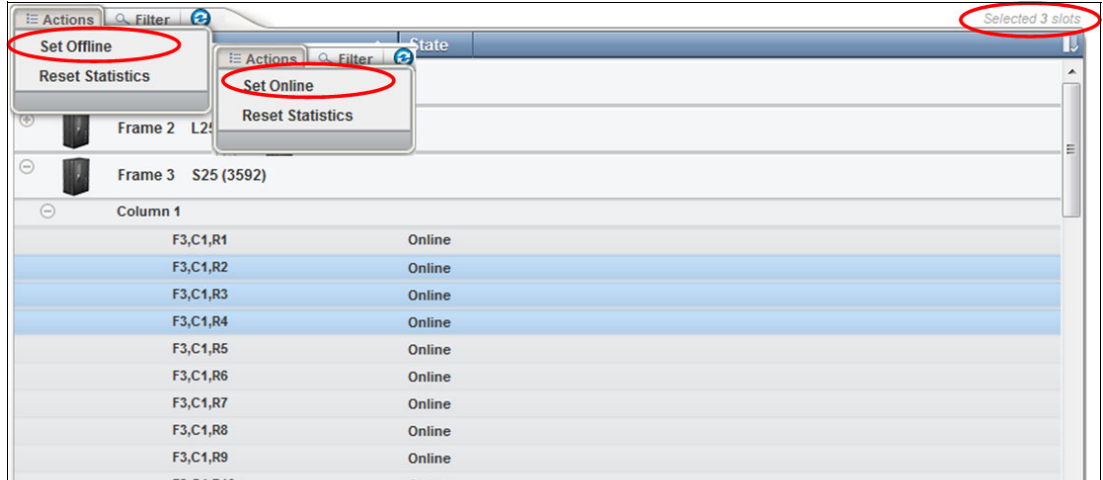
Figure 4-137   Slots

4.8 Monitoring

The TS4500 management GUI pages under the Monitoring icon can help you to monitor the system, events, and tasks, as shown in Figure 4-138.

Figure 4-138   Monitoring

4.8.1 System

The System page, as shown in Figure 4-139, displays the physical configuration of your TS4500 tape library. Start at this page to identify health and status issues with the library and library components.

Figure 4-139   System

Viewing component status

View the status of the library frames, storage slots, tape drives, I/O stations, and the cartridge accessors on the System page.

Hover over the top of a frame, or over an I/O station, to view its state and contents, as shown in Figure 4-140.
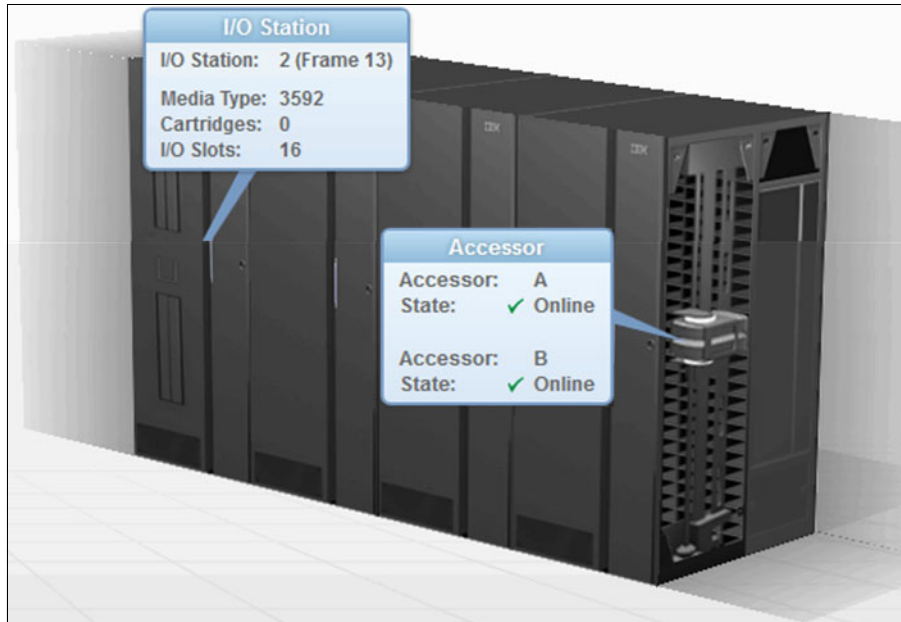
Figure 4-140   Component status

If a problem occurs with any of the components, a warning or error icon is displayed. Hover over the icon to see a message about the affected component that includes the amount of time that passed since the event occurred and a short description of the event. Go to the Events page to view the detailed information about the error or warning.

Library frame

An error or a warning icon at the base of a library frame indicates a problem with the frame door, I/O station (if applicable), or with any of the slots, cartridges, or drives in that frame.

Cartridge accessor

An error or a warning icon on the cartridge accessor indicates a degraded state of operation for the accessor or an issue with any of the accessor components (gripper, scanner, or calibration sensor).

I/O station

Click an I/O station to view the I/O station properties, including the state of the I/O station. The possible states are empty, cartridges in I/O for 60 minutes or more, or a magazine that is missing for 60 minutes or more. Icons on the door of the library frame also indicate the I/O station status. For a detailed description of each icon, see the following section.

What do the icons mean

The System page shows a graphical representation of your library. The icons provide basic status and event information. Hover over error and warning icons to view the length of time since the event was generated and a short description of the event.

Table 4-7 describes each icon.

Table 4-7   Status icons

Icon	Description
	An error occurred with a frame, tape drive, cartridge, or accessor. Hover over the icon to see a list of the most important issues that cause this state. Click any issue to open the Events Page to see more information.
	A warning occurred with a frame, tape drive, cartridge, or accessor. Hover over the icon to see a list of the most important issues that cause this state. Click any issue to open the Events page to see more information.
	The Tasks icon shows whether tasks are running.
	The Alerts icon shows whether alerts exist.
	The I/O station is full.
	The I/O station is full for 60 minutes or longer. This situation might occur with input operations if a shortage of storage slots exists. This situation also might occur with output operations if the I/O station is unattended. View the state of the cartridges, I/O slot (import queued), or I/O slot on the Cartridges page.
	The I/O station is partially full.
	The I/O station is partially full for 60 minutes or longer. This situation might occur with input operations if a shortage of storage slots exists. This situation might occur with output operations if the I/O station is unattended. View the state of the cartridges, I/O slot (import queued), or I/O slot on the Cartridges page.
	The I/O station is empty.
	The cartridge magazine is missing.
	The cartridge magazine is missing for 60 minutes or longer.

Frame selection

The main System status display shows up to four frames at a time. Use the mouse to select the four frames that you want to display from the System status display window, as shown in Figure 4-141.
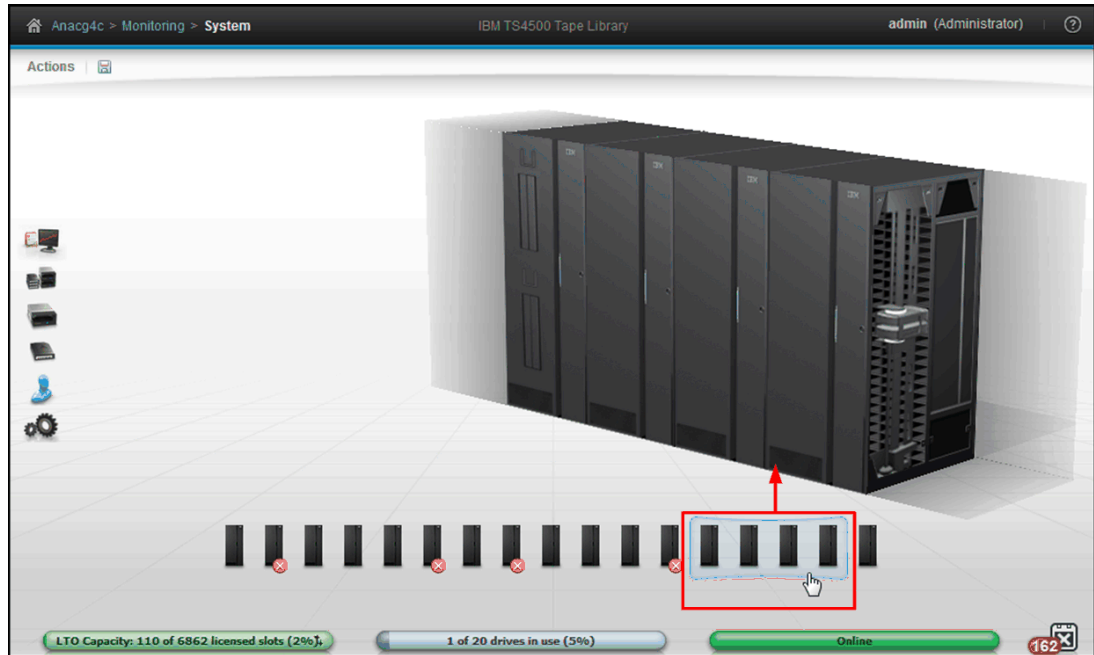
Figure 4-141   Frame selection

Status pods

Status pods at the bottom of the System page show a quick view of the capacity, drive use, and logical library health status, as shown in Figure 4-142.
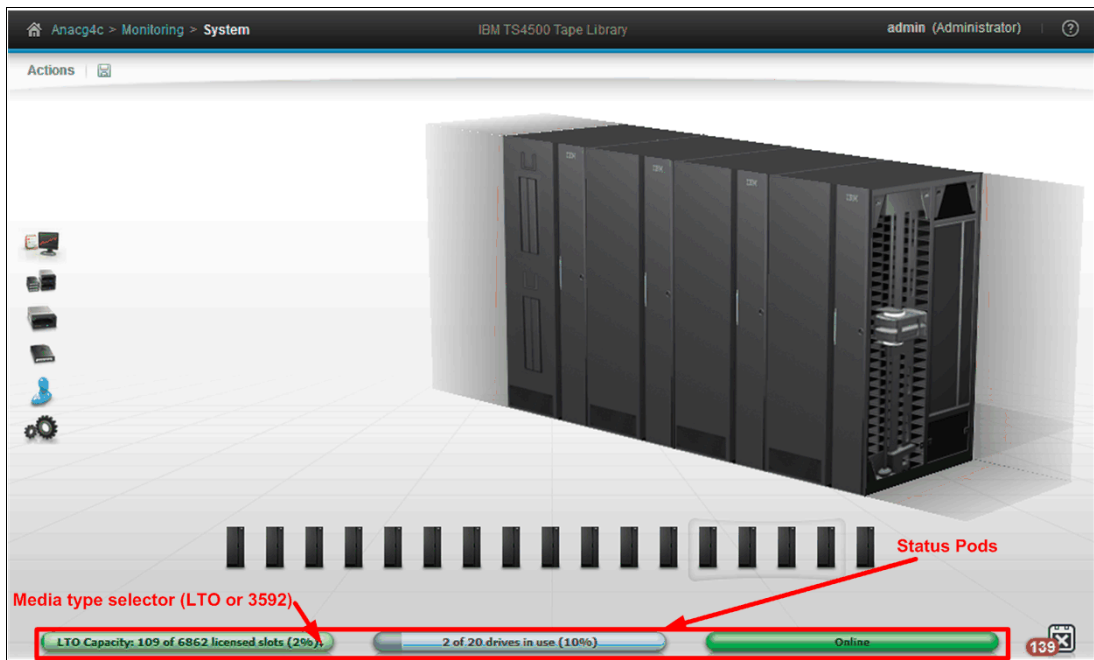
Figure 4-142   Status pods

Physical capacity status pod

The physical capacity pod displays how many licensed slots are filled by cartridges in this tape library. In a mixed media library, you can select to display a summary of either LTO or 3592 slots by using the selector button on this pod.

The pod is green when the number of cartridges in the library is fewer than the number of licensed slots.

The pod is yellow when the physical capacity exceeds the capacity use threshold. If this situation occurs, you can remove cartridges or purchase additional capacity.

The pod is red when the number of cartridges exceeds the number of licensed slots. If this situation occurs, you must remove cartridges or purchase additional capacity.

Drive use status pod

The drive use status pod displays the status of the drives across the library. Click the **status pod** to go to the Drives by Logical Libraries page.

The blue pod fills as the number of drives (in use out of the total number of drives in the library) increases.

If multiple logical libraries exist, a warning icon displays if all of the drives in any logical library are in use.

Health status pod

The color of the health status pod indicates the current state of the library by severity. Click the **status pod** if the pod is yellow or red to go to the correct page so that you can understand and troubleshoot the warning or error. If a library is in more than one state, the higher priority state is shown.

Actions and remote management of the library

Use the Actions menu on the upper-left corner of the page, or right-click a frame or I/O station. See Figure 4-143. The menu of available actions changes depending on whether the entire library, a specific frame, or an I/O station is selected.
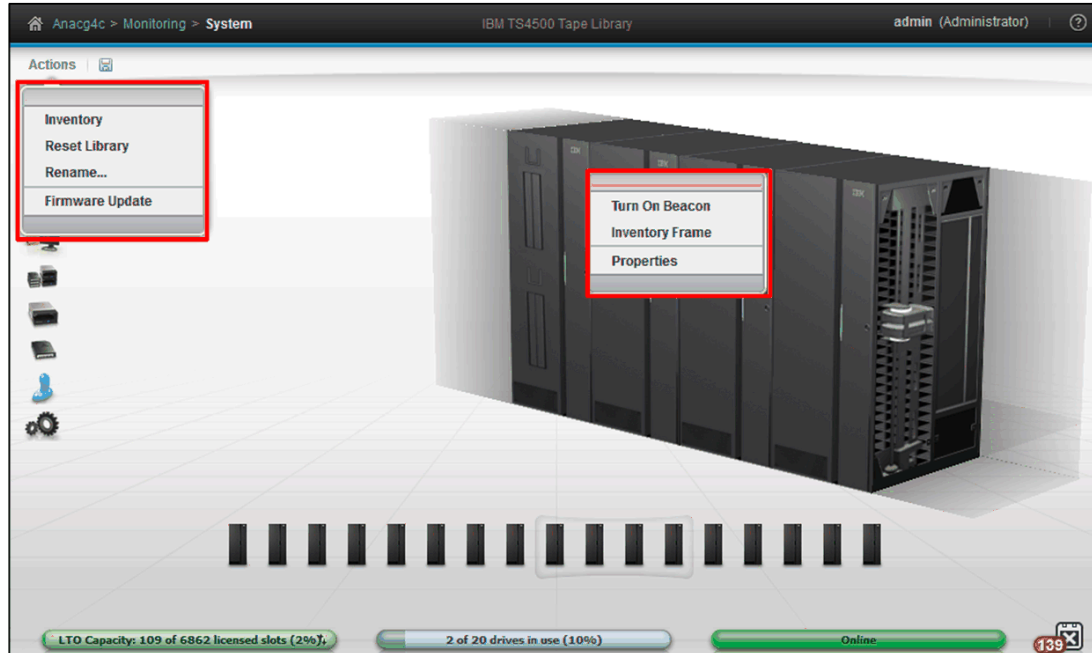
Figure 4-143   Actions menu

You can use certain actions on the System page to perform physical actions on the library remotely. For example, you can open and close I/O station doors from the I/O station Actions menu. You can turn on or turn off the beacon light-emitting diode (LED) from the Actions menu of any frame with an I/O station. You can use the beacon LED to signal remotely to operators the frame that requires attention or the I/O station that contains a specific cartridge. For more information, see "I/O stations" on page 38.

Running an inventory

An inventory operation (Figure 4-144) 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. You can run an inventory on a single library frame or an entire library.
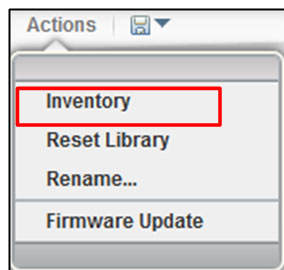
Figure 4-144   Inventory

The TS4500 tape library automatically inventories the library. However, certain conditions necessitate that you manually initiate an inventory. For example, if an automatic inventory of the media was inconsistent, you might need to run an inventory to reconcile an inconsistency.

Similarly, you might need to start a manual inventory if the host application software indicates that a problem exists with the library inventory.

The TS4500 tape library provides two inventory options, as shown in Figure 4-145.
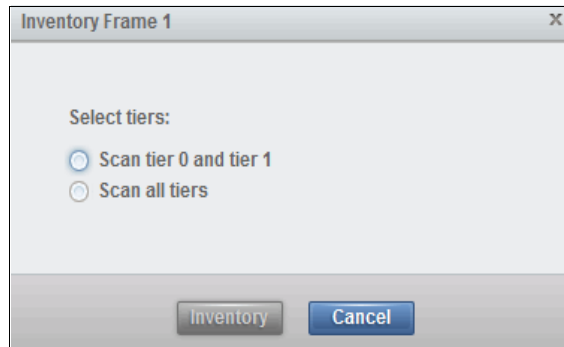
Figure 4-145   Inventory Frame

You can select the type of scan that is required:

► Scan tier 0 and tier 1. Use this option when a faster inventory is preferred. This option scans other tiers only if a discrepancy is identified.

► Scan all tiers. Use this option when a full library inventory is required. This option is not concurrent, and it can last many hours, depending on the number of cartridges in the library.

When no frame is selected, you can select **Inventory** from the Actions menu to start an inventory of the library. When a frame is selected, the Inventory option inventories only that frame. Right-click any frame and select **Actions** → **Inventory** to inventory only that frame.

You can inventory a single frame by selecting it and then by clicking **Actions** → **Inventory**. If you do not select a frame, all frames are inventoried.

Inventory all tiers

In a high-density (HD) library, a standard inventory is a scan of tier 0 and tier 1. However, at certain times, it is necessary to inventory all tiers. This operation takes more time because it requires moving the cartridges within an HD slot to scan each bar code. For all inventory operations, tier 2 and higher in an HD slot are only scanned when one of the following changes occurs:

► A tier 1 cartridge bar code label changed, which is detected during inventory. Only the slots for which the tier 1 label changed are audited.

► Enough tier 1 bar code labels changed in a column to warrant an audit of the entire column of HD slots.

► An "Inventory all tiers" is requested through the TS4500 management GUI.

Important: We suggest that you limit the manual access of HD slots to the initial bulk loading of the frame because of the length of time that is required to complete a full inventory with an audit.

Typically, the following time frames are required for the TS4500 tape library to audit cartridges:

- Less than 30 seconds for each HD slot
- Up to 10 minutes to inventory a column of full HD LTO slots
- Up to 8 minutes to inventory a column of full HD 3592 slots
- More than 45 minutes to perform a full inventory with an audit on a single HD frame, depending on the frame type

Reset Library

You can reset the TS4500 tape library control system if the library experiences a stopped state. This action (Figure 4-146) resets the node cards in the library.
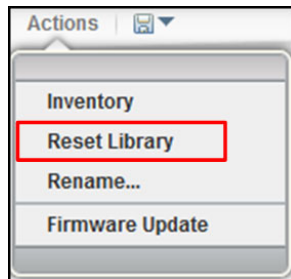
Figure 4-146   Reset Library

A reset can take up to 3 minutes. A reset might require you to reconnect to the web server after the reset completes.

Rename the library

You can rename the library by using the Actions menu and by selecting **Rename**, as shown in Figure 4-147.
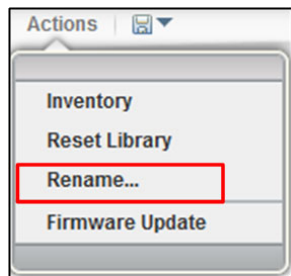
Figure 4-147   Rename the library

Turn on or turn off the beacon LED

Each frame with an I/O station has a beacon light-emitting diode (LED) that can be turned on or turned off. You can use the beacon LED to identify a frame that is in service or needs service, or to identify a frame for other reasons.

Select a frame with an I/O station. Then, select **Actions** → **Turn On Beacon** or **Actions** → **Turn Off Beacon**, as shown in Figure 4-148.

Figure 4-148   Turning on or turning off the beacon

Updating library firmware

Use the Firmware Update option on the Actions menu to nondisruptively update the library firmware to use the latest library enhancements. You can also use this option to update the drive firmware.

Use the TS4500 tape library to update library firmware without scheduling downtime and without interrupting the job flow or reducing productivity.

A TS4500 tape library firmware upgrade is generally performed by the IBM service support representative (SSR) if the update fixes a field issue or if the update is suggested by IBM. For client-initiated requests, the upgrade is the responsibility of the client. Contact your IBM SSR with any questions about a specific scenario, who is responsible for the upgrade, and whether a charge is associated with the upgrade.

Update procedure

Obtain the library firmware package from IBM Support or from IBM Fix Central at the following website and install the package on your workstation:

http://www.ibm.com/support/fixcentral/

Follow these steps to update the firmware:

1. From the System page of the TS4500 management GUI, select **Actions** → **Firmware Update**, as shown in Figure 4-149.
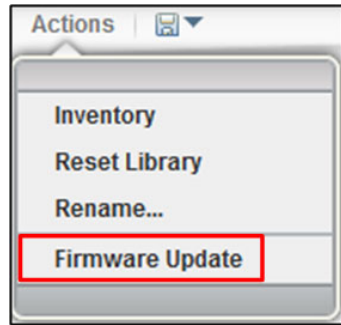
Figure 4-149   Firmware Update

2. On the File Upload window, browse to the library firmware image and click **Open**, as shown in Figure 4-150.
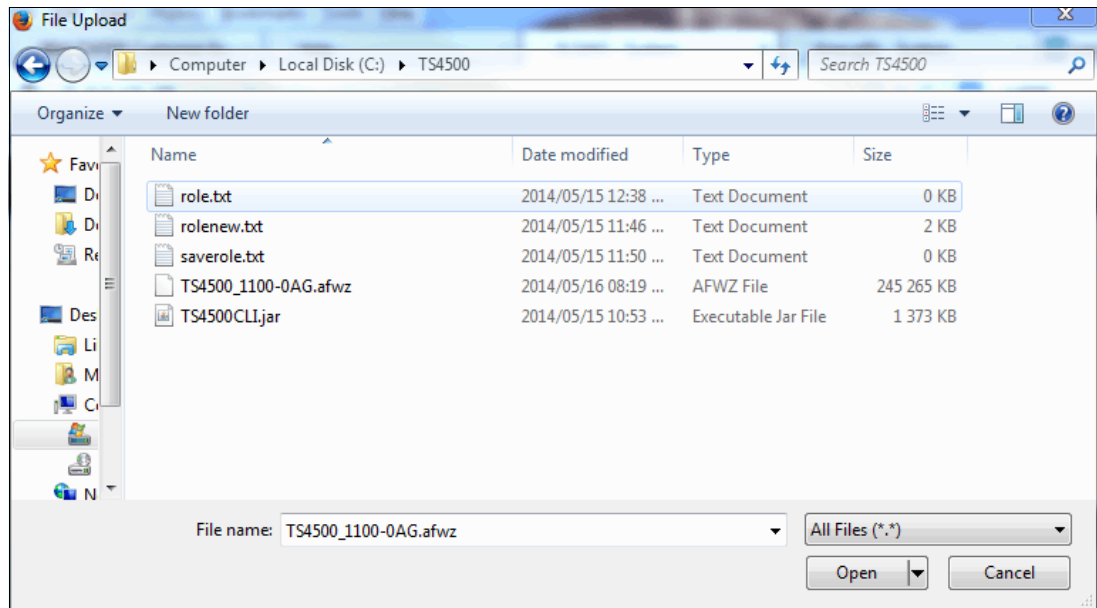
Figure 4-150   File Upload

Note: The library firmware image file is named `TS4500_WXYZ.afwz`, where *W*, *X*, *Y*, and *Z* are different numbers or letters, depending on the firmware version.

3. The Apply Library Firmware window opens. Click **Yes** to continue, as shown in Figure 4-151.
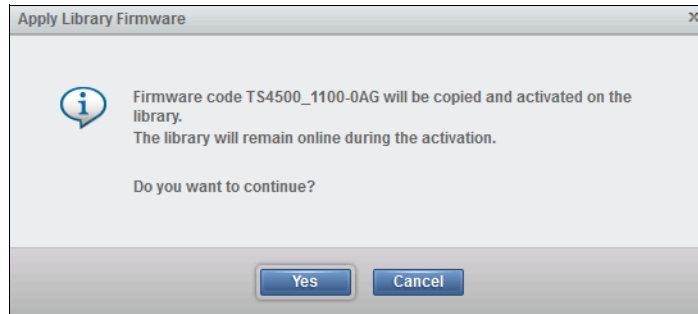
Figure 4-151   Firmware update confirmation

4. The firmware is downloaded to the TS4500 tape library first, and this download can take a few minutes. Then, the update starts and the Tasks pod, which is at the lower-left corner of the System page, indicates that the firmware update task is in progress. Monitor the status of the update from the Tasks page by selecting **Monitoring** → **Tasks**, as shown in Figure 4-152.
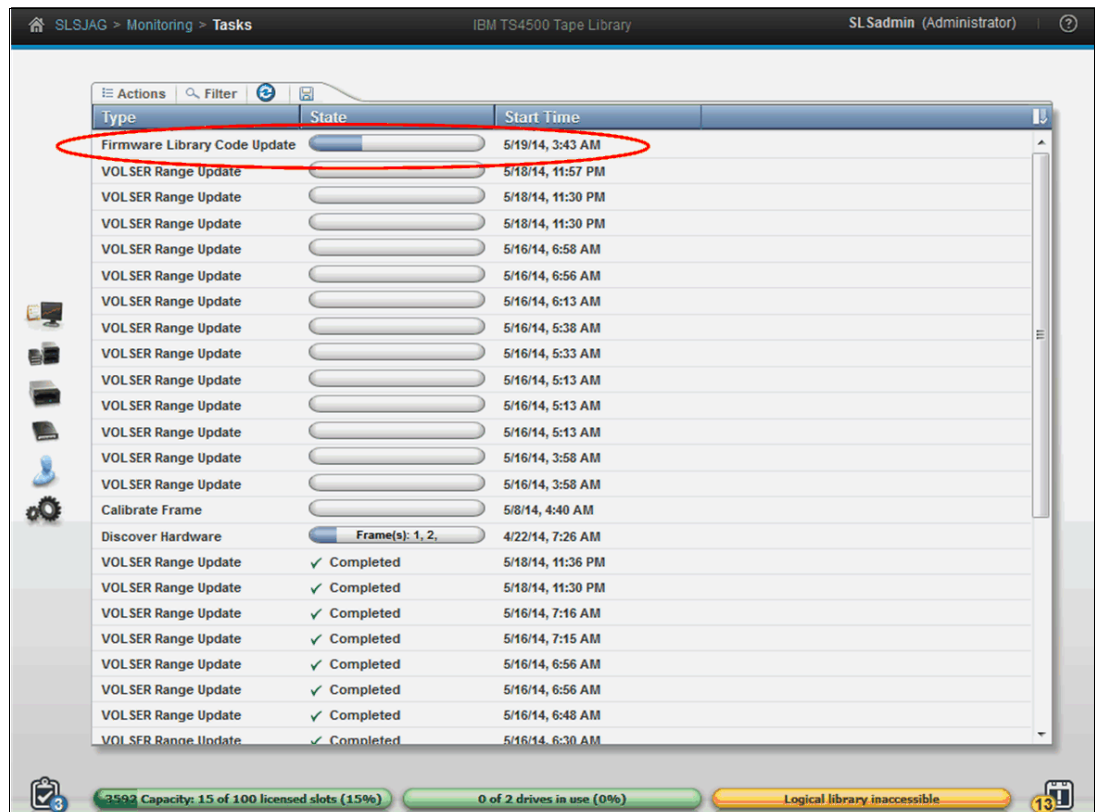
Figure 4-152   Firmware update status

5. You will lose connection after the firmware is upgraded. Log back in to the TS4500 tape library and select **Actions** → **Events** to display the status of the update.

Note: If the library firmware update stops, nondisruptively reset the library from the System page by selecting **Actions** → **Reset Library**. Then, try the firmware update again.

Downloading the statistics and logs

Click the **Save** icon (highlighted) on the toolbar to view a list of available downloads, including library logs, component usage statistics, and library configuration information, as shown in Figure 4-153.
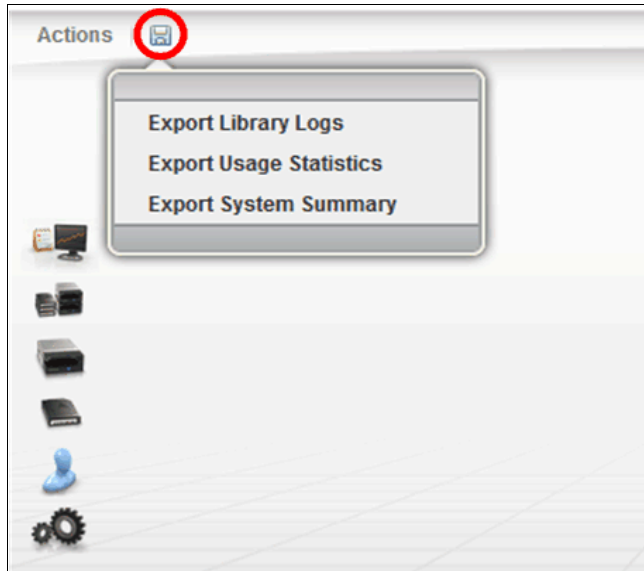
Figure 4-153   Export files

The following files are available for download and export:

► Library logs: This option downloads a `.zip` file that includes event logs, servo logs, nonvolatile random access memory (NVRAM) event logs, Fatal Exception logs, and so on.

► Usage statistics: This option downloads a comma-separated value (`.csv`) file that contains the usage statistics of important library components.

► System summary: This option downloads a `.csv` file that lists the library properties and configuration settings. The downloaded file name uses the following format where *libraryname* is the name that you set for the library. The file name format is *libraryname_YYYYMMDD.*csv.

> **Note:** It is helpful to download this file periodically to compare the library configuration over time or to retain the configuration for auditing purposes.

4.8.2 Events

Events are informational notices, warning alerts, and error alerts that provide details about the library and library components. Use the Events page to view these events and to monitor their status.

Event categories

Error, warning, and information-only events are displayed on this page. The events are defined in order of severity.

Error

The error icon is a red circle that contains a white X. The error icon is shown in Figure 4-154.

Figure 4-154   Error

Error events are the highest priority events, and they require immediate intervention. They are identified by the error icon (a red circle that contains a white X) in the Events table. Errors indicate a hardware or communication failure that can impair library operations or damage the system.

Warning

The warning icon is a yellow triangle that contains an exclamation mark, as shown in Figure 4-155.

Figure 4-155   Warning

Warning events are the second-highest priority events, and they require attention when time allows. They are identified by the warning icon (a yellow triangle that contains an exclamation mark) in the Events table. Warnings indicate a problem that does not pose an immediate threat, but warnings require resolution to ensure that library operations continue smoothly.

Information

The information icon is a blue balloon that contains the lowercase letter i, as shown in Figure 4-156.
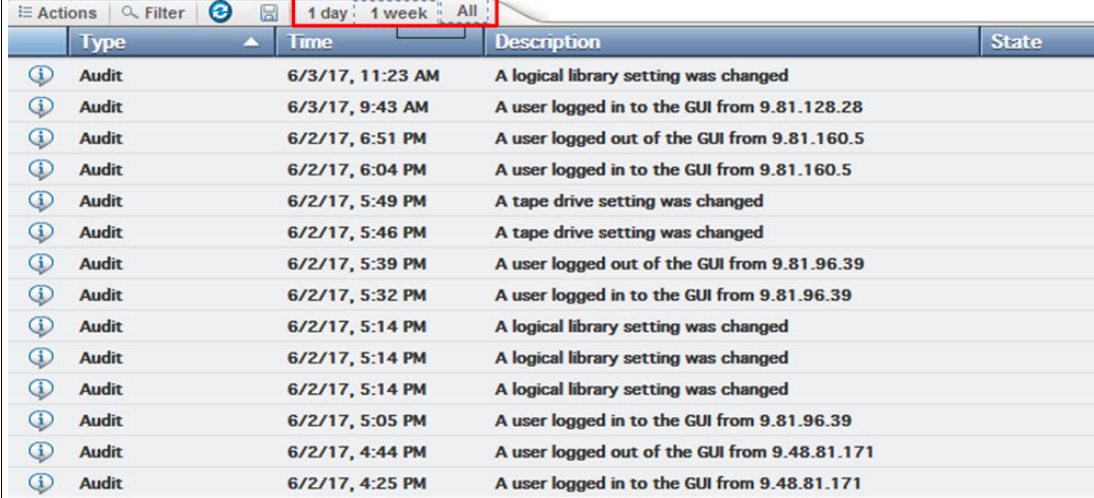
Figure 4-156   Information

Informational events are the lowest-priority events, and they do not require corrective action. They are identified by the information icon (a blue balloon that contains a lowercase letter i) in the Events table. Information-only events provide information about the library or library operations, such as the user login and tape movements.

Monitoring events

The events that are displayed on the Events page are sorted first by severity and second by time. If the Events table is full and a new event is generated, the oldest, inactive events are deleted first. The even tog can be limited to show events for 1 day, 1 week, or all. Shown in Figure 4-157 is the Events list (or Events *table*).

	Type	Time	Description	State
	Audit	6/3/17, 11:23 AM	A logical library setting was changed	
	Audit	6/3/17, 9:43 AM	A user logged in to the GUI from 9.81.128.28	
	Audit	6/2/17, 6:51 PM	A user logged out of the GUI from 9.81.160.5	
	Audit	6/2/17, 6:04 PM	A user logged in to the GUI from 9.81.160.5	
	Audit	6/2/17, 5:49 PM	A tape drive setting was changed	
	Audit	6/2/17, 5:46 PM	A tape drive setting was changed	
	Audit	6/2/17, 5:39 PM	A user logged out of the GUI from 9.81.96.39	
	Audit	6/2/17, 5:32 PM	A user logged in to the GUI from 9.81.96.39	
	Audit	6/2/17, 5:14 PM	A logical library setting was changed	
	Audit	6/2/17, 5:14 PM	A logical library setting was changed	
	Audit	6/2/17, 5:14 PM	A logical library setting was changed	
	Audit	6/2/17, 5:05 PM	A user logged in to the GUI from 9.81.96.39	
	Audit	6/2/17, 4:44 PM	A user logged out of the GUI from 9.48.81.171	
	Audit	6/2/17, 4:25 PM	A user logged in to the GUI from 9.48.81.171	

Figure 4-157   Events

Active events, which are displayed in color in the Events table, are events that are not yet fixed. Inactive events, which are displayed in gray in the Events table, are events that are being addressed or events that are fixed. Use the **Actions** → **Mark Inactive** option to manually mark an event as inactive. Events can also be marked as inactive manually by an IBM SSR.

Only errors and warnings can be marked as inactive. Information-only messages are not alerts, and they cannot be marked as inactive.

Select **Actions** → **Properties** when a specific event is selected to view details about the event. The Event Properties window includes a complete history of the event. If an action can be performed to resolve an error or warning event, a fix procedure is also provided, as shown in Figure 4-158.
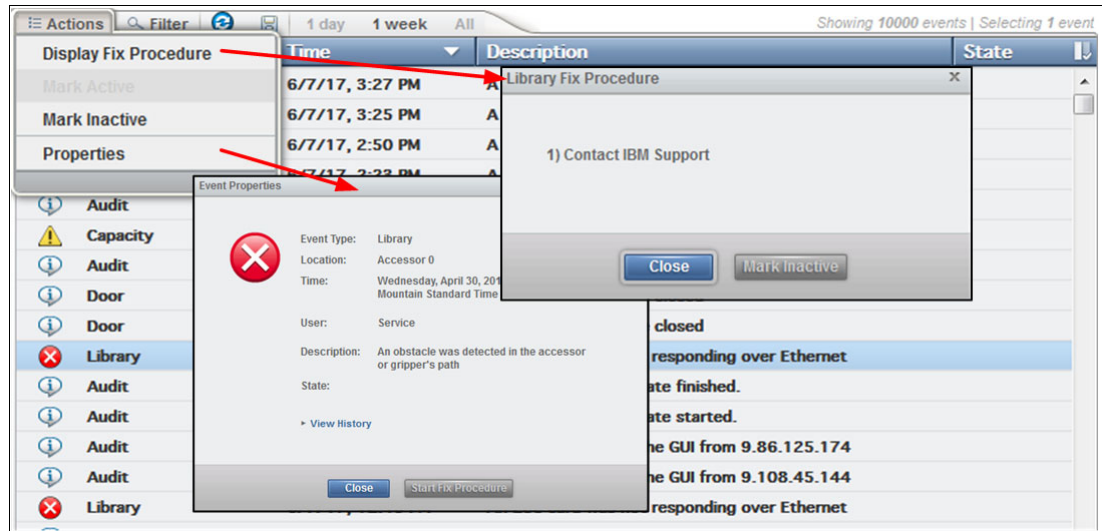
Figure 4-158   Event details

View the status of each event in the State column. For events that require service, the State column shows when a Call Home is generated, when the Call Home is complete, and when the service action is complete.

If SNMP traps are enabled, notification messages are also sent to the SNMP server based on the subscription level (error, warning, or information). Select **Notifications** from the Settings page to manage SNMP traps and subscriptions.

Monitoring tape cartridge moves

Tape cartridge moves are displayed as information events. The default table sort displays all information events last. Sort by location to see a history of moves by drive, I/O station, or storage slot. Sort by time to see the most recent moves, moves on a specific date, or moves at a specific time.

Monitoring when tapes are moved, and where they are moved to and from, can be helpful to view overall library activity. This view can also help you diagnose recurring problems if you use a filtered view of the Events table to display the most recent actions with any component.

Events at a glance

If any events are active, the Events icon displays in the lower-right corner of the System page and the Events page. The number next to the icon indicates the total number of active alerts (both errors and warnings). The color indicates the highest level of the active alerts. If the number is in a red circle, at least one of the indicated alerts is an error (Figure 4-159). If the number is in a yellow circle, the most severe active alert is a warning.
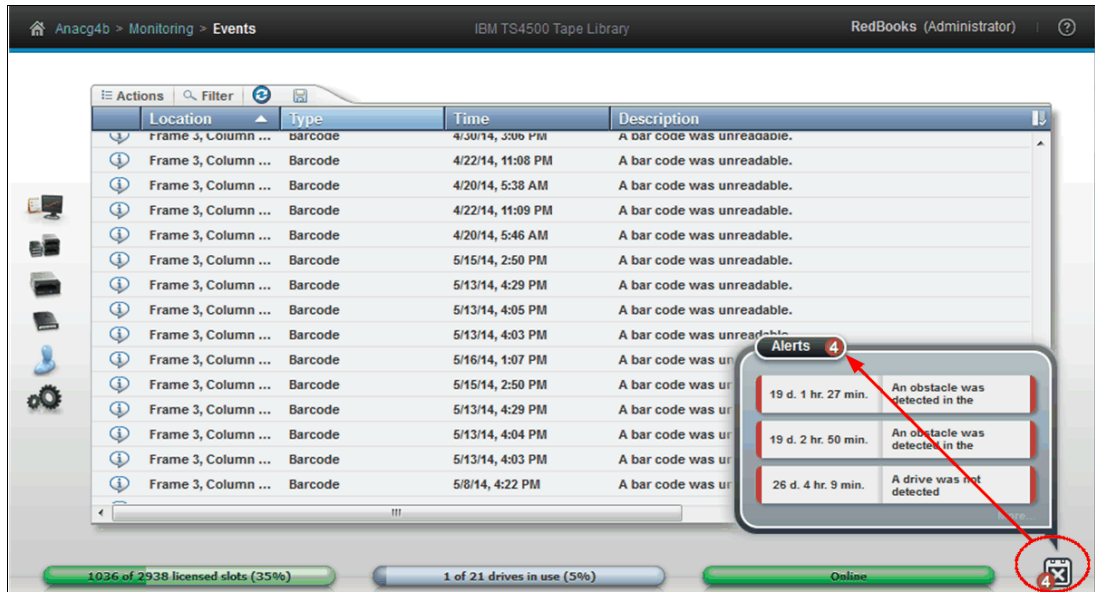
Figure 4-159   Events

Hover over the Events pod to see the location of the event, the relative time since the event occurred in days (d.), hours (hr.), and minutes (min.), and a short description of the event.

Monitoring tasks

The Tasks page displays long-running actions, such as inventory and reset, that run in the background while the library performs other operations. Use this page to monitor the progress of tasks and to view task properties.

The Tasks table displays all active tasks. They are sorted first by state and second by time. Tasks are removed from the table after a certain amount of time when they expire.

Highlight a task in the table, and select **Actions** → **Monitor** to view the status of the task, as shown in Figure 4-160.
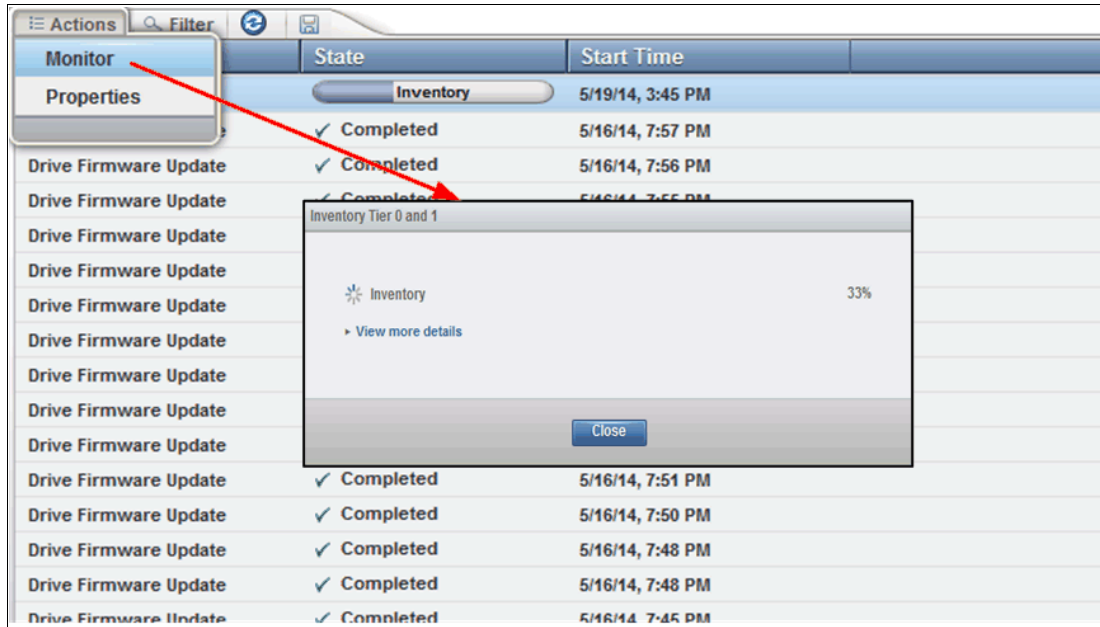
Figure 4-160   Task monitoring

Highlight a task in the table and select **Actions** → **Properties** to view a complete description of the task and the task history, as shown in Figure 4-161.

> **Note:** If a long-running task stops or appears to take more time than necessary, you can reset the library and then start the task again. You can nondisruptively reset the library by selecting **Actions** → **Reset** from the System page to reset the library.
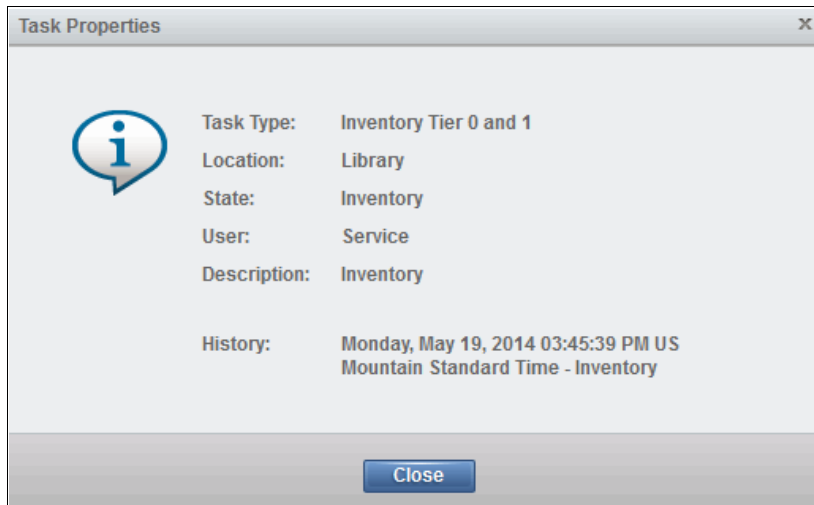
Figure 4-161   Task Properties

The Tasks pod displays in the lower-left corner of the System page when tasks are running. The number next to the Tasks pod indicates the number of tasks. If no icon is displayed, no tasks are active. Hover over the Tasks pod to see the three oldest running tasks that are sorted in the time sequence that they were created, as shown in Figure 4-162.

Figure 4-162   Tasks pod

4.9 Tape System Library Manager (TSLM)

Tape System library Manager (TSLM) software provides consolidation and simplification benefits in an IBM TS4500 tape library environment.

TSLM provides a resource management layer between applications, such as IBM Spectrum Protect, and the tape library hardware. TSLM decouples tape resources from applications. This capability simplifies the aggregation and sharing of tape resources.

TSLM can combine the capacity of multiple TS4500 and TS3500 libraries into a single reservoir of tape storage that can be managed from a single point. This capability allows more effective management, monitoring, and reporting of the use of tape storage resources for new and existing TS4500 and TS3500 systems.

TSLM is software that is designed to exceed today's tape storage management challenges for various clients that are involved in High Performance Computing (HPC) environments, such as oil and gas exploration and genomic analysis, where dozens of tape libraries and hundreds of tape drives must be shared and managed to back up and archive petabytes of data at the lowest cost possible.

The IBM TS4500, IBM TS3500, IBM Tape System Library Manager, and IBM Spectrum Protect are the ideal solutions for these clients.

TSLM provides the following benefits:

► Consolidated, mainframe-class media management services
► Centralized repository, access control, and administration
► Management beyond physical library boundaries:
  – Access to 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 a 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:

http://www.ibm.com/support/docview.wss?uid=pub1ga32220802

4.10 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. Whenever a failure is detected, Call Home sends detailed error information to IBM Support.

The IBM service support representative (SSR) can then prepare an action plan to handle the problem before the SSR travels to the library. 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 of the TS4500 tape library has three different, but related, capabilities: Problem Call Home, Heartbeat Call Home, and Test Call Home. The TS4500 tape library sends data files that might be helpful to IBM Support Center personnel for all three types of Call Home functions. 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):

► Number of frames and drives
► Model and serial number of each frame
► Type and serial number of each drive
► Code version of the library and each drive
► Any machine-detectable features, such as additional I/O stations and capacity expansion

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

Problem Call Home

The TS4500 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 (IBM RETAIN). This single page of text data can help the IBM Support Center or SSR determine an action plan and a list of parts (which are called field-replaceable units (FRUs)).

Heartbeat Call Home

The TS4500 tape library sends the Heartbeat Call Home on a scheduled basis to ensure that the Call Home function operates correctly. By default, the Heartbeat Call Home is sent once a week, 1 hour after a power cycle, and 1 hour after a code update completes. The frequency of Heartbeat Call Home is set on the service menu as shown in Figure 4-163.

A service user is requred to access this option.

Figure 4-163   Call home settings

Test Call Home

When the SSR services the library, the SSR can issue a Test Call Home operation to RETAIN from the TS4500 management GUI. Through the library, the SSR can include drive dumps in the Test Call Home for analysis. In this way, a drive dump can be accessed by IBM Support Center personnel through the Call Home database.

4.10.1 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 IBM TotalStorage System Console (TSSC), the IMC comes installed with a set of software tools to help with both the local service and remote support of the attached TS4500 tape library.

Table 4-8 lists the system console features that can be ordered for the library.

Table 4-8   System console and remote support features

Feature code supported models	Supported models	Client setup unit (CSU)	Description
2704	D25, D55, S25 S55, S24, and S54	No	Console expansion 26-port Ethernet switch, rack mount
2715	L25 and L55	No	TSSC Console attachment

The default 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 IBM Remote Technical Assistance Information Network (RETAIN) through the system console's modem or Ethernet (broadband) connection.

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

Table 4-9 presents the capabilities of remote support with a system console.

Table 4-9   Remote support capabilities

Location	Event support	Support
Client site	Call Home events	► Error initiated ► Heartbeat (regular interval) ► Test
	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 (Transmission Control Protocol/Internet Protocol (TCP/IP)) supported
	IBM Call Home database	► Always available (24x7) access by IBM Support staff ► Error analysis and search capability

4.10.2 Remote support security

The system console provides Ethernet connectivity through a private internal network. This section describes the security design for remote support of the network-attached devices.

The system console also provides optional Ethernet outbound connectivity through the client's network to the IBM service support system, RETAIN. All inbound communication over this connection is restricted. The system console uses the following protocols to port numbers:

► HTTPS: Port 443
► HTTP: Port 80
► Domain Name System (DNS): Port 53

For outbound and bidirectional data to and from RETAIN, the system console uses the ports (by default) that are shown in Table 4-10. You can modify the port numbers by using the TS4500 management GUI.

Table 4-10   Default system console ports for outbound and bidirectional data to and from RETAIN

Port	Type of data	Direction	Protocol
67/68	Dynamic Host Configuration Protocol (DHCP)	Outbound	User Datagram Protocol (UDP)
80	HTTP	Bidirectional	Transmission Control Protocol (TCP)
161/162	SNMP	Outbound	TCP
443	Secure Sockets Layer (SSL)	Bidirectional	TCP
1443	IBM Security Key Lifecycle Manager for z/OS (SKLM) server (library-managed encryption (LME) only)	Outbound	TCP
3801	IBM SKLM server (LME only)	Outbound	TCP
389	Lightweight Directory Access Protocol (LDAP)	Bidirectional	TCP and UDP
636	LDAP	Bidirectional	TCP and UDP
443	HTTPS	Bidirectional	TCP

Dial-out security features of the IMC

Dial-out is used by the Call Home feature to send service-related information from the attached systems to the IBM service support system. The following dial-out security properties are available for the attached systems:

- ► Dial-out is from the client location to the IBM connection point. The IBM service support system (RETAIN) does not initiate connections to the attached systems.

- ► Dial-out through the system console is over an outbound Ethernet connection to the client network. All outbound traffic is limited to HTTP, HTTPS, and Domain Name System (DNS) information. All service-related data is communicated by using HTTPS, and it is encrypted.

- ► The data that is exchanged between the attached systems and RETAIN is service-related data. The protocol that is used is specific to this application and not publicly available.

- ► On the first data exchange of each transmission, RETAIN validates that the calling system is entitled to service. If the calling system is not validated, it is disconnected.

- ► The default setting for the Call Home feature is enabled. The Call Home feature can be disabled by an IBM SSR.

None of the client data that is stored on the tape or in memory for the TS4500 tape library is transmitted or accessed in a Call Home session. Call Home is enabled or disabled through the service menu of the TS4500 management GUI. When Call Home is correctly configured, Call Home uses an IBM Global Services secure network or an internet connection. A unique account code is used that establishes connections only to RETAIN.

Dial-in security features of the IMC

Dial-in is used by IBM support to log on to the system console and provide service support. All dial-in connectivity to the system console is through a broadband connection, which restricts all incoming traffic. Separate logon IDs are required for access to each attached system.

> **Note:** The TS4500 tape library does not support dial-in. Only the IMC/TSSC supports dial-in.

The system console supports the following data security requirements when the system console is configured correctly:

- ► Client data, which is stored on tape or in memory, cannot be transmitted or accessed in remote support sessions.

- ► Remote dial-in is enabled or disabled by the client by using the TS4500 management GUI. Remote dial-in is disabled, by default. When remote dial-in is enabled, it is enabled for 24 hours, by default.

- ► Remote dial-in requires a password for access. The password is managed by the client. The default setting for dial-in is to not require a password. A password can be specified by the client and set by the IBM SSR.

> **Note:** The IMC and TSSC both run system console code, so all of the TSSC functions are integrated into the IMC. The security requirements for the IMC are the same as the security requirements for the TSSC.

Port information for firewall environments

Table 4-11 shows the only ports that are required to be opened on the firewall for environments where the tape configuration is separated from the LAN-attached hosts and web clients by a firewall. All other ports can be closed.

Table 4-11   TS4500 default port information for firewall environments

Function	Port	Direction (from library)	Protocol
Library operations	3494	Bidirectional	TCP
TotalStorage Specialist	80	Inbound	TCP
SNMP traps	161/162	Bidirectional	UDP
Encryption Key Manager	1443	Outbound	SSL
Encryption Key Manager	3801	Outbound	TCP
LDAP	389	Bidirectional	TCP and UDP
LDAP	636	Bidirectional	TCP and UDP
Kerberos	88	Bidirectional	TCP and UDP
HTTPS and SSL	443	Bidirectional	TCP

Note: The system console uses the following ports:

► HTTPS: Port 443
► HTTP: Port 80
► DNS: Port 53

Port information communications can be initiated either by the tape library or by the host. Typically, the library initiates a connection only when it is responding to the host. However, in unsolicited messages, such as statistics notifications and operator interventions, the library initiates a connection through port 3494. If the library needs to make a connection to the host, the library chooses a temporary port and uses that port to make an outbound connection to a 3494 listening port on the host.

When the host has a message to deliver to the library, the host chooses its own ephemeral port by which to make an outbound connection to listening port 3494 on the library manager. The connection is only maintained for the duration that is required to pass a single message, and then the connection is disabled.

Table 4-11 describes the minimum level of connectivity that is required to perform library operations. The following ports can be opened on the firewall, but they are not necessary for full functionality:

► The standard HTTP port, 80, allows inbound communication to the library from the TS4500 management GUI.

► Ports 161 and 162 are the standard ports for sending SNMP traps. SNMP traps can be sent from the TS4500 tape library or from the IMC. The tape library can be configured to send traps to SNMP target machines. In this case, the firewall needs to allow outbound connections from the library from its port 161 to port 162 on the listening SNMP target machine.

Figure 4-164 illustrates all of the external communication connections to the TS4500 tape library control system.
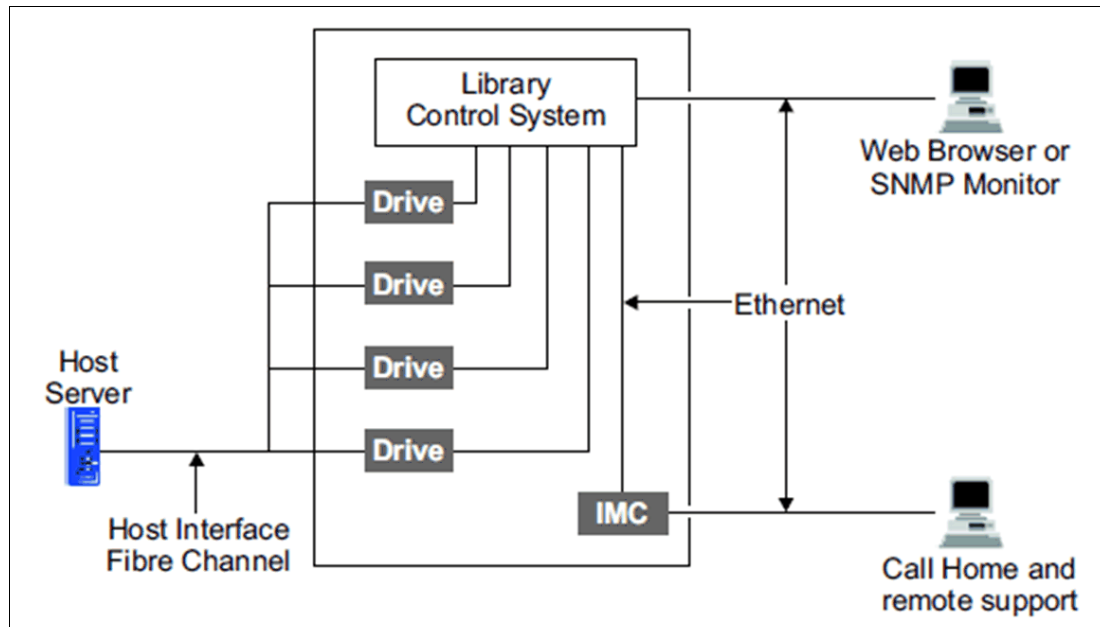
Figure 4-164   External communication connections to the TS4500 tape library control system

The host interface is provided by the drives. The library communicates with the drives through the Library/Drive Interface. The Ethernet port and modem port do not have any direct access to the Library/Drive Interface. All communication between the various interfaces is through the library control system.

All library communication requires explicit support by the library firmware that is running in the library control system. The library firmware does not provide capability for any of the following functions:

► Answering an incoming call to the modem
► Communicating between the Ethernet port and the modem port
► Communicating between the Ethernet port and the TS4500 management GUI
► Communicating between the TS4500 management GUI and the modem port
► Accessing data from tape cartridges through the Library/Drive Interface
► Sending or receiving data from tape cartridges through any port

Security considerations with the TS4500 management GUI

Remote support security for the TS4500 tape library through a system console when you use the management GUI is described.

The management GUI does not allow any access to client data, and it does not allow File Transfer Protocol (FTP) or Telnet type operations. It provides only those functions that are specifically 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 client cartridge or otherwise access client data.

The management GUI allows the client to set up an administrator password that is required to use the management GUI to perform any library task. The management GUI also provides several levels of access through various preset roles.

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

► A management GUI user might move a cartridge from one location to another location within the library, potentially confusing a host application or making a cartridge unavailable by moving it to a different partition.

► A user can reconfigure the library, possibly causing problems at the hosts because of changes in partitioning or device IDs.

► A remote user can update library or drive firmware. However, because the library and drives ignore any firmware that they do not recognize, the only exposure is to loading firmware that is not the latest level.

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.

For the latest details about security and firewall information to connect the TS4500 and IMC to your local network for call home and remote support, see *IBM Data Retention Infrastructure (DRI) System Connectivity and Security*:

http://www.ibm.com/support/techdocs/atsmastr.nsf/WebIndex/WP102531

5

Command-line interface (CLI)

This chapter describes the TS4500 command-line interface (CLI) in the following areas: CLI installation, CLI commands that are categorized by management function, and commands.

This chapter includes the following topics:

- ► TS4500 command-line interface summary
- ► Install the CLI
- ► Commands

5.1 TS4500 command-line interface summary

The TS4500 command-line interface (CLI) program enables access to TS4500 tape library functions through commands.

The following TS4500 tape library CLI commands are available:

- ► `assignDataCartridges`
- ► `batch`
- ► `bulkAssignDataCartridges`
- ► `bulkAssignDataCartridgesByLL`
- ► `cleanDrive`
- ► `codeUpdate`
- ► `continueCloseLibraryVerify`
- ► `continueLibraryVerify`
- ► `createBEP`
- ► `createKeyLabelMapping`
- ► `createVolserRanges`
- ► `deleteBEP`
- ► `deleteKeyLabelMapping`
- ► `deleteVolserRanges`
- ► `destageDataCartridges`
- ► `downloadLog`
- ► `downloadDrivesLog`
- ► `downloadPropertiesFile`
- ► `downloadSnapshot`
- ► `driveCodeUpdate`
- ► `editKeyLabelMapping`
- ► `encrypt`
- ► `getVIOStatus`
- ► `modifyAdvancedEncSettings`
- ► `modifyBEP`
- ► `modifyFibreChannelSettings`
- ► `modifyVolserRanges`
- ► `modifyVolserReporting`
- ► `moveFromAllDrives`
- ► `moveFromDrive`
- ► `moveToDrive`
- ► `prestageDataCartridges`
- ► `removeDataCartridges`
- ► `resetDrive`
- ► `resetNodeCards`
- ► `restoreConfiguration`
- ► `saveConfiguration`
- ► `setAccessorZones`
- ► `setAutoEjectCleaningCarts`
- ► `setDrivePortsId`
- ► `setISCSI`
- ► `setLibraryTime`
- ► `setMacAddress`
- ► `setMaximumVIOCartridges`
- ► `setNMADetection`
- ► `setRolePermissions`
- ► `setScannerSpeed`
- ► `setSlotOffline`

- ► **setSlotOnline**
- ► **setSSL**
- ► **showQueuedExports**
- ► **startLibraryVerify**
- ► **version**
- ► **viewAccessor**
- ► **viewAccessorZones**
- ► **viewAdvancedEncryptionSettings**
- ► **viewBEP**
- ► **viewCleaningCartridges**
- ► **viewDataCartridges**
- ► **viewDriveDetails**
- ► **viewDriveSummary**
- ► **viewDriveVPD**
- ► **viewFibreChannel**
- ► **viewIoStation**
- ► **viewISCSI**
- ► **viewKeyLabelMapping**
- ► **viewLibraryVPD**
- ► **viewLogicalLibraries**
- ► **viewLogicalLibraryDetails**
- ► **viewMacAddress**
- ► **viewNodeCards**
- ► **viewOfflineComponents**
- ► **viewRolePermissions**
- ► **viewRoles**
- ► **viewSnapshots**
- ► **viewSystemSummary**
- ► **viewSystemSummaryDetails**
- ► **viewUsers**
- ► **viewVolserRanges**
- ► **viewVolserRangesByLL**

CLI commands instruct the system to perform specific data cartridge management, cleaning cartridge management, and service-oriented procedures.

Many of the procedures that are started with CLI commands cannot be started through the TS4500 management GUI.

5.2 Install the CLI

Download the license and CLI from the IBM TS4500 Command Line Interface web page:

http://www.ibm.com/support/docview.wss?uid=ssg1S4001255

You can run the CLI from any directory. However, it is simplest to run it from the directory where the `TS4500CLI.jar` file is stored. By running the CLI from that directory, you can run the CLI commands without entering the path name of the `TS4500CLI.jar` file. However, if you run the CLI from any other directory, you must include the entire path name of the `TS4500CLI.jar` file as a part of the command.

If you run the CLI from the directory where the `TS4500CLI.jar` file is stored, your command looks like this example:

```
java -jar TS4500CLI.jar -ip [LCC ip] -u [username] -p [password] --[cli_command]
```

If you run the CLI from any other directory, your command looks like this example:

```
java -jar TS4500CLI.jar "C:\[pathname_of_ts4500cli.jar]\TS4500CLI.jar" -ip [LCC
ip] -u [username] -p [password] --[cli_command]
```

Note: If Secure Sockets Layer (SSL) is enabled on the TS4500 tape library, you need to add the **--ssl** parameter to the command after the password:

```
java -jar TS4500CLI.jar -ip [LCC ip] -u [username] -p [password] --ssl
--[CLI_command]
```

The latest TS4500 CLI information and commands can be found in:

https://www.ibm.com/support/knowledgecenter/en/STQRQ9/com.ibm.storage.ts4500.doc/t
s4500_cli.html

Commands that are categorized by management function

The TS4500 tape library commands are categorized by management function and listed in Table 5-1.

Table 5-1   TS4500 CLI commands that are categorized by management function

Management function	Command usage	Command
Data cartridges	Assigns data cartridges to a logical library	`assignDataCartridges`
	Assigns cartridges in bulk instead of one at a time	`bulkAssignDataCartridges`
	Assigns cartridges from the same logical library in bulk instead of one at a time	`bulkAssignDataCartridgesByLL`
	Moves cartridges from cartridge cache locations to high-density slots	`destageDataCartridges`
	Ejects all cartridges	`moveFromAllDrives`
	Ejects a cartridge from a drive	`moveFromDrive`
	Mounts a specified cartridge to the specified drive	`moveToDrive`
	Moves cartridges from high-density slots to cartridge cache locations	`prestageDataCartridges`
	Removes the data cartridges to and from the I/O station	`removeDataCartridges`
	Lists high-level information for all of the data cartridges in the library	`viewDataCartridges`
Cleaning cartridges	Sets the auto eject expired cleaning cartridges flag in the library	`setAutoEjectCleaningCarts`
	Lists high-level information for all of the cleaning cartridges in the library	`viewCleaningCartridges`

Management function	Command usage	Command
CLI	Performs actions that are specified within a file	`batch`
	Creates an encrypted password that can be used with any other CLI command	`encrypy`
	Used to view the current version of the Web Interface CLI program	`version`
Fibre Channel Drives	Cleans a specific drive	`cleanDrive`
	Sets ports' speed and topology for the specific drive	`modifyFibreChannelSettings`
	Power-cycles a specified drive	`resetDrive`
	Sets the ports' IDs for a specified drive	`setDrivePortsId`
	Lists the high-level details of a specific drive	`viewDriveDetails`
	Lists the high-level details of all of the drives in the library	`viewDriveSummary`
	Displays vital product data (VPD) information for all drives	`viewDriveVPD`
	Displays the Fibre Channel (FC) settings for both ports in each drive	`viewFibreChannel`
Ethernet Drives	Sets the network configuration settings for a single Ethernet drive or to change the name and alias of the drive.	`setISCSI`
	Sets the MAC address for an Ethernet port or both ports	`setMacAddress`
	Displays the configuration settings for a specific Ethernet drive	`viewISCSI`
	Displays the MAC addresses for a drive's Ethernet ports	`viewMacAddress`
Encryption Key Managers/bar code encryption policy (BEP)	Creates a bar code encryption policy	`createBEP`
	Edits a bar code encryption policy	`modifyBEP`
	Deletes a bar code encryption policy	`deleteBEP`
	Displays a list of all of the VOLSER ranges, showing the BEP settings	`viewBEP`
Key label mapping	Creates a key label mapping	`createKeyLabelMapping`
	Edits a key label mapping	`editKeyLabelMapping`
	Deletes a key label mapping	`deleteKeyLabelMapping`
	Displays the list of available key labels	`viewKeyLabelMapping`

Management function	Command usage	Command
Logical libraries	Gets and displays the status of the virtual I/O (VIO) flag on the library	`getVIOStatus`
	Modifies the advanced encryption settings for a logical library	`modifyAdvancedEncSettings`
	Modifies the VOLSER reporting value to the host in a six-character format or an eight-character format (6 or 8)	`modifyVolserReporting`
	Updates the maximum number of virtual I/O slots for the logical library	`setMaximumVIOCartridges`
	Sets flag to Show/Hide (`true` or `false`) queued exports	`showQueuedExports`
	Lists all of the logical libraries	`viewLogicalLibraries`
	Views the detailed information about a specific logical library	`viewLogicalLibraryDetails`
	Shows the encryption settings for a certain logical library	`viewAdvancedEncryptionSettings`
Security	Sets the SSL flag to `Enabled` or `Disabled`	`setSSL`
Service	Updates the library firmware	`codeUpdate`
	Used to finish the library verification process for I/O stations	`continueCloseLibraryVerify`
	Used to perform the second step of the library verification process for I/O stations	`continueLibraryVerify`
	Downloads the `.zip` file with all of the logs	`downloadLog`
	Downloads the `.zip` file with all of the logs	`downloadDrivesLog`
	Downloads the properties file (IBM TotalStorage System Console (TSSC) file)	`downloadPropertiesFile`
	Downloads snapshots	`downloadSnapshot`
	Updates the drive firmware	`driveCodeUpdate`
	Restores the configuration database to the library	`restoreConfiguration`
	Saves the configuration database to the user's computer	`saveConfiguration`
	Sets scanner speed	`setScannerSpeed`
	Sets a specific slot offline	`setSlotOffline`
	Sets a specific slot online	`SetSlotOnline`

Management function	Command usage	Command
Service	Starts the library verification process for I/O stations	`startLibraryVerify`
	Displays the list of available snapshots	`viewSnapshots`
System	Resets all specified node cards	`resetNodeCards`
	Sets which tape drives and I/O stations are served by which accessor or can also be used to inactivate an accessor	`setAccessorZones`
	Sets the library date, time, and time zone to that of the server on which the CLI is running	`setLibraryTime`
	Sets the No Motion Allowed (NMA) detection flag in the library	`setNMADetection`
	Shows the accessor's status and usage statistics	`viewAccessor`
	Displays which tape drives and I/O stations (within sets of frames) are being served by which accessor	`viewAccessorZones`
	Lists the high-level details of all of the cartridges in the I/O station	`viewIoStation`
	Displays the vital product data (VPD) for the library	`viewLibraryVPD`
	Displays the information on the node cards	`viewNodeCards`
	Views offline slots	`viewOfflineComponents`
	Displays the physical library system summary	`viewSystemSummary`
	Displays the physical library system summary for the specified frame	`viewSystemSummaryDetails`
Users and roles	Revises the existing permissions for a specified role	`setRolePermissions`
	Displays a list of all of the permissions for a specified role	`viewRolePermissions`
	Displays a list of all of the defined roles in the library	`viewRoles`
	Displays a list of all of the users in the library	`viewUsers`

Management function	Command usage	Command
Volume serial number (VOLSER) ranges	Creates new VOLSER ranges	`createVolserRanges`
	Deletes all of the VOLSER ranges with the file	`deleteVolserRanges`
	Provides the capability to modify the logical library, media type, and the flag to enable the VOLSER range only for new cartridges	`modifyVolserRanges`
	Shows all of the VOLSER ranges in the physical library	`viewVolserRanges`
	Shows all of the VOLSER ranges in a specific logical library	`viewVolserRangesByLL`

5.3 Commands

The command syntax and examples are shown.

If the CLI is run from the directory where the TS4500CLI.jar file is stored, the command looks like this example:

```
java -jar TS4500CLI.jar -ip [LCC ip] -u [username] -p [password] --[cli_command]
```

If the command is run from any other directory, the command looks like this example:

```
java -jar TS4500CLI.jar "C:\[pathname_of_ts4500cli.jar]\TS4500CLI.jar" -ip [LCC ip] -u [username] -p [password] --[cli_command]
```

We show only the **[cli_command]** section of the command in the following section. An example of a full command is shown in Example 5-1.

Example 5-1   Command example

```
C:\TS4500>java -jar TS4500CLI.jar -ip 10.1.1.37 -u Redbooks -p RedB00ks
--viewSystemSummary
```

Note: If SSL is enabled on the TS4500 tape library, you need to add the **--ssl** parameter to the command after the password and the server has to have the correct SSL certificates:

```
java -jar TS4500CLI.jar -ip [LCC ip] -u [username] -p [password] --ssl
--[CLI_command]
```

Specific commands require a service user to run.

assignDataCartridges

Use the **assignDataCartridges** command to assign or reassign data cartridges to a logical library.

The command uses this syntax:

```
assignDataCartridges filename.txt
```

The **assignDataCartridges** command receives a text file with one or more assign operations as input. Each line in the text file is interpreted as an assign operation. In the text file, the data cartridge location can be specified with the format: `[F,C,R,T]`, where F = frame, C = column, R = row, and T = tier, as shown in Example 5-2, or the VOLSER, as shown in Example 5-3.

Example 5-2   Using assign_by_location_DataCartridges.txt

```
F1,C2,R8,T0, testltolib1
F2,C2,R8,T0, testltolib2
```

Example 5-3 shows the VOLSER format.

Example 5-3   Using assign_by_volser_DataCartridges.txt

```
A57654L7, testltolib1
A56654L7, testltolib2
```

Example 5-4 shows an example of this command using the defined `.txt` files.

Example 5-4   The assignDataCartridges command

```
assignDataCartridges assign_by_location_DataCartridges.txt
assignDataCartridges assign_by_volser_DataCartridges.txt
```

batch

Use the **batch** command to instruct the system to perform multiple commands that are specified in a file.

The command uses this syntax:

```
batch filename.txt
```

The **batch** command receives a text file with one or more command operations as input. The text file is in the following format:

```
commandName [commandParameters]

next commandName [commandParameters]
```

Each line in the text file is interpreted as a command. When the **batch** command executes successfully, the system returns output that corresponds to the successful execution of each command that is listed in the input file to your display.

Example 5-5 instructs the system to run all of the commands that are contained in the `todays_batch.txt` file.

Example 5-5   The batch command

```
batch todays_batch.txt
```

bulkAssignDataCartridges

Use the **bulkAssignDataCartridges** command to assign cartridges in bulk to a logical library, rather than assigning cartridges one at a time. You can bulk-assign up to 100 cartridges to a common logical library.

The command uses this syntax:

```
bulkAssignDataCartridges filename.txt, Logical_library_name
```

This command receives a text file with one or more assign operations as input. Each line in the file is interpreted as an assign operation. The input file is in the following format, [F,C,R,T] #1 or VOLSER, as shown in Example 5-6. F = frame, C = column, R = row, and T = tier.

Example 5-6   Todays_bulk_assigns.txt file

```
F1,C2,R8,T0
F2,C2,R8,T0
F3,C2,R8,T0
BT1956L7
BT1957L7
```

The logical library name (assignment destination) is the same for all of the entries.

Example 5-7 instructs the system to execute the assignment of the cartridges that are contained in the todays_bulk_assigns.txt file.

Example 5-7   The bulkAssignDataCartridges command

```
bulkAssignDataCartridges todays_bulk_assigns.txt, LibTest
```

bulkAssignDataCartridgesByLL

Use the **bulkAssignDataCartridgesByLL** command to assign, in bulk, cartridges from a common logical library source to multiple logical library destinations. The **bulkAssignDataCartridgesByLL** command is faster than the **bulkAssignDataCartridges** command because the system needs to search in only one logical library source.

The command uses this syntax:

```
bulkAssignDataCartridgesByLL filename.txt
```

This command receives a text file with one or more assign operations as input. Each line in the file is interpreted as an assign operation. The input file is in the following format: [F,C,R,T] #1, or VOLSER and the destination logical library name, as shown in Example 5-8.

Example 5-8   Input file todays_bulk_assignsLL.txt

```
F1,C2,R8,T0, testltolib1
F2,C2,R8,T0, testltolib2
F3,C2,R8,T0, testltolib1
BT1957L7, testltolib1
BA1955L7, testltolib2
```

Example 5-9 shows an example of this command.

Example 5-9   Command bulkAssignDataCartridgesByLL

```
bulkAssignDataCartridgesByLL todays_bulk_assignsLL.txt
```

cleanDrive

Use the `cleanDrive` command to clean a specific drive.

The command uses the syntax:

```
cleanDrive -f# -c# -r#
```

Each drive location must be delimited by a comma. However, do not insert commas between the frame #, column #, and row #. The number sign (#) variables in the syntax have the following values, a space is required between the delimiter:

-f#   Frame number of the drive to update
-c#   Column number of the drive to update
-r#   Row number of the drive to update

When the `cleanDrive` command runs successfully, the system returns output to your display as shown in Example 5-10.

Example 5-10   The cleanDrive command

```
cleanDrive -f3 -c2 -r1
The drive was cleaned successfully
```

codeUpdate

Use the `codeUpdate` command to update the library firmware. (To update the firmware in a specific drive, use the `driveCodeUpdate` command or use the TS4500 management GUI.)

The command uses this syntax:

```
codeUpdate filename of firmware image
```

When the `codeUpdate` command executes successfully, the system returns output to your display, as shown in Example 5-11.

Example 5-11   The codeUpdate command

```
codeUpdate TS4500_1100-04Q.afwz
Example codeUpdate output
Name: TS4500_1100-04Q.afwz
>>>Uploading file...
......................................................
Done
```

continueCloseLibraryVerify

Use the `continueCloseLibraryVerify` command to finish the library verification process for I/O stations. Before you run this command, you must run the `continueLibraryVerify` command and then close all of the I/O station doors. (Library verification is a three-step process in which the following commands must be run in this order: `startLibraryVerify`, `continueLibraryVerify`, and `continueCloseLibraryVerify`.)

The command uses this syntax:

```
continueCloseLibraryVerify
```

When the **continueCloseLibraryVerify** command executes successfully, the system returns output to your display, as shown in Example 5-12.

Example 5-12   The continueCloseLibraryVerify command

```
continueCloseLibraryVerify
IO doors closed.
Library verify continues now...The test has been completed
successfully
```

continueLibraryVerify

Use the **continueLibraryVerify** command to perform the second step of the library verification process for I/O stations. Before you run this command, you must run the **startLibraryVerify** command and then open all of the I/O station doors. (Library verification is a three-step process in which the following commands must be run in this order: **startLibraryVerify**, **continueLibraryVerify**, and **continueCloseLibraryVerify**.)

The command uses this syntax:

```
continueLibraryVerify
```

When the **continueLibraryVerify** command executes successfully, the system returns output to your display, as shown in Example 5-13.

Example 5-13   The continueLibraryVerify command

```
continueLibraryVerify
IO doors opened. Library verify continues now.......Done!
Next step: CLOSE all IO doors, and then use "continueCloseLibraryVerify" command
to continue the test.
```

createBEP

Use the **createBEP** command to create the cartridges' bar code encryption policy (BEP). You must run the **viewKeyLabelMapping** command before you run the **createBEP** command to see the key label mapping index number of the cartridges for the encryption policy.

The command uses this syntax:

```
createBEP VOLSER_start,VOLSER_end,logical_library_name, media_type, klm_index_1,klm_index_2
```

The following explanations relate to the command syntax:

VOLSER_start   The volume serial number that starts the series of cartridges for the encryption policy.

VOLSER_end   The volume serial number that ends the series of cartridges for the encryption policy.

logical_library_name   The name of the logical library that contains the series of cartridges for the encryption policy.

media_type   The media type of the cartridges for the encryption policy. The following values are valid values for media type: LTO or 3592.

klm_index_1   The key label mapping index number of the cartridges for the encryption policy.

`klm_index_2`	Optional: This parameter is an optional value to use if you want to create encryption policies for cartridges in a second index.
`createBEP`	When the **createBEP** command executes successfully, the system returns output to your display.

Example 5-14 creates the cartridges' bar code encryption policy for the VOLSER range `TT2000` - `TT3000` in the `test1` logical library for the 3592 cartridges, which are referenced in index 1.

Example 5-14   The createBEP command

```
createBEP TT2000,TT3000,test1,3592,1
The cartridge encryption policy was created successfully
```

createKeyLabelMapping

Use the **createKeyLabelMapping** command to create a key label mapping.

The command uses this syntax:

```
createKeyLabelMapping keyLabelFrom,keyModeFrom,keyLabelTo
```

The following explanations relate to the command syntax:

► **keyLabelFrom** is a string that cannot be repeated in the list of key labels. The maximum length of this string is 50 characters.

► **keyModeFrom** is a parameter with the following possible values:

  – **Wrapped-Hash**

  – **Wrapped-Default** (Specifying this value for the **keyModeFrom** parameter disables the **keyLabelTo** parameter, and it is not necessary to specify a string value for the **keyLabelTo** parameter.)

  – **Wrapped-Clear**

► **keyLabelTo** is a string. The maximum length of this string is 50 characters.

When the **createKeyLabelMapping** command runs successfully, the system returns output to your display. See Example 5-15, which instructs the system to create a mapping from the key label `START` to the key label `END` by using the wrapped-hash key mode.

Example 5-15   The createKeyLabelMapping command

```
createKeyLabelMapping START,Wrapped-Hash,END
The Key Label Mapping was created successfully
```

createVolserRanges

Use the **createVolserRanges** command to create one or more VOLSER ranges. This task is a long-running task. The CLI shows the percentage of task completion while the task progresses.

The command uses this syntax:

```
createVolserRanges filename.txt
```

The **createVolserRanges** command receives a text file with one or more VOLSER ranges as input. Each line of the input file is interpreted as a VOLSER range. The input file is in the following format:

```
startRange,endRange,LLName,mediaType,Enable
```

The following parameter information is required:

- ► **startRange** is the starting VOLSER in the range to create.

- ► **endRange** is the ending VOLSER in the range to create.

- ► **LLName** is the name of the logical library.

- ► **mediaType** is `LTO` or `3592`.

- ► **Enable**:
  - – **TRUE** = Enable this range for new cartridges only.
  - – **FALSE** = Do not enable this range for new cartridges only.

While each line of the input file executes successfully and each VOLSER range is created, the system returns the results to your display.

Example 5-16 is an example of the **createVolserRanges** input file.

Example 5-16   The volser_ranges.txt input file

```
UAA9RH,UBB9RH,Library1,3592,FALSE
```

Example 5-17 uses the input file to instruct the system to create the VOLSER range that starts with `UAA9RH` and ends with `UBB9RH` in logical library `1` for the 3592 frame. This VOLSER range is not enabled for new cartridges.

Example 5-17   The createVolserRanges command

```
createVolserRanges volser_ranges.txt
The Volser Range was created successfully
Done
```

deleteBEP

Use the **deleteBEP** command to delete a cartridge bar code encryption policy. You must run the **viewBEP** command before you run this command to see the list of valid indexes.

The command uses this syntax:

```
deleteBEP index
```

Example 5-18 shows a command that instructs the system to delete the BEP for index 1. It is necessary to run the **viewBEP** command before you run the **deleteBEP** command to see the index number.

Example 5-18   The deleteBEP command

```
deleteBEP 1
The cartridge encryption policy was deleted successfully
```

deleteKeyLabelMapping

Use the **deleteKeyLabelMapping** command to delete a key label mapping. You must run the **viewKeyLabelMapping** command before you run this command to see the index of the key label mapping that you want to delete.

The command uses this syntax:

```
deleteKeyLabelMapping index
```

When the `deleteKeyLabelMapping` command executes successfully, the system returns output to your display, as shown in Example 5-19.

Example 5-19   The deleteKeyLabelMapping command

```
deleteKeyLabelMapping 1
The Key Label Mapping was deleted successfully
```

deleteVolserRanges

Use the `deleteVolserRanges` command to delete VOLSER ranges. This task is a long-running task.

The command uses this syntax:

```
deleteVolserRanges filename.txt
```

The `deleteVolserRanges` command receives a text file with one or more VOLSER ranges as input. Each line of the input file is interpreted as a VOLSER range to delete. The input file is in the following format: `LLName,startRange,endRange`. The following explanations relate to the input file:

▶ `LLName` is the name of the logical library.
▶ `startRange` is the starting VOLSER in the range to delete.
▶ `endRange` is the ending VOLSER in the range to delete.

Example 5-20 shows an example of a `deleteVolserRanges` input file. The example input file instructs the system to delete the VOLSER that starts with `TUU9RH` and ends with `TXX9RH` from logical library 1.

Example 5-20   The ranges_to_delete.txt file

```
Library 1,TUU9RH,TXX9RH
```

Example 5-21 show the command. As each line of the input file executes successfully and each VOLSER range is deleted, the system returns the results to your display.

Example 5-21   The deleteVolserRanges command

```
deleteVolserRanges ranges_to_delete.txt
The Volser Range was removed successfully
Done
```

destageDataCartridges

Use the `destageDataCartridges` command to move cartridges from their cartridge cache locations as specified in a text file or by using a list of VOLSERs to a high-density slot. This command requires that all data cartridges that are being destaged are in tier 0.

The command uses the following syntax:

```
destageDataCartridges filename.txt or
destageDataCartridges [VOLSER1],[VOLSER2],[VOLSERX],...
```

The `destageDataCartridges` function can use a text file with one or more destage operations as input. The *filename.txt* variable specifies the file name of the input file. The text file is in one of the following formats:

From a storage location: `[F,C,R,T]`

VOLSER: `[VOLSER]`

Each line in the text file is interpreted as a prestage operation. In the text file, the data cartridge location can be specified with the `[F,C,R,T]` location or the `VOLSER`.

> **Note:** All source cartridges that are being destaged must be in tier 0 (T0).

Example 5-22 shows a **destageDataCartridges** input file with the F,C,R,T reference.

Example 5-22   Input file with F,C,R,T reference

```
F1,C2,R8,T0
F1,C3,R18,T5
```

Example 5-23 shows a **destageDataCartridges** input file with a VOLSER reference.

Example 5-23   Input file with VOLSER reference

```
VOLSER UAA9RHL7
VOLSER UBB9RHL7
```

Example 5-24 gives an example of the **destageDataCartridges** command. When the **destageDataCartridges** command executes successfully, the system returns output to your display. The **destageDataCartridges** command instructs the system to destage the data cartridges from the correct library location based on the information in the `destage.txt` input file.

Example 5-24   The destageDataCartridges command

```
destageDataCartridges destage.txt
The cartridge [location] was moved successfully. Next element...

...
Done
```

downloadLog

Use the **downloadLog** command to download a `.zip` file with the logs from all of the node cards. This command is useful for troubleshooting.

The command uses this syntax:

```
downloadLog
```

The **downloadLog** command does not have any required parameters. It downloads all of the logs for all of the libraries. When the command executes successfully, the system returns output to your display, as shown in Example 5-25.

Example 5-25   The downloadLog command

```
downloadLog
Downloading... [completed] / [totalSize] has been downloaded.
The log file: "TS4500_FWLOGS_[yyyy-MM-dd_hh.mm.ss].zip has been downloaded.
```

downloadDrivesLog

Use the **downloadDrivesLog** command to download a .zip file containing the logs from the specified (or all) drives This command is useful for troubleshooting.

The command uses this syntax:

downloadDrivesLog

```
driveCodeUpdate F#C#R#,F#C#R#, / ALL
```

Specify the drive locations of the drives, that you want to retrieve logs from. You can select to download all drives at the same time. Each drive location must be delimited by a comma. However, do not insert commas between the frame #, column #, and row #. The number sign (#) variables in the syntax have the following values:

F#   Frame number of the drive to update
C#   Column number of the drive to update
R#   Row number of the drive to update
All   All drives

The **downloadDrivesLog** command does not have any required parameters. It downloads the logs for all the drives requested, or using the **All** option will download from all drives. When the command executes successfully, the system returns output to your display, as shown in Example 5-26.

Example 5-26   The downloadDrivesLog command

```
downloadDrivesLog F1C1R1,F1C2R2
Gathering logs...
Downloading...3638135/3638135 bytes
The drivelog file: TS4500_DRIVELOGS_2017-06-06_11.41.58.zip has been downloaded
```

downloadPropertiesFile

Use the **downloadPropertiesFile** command to download the properties file (IBM TotalStorage System Console (TSSC) file).

The command uses this syntax:

```
downloadPropertiesFile
```

The **downloadPropertiesFile** does not have any required parameters. When the command executes successfully, the system returns output to your display, as shown in Example 5-27.

Example 5-27   The downloadPropertiesFile command

```
downloadPropertiesFile
Downloading... [completed] / [totalSize] has been downloaded.
The file: ""LIBLG_01_VP_[yyyy-MM-dd_hh.mm.ss] has been downloaded.
```

downloadSnapshot

Use the **downloadSnapshot** command to display a list of all available snapshots in the library. You must run the **viewSnapshots** command before you run the **downloadSnapshot** command to display a current list of indexes.

The command uses this syntax:

```
downloadSnapshot index
```

The **index** is the index number of the snapshot to download. (The index numbers are displayed with the **viewSnapshots** command.)

The snapshot file is downloaded to the same directory where the CLI is running. When the **downloadSnapshot** command executes successfully, the system returns output to your display, as shown in Example 5-28.

Example 5-28   The downloadSnapshot command

```
downloadSnapshot 1
Downloading... [completed] / [totalSize] has been downloaded.
..
The snapshot file: "TS4500_Snapshot_01122013.zip has been downloaded.
```

driveCodeUpdate

Use the **driveCodeUpdate** command to update the firmware in a specified drive or specified list of drives.

The command uses this syntax:

```
driveCodeUpdate Filename of firmware image -l F#C#R#, F#C#R# --reset reset_option
```

The list of drives that you want to update must be preceded by an **-l**. Specify the drive locations of the drives that you want to update. Each drive location must be delimited by a comma. However, do not insert commas between the frame #, column #, and row #. The number sign (#) variables in the syntax have the following values:

F#   Frame number of the drive to update
C#   Column number of the drive to update
R#   Row number of the drive to update
--reset   Reset method for the drive after the code is updated

The following values are the valid values for the **reset** parameter:

IMMEDIATE   The reset occurs immediately after the code is on the drive. The drive must be empty before the update. If the drive has a tape before you perform an IMMEDIATE reset, execute the **moveFromDrive** command to eject a cartridge from the drive.

UNLOAD   The reset occurs after the drive is unloaded.

MANUAL   A manual reset must be performed to activate the code.

When the command executes successfully, the **driveCodeUpdate** command instructs the system to update the drives in the list. The system returns output to your display. Example 5-29 instructs the system to update the drives in frame 1, column 4, row 2, and frame 1, column 4, row 3 by using the code update that is contained in the TS4500_1100-04Q.afwz file.

Example 5-29   The driveCodeUpdate command

```
driveCodeUpdate TS4500_1100-04Q.afwz -l F1C4R2,F1C4R3 --reset IMMEDIATE
The code update has started
Name: LTO6_DAQM.fcp_fh.fmrz
>>>Uploading file...
.........................................................
Done
```

editKeyLabelMapping

Use the **editKeyLabelMapping** command to edit a key label mapping. You must run the **viewKeyLabelMapping** command before you run this command to see the index of the key label mapping that you want to edit. The command uses this syntax:

```
editKeyLabelMapping index,keyLabelFrom,keyModeFrom,keyLabelTo
```

The following explanations relate to the command syntax:

► **index** is the index number of the key label to edit. You must run the **viewKeyLabelMapping** command to see the index number.

► **keyLabelFrom** is a string that cannot repeat in the list of key labels. The maximum length of this string is 50 characters.

► **keyModeFrom** is a parameter with the following possible values:

  – **Wrapped-Hash**

  – **Wrapped-Default** (Specifying this value for the **keyModeFrom** parameter disables the **keyLabelTo** parameter, and you do not need to specify a string value for the **keyLabelTo** parameter)

  – **Wrapped-Clear**

  – **Direct-Default-Set**

  – **Direct-Specific**

► **keyLabelTo** is a string. The maximum length of this string is 50 characters.

When the **editKeyLabelMapping** command executes successfully, the system returns output to your display, as shown in Example 5-30. The **editKeyLabelMapping** command instructs the system to edit the key label mapping for index 1. The revised mapping is from the key label START to the key label END by using the Wrapped-Hash key mode.

Example 5-30   The editKeyLabelMapping command

```
editKeyLabelMapping 1,START,Wrapped-Hash,END
The Key Label Mapping was edited successfully
```

encrypt

Use the **encrypt** command to create an encrypted password that can be used with any other CLI command. When using an encrypted password in a command, use **-ep** instead of **-p** before the password.

Use this syntax:

```
encrypt [PlainTextPassword] -ssl
```

<PlainTextPassword> is a required field and is the plain text password that should be encrypted.

-ssl is required if SSL (HTTPS) is enabled.

The **encrypt** command is shown in Example 5-31.

Example 5-31   The encrypt command

```
encrypt AdminPW1
xEeUtEr9
```

In this example the command encrypted the password `AdminPW1`, the TS4500 responded with an encrypted version of this password, so any command after this can use the encrypted version. As shown in the following example, the encrypted password `xEeUtEr9` is being used with the `-ep` parameter to run the `viewSystemSummary` command, as shown in Example 5-32.

Example 5-32   Using the encrypted PW

```
java -jar TS4500CLI.jar -ip 10.129.251.127 -u admin -ep xEeUtEr9
--viewSystemSummary
```

getVIOStatus

Use the `getVIOStatus` command to show the status of the virtual I/O (VIO) flag on the library. The `getVIOStatus` command can help an administrator decide about the type of information (or the quantity of information) to store in the library.

Use this syntax:

```
getVIOStatus
```

The `getVIOStatus` command does not require any parameters. When the `getVIOStatus` command successfully executes, the system returns the result of the query (`Enabled or Disabled`) to your display. If the VIO status is enabled, you can increase the maximum VIO cartridge value for a logical library, but the processing is slower. See the `getVIOStatus` command that is shown in Example 5-33.

Example 5-33   The getVIOStatus command

```
getVIOStatus
VIO Status is set to: Enabled
```

modifyAdvancedEncSettings

Use the `modifyAdvancedEncSettings` command to make the advanced encryption settings more or less restrictive for data that is stored in a library.

The command uses this syntax:

```
modifyAdvancedEncSettings <Logical Library Name>, <Advanced Method> [TRUE /
FALSE], <Advanced Policy>, <Density code>, <keypath>
```

The following values are valid for **Advanced Policy**:

► No advanced setting = 0
► Do not encrypt if no policy = 1
► Encrypt if no policy = 2
► Policy required = 3
► Never encrypt (policy override) = 4
► Always encrypt (policy override) = 5
► Internal label: selective encryption = 6
► Internal label: encrypt all = 7

The following values are valid for the **Density code** setting:

► No advanced setting = 0
► Show encryption = 1
► Mask encryption = 2

The following values are valid for the **keypath** setting:

- ► No advanced setting = 1
- ► System = 2
- ► Application (IBM) = 3
- ► Application (T10) = 4
- ► Library = 6

In Example 5-34, the **modifyAdvancedEncSettings** operation modifies the encryption settings for `Library1` by using the advanced policy that the system must encrypt the data if the data is not already attached to an encryption policy. The density code of 2 instructs the system to mask the encryption. The key path of 2 is an instruction that the path to the encryption key to encrypt the incoming data is stored in the system, rather than in the specific library or specific application.

Example 5-34   The modifyAdvancedEncSettings command

```
modifyAdvancedEncSettings Library1,TRUE,2,2,2
The advanced encryption settings for Logical Library Library1 were updated
successfully
```

modifyBEP

Use the **modifyBEP** command to edit the cartridges' bar code encryption policy. You must run the **viewKeyLabelMapping** and the **viewBEP** commands before you run this command to see the list of valid indexes.

The command uses this syntax:

```
modifyBEP index -KLM1 # -BEP true/false -KLM2 #
```

The following explanations relate to the syntax:

index   The index number of the cartridges' encryption policy to edit. You must run the **viewBEP** command to see a current list of valid index numbers.

-KLM1   The index number of the key label mapping that contains the encryption policy to edit. You must run the **viewKeyLabelMapping** command to see a current list of valid index numbers.

-KLM2   Optional: An optional parameter to use if you want to edit encryption policies in a second key label mapping index.

-BEP   A flag to enable BEP (value is `true` or `false`).

When the **modifyBEP** command executes successfully, the system returns output to your display. Example 5-35 shows the command that updates the cartridges' bar code encryption policy in BEP index 1, key label mapping index 3 with BEP not enabled.

Example 5-35   The modifyBEP command

```
modifyBEP 1 –KLM1 3 –BEP false
The cartridge encryption policy was updated successfully
```

modifyFibreChannelSettings

Use the `modifyFibreChannelSettings` command to set the ports' speed and topology for a specified drive. The speed and topology are the same for both ports in the drive.

The command uses this syntax:

```
modifyFibreChannelSettings speed,topology -f# -c# -r#
```

The following values are valid for **speed**:

- ► 1
- ► 2
- ► 4
- ► 8

The following values are valid for **topology**:

- ► Auto-L
- ► L
- ► N
- ► Auto-N

The number sign (#) variables in the syntax have the following values:

-f#	Frame number of the drive that contains ports 1 and 2
-c#	Column number of the drive that contains ports 1 and 2
-r#	Row number of the drive that contains ports 1 and 2

In Example 5-36, the `modifyFibreChannelSettings` operation sets the port speeds to 4 and the topology to N for both ports in the drive at frame 1, column 1, row 1.

Example 5-36   The modifyFibreChannelSettings command

```
modifyFibreChannelSettings 4,N -f1 -c1 -r1
The Fibre Channel settings were updated successfully
```

modifyVolserRanges

Use the `modifyVolserRanges` command to modify existing VOLSER ranges.

The command uses this syntax:

```
modifyVolserRanges filename.txt
```

The `modifyVolserRanges` command receives a text file with one or more VOLSER ranges as input. Each line of the input file is interpreted as a VOLSER range to modify.

The input file is in the following format:

```
startRange,endRange,LLName,mediaType,Enable
```

The following parameter information is required:

- ► **startRange** is the starting VOLSER in the range to modify.

- ► **endRange** is the ending VOLSER in the range to modify.

- ► **LLName** is the name of the logical library that contains the VOLSER to modify.

- ► **mediaType** is LTO or 3592.

▶ **Enable**:
  – **TRUE** = Enable this range for new cartridges only.
  – **FALSE** = Do not enable this range for new cartridges only.

The **startRange** parameter and the **endRange** parameter are used to get the range index in the logical library table. These values cannot be modified.

Example 5-37 shows an input file that instructs the system to modify the VOLSER that starts with UAA9RH and ends with UBB9RH in logical library 1 for the 3592 frame. As a result of the TRUE flag for the **Enable** parameter, the VOLSER range is enabled for new cartridges.

Example 5-37   The volser_ranges.txt input file

```
UAA9RH,UBB9RH,Library 1,3592,TRUE
```

Example 5-38 shows an example of the **modifyVolserRanges** command. While each line of the input file executes successfully and each VOLSER range is created, the system returns the results to your display.

Example 5-38   The modifyVolserRanges command

```
modifyVolserRanges volser_ranges.txt
The Volser Range was modified successfully
Done
```

modifyVolserReporting

Use the **modifyVolserReporting** command to set whether the VOLSER is reported to the host in a 6-character format or an 8-character format.

The command uses this syntax:

```
modifyVolserReporting logical library name, flag value [6/8]
```

When this command executes successfully, the system returns the results of the **modifyVolserReporting** operation to your display. In Example 5-39, the **modifyVolserReporting** operation instructs the system to modify the VOLSER reporting to the host for the cartridges in Library1 to a 6-character format.

Example 5-39   The modifyVolserReporting command

```
modifyVolserReporting Library1,6
Volser Reporting flag was updated successfully
```

moveFromAllDrives

Use the **moveFromAllDrives** command to eject all cartridges from all full drives and move them to the home storage location. If the home storage location is unavailable, the **moveFromAllDrives** command moves the cartridge to the first empty slot. (If you want to eject a cartridge from a specific drive, use the **moveFromDrive** command.)

The command uses this syntax:

```
moveFromAllDrives
```

This command does not require any parameters. It performs the eject function for all of the cartridges in all of the drives where cartridges are mounted.

When the `moveFromAllDrives` command executes successfully, the system returns output to your display, as shown in Example 5-40.

Example 5-40   The moveFromAllDrives command

```
moveFromAllDrives
The drive [location] is empty now. Moving to next drive...
...
Done. All drives are empty.
```

moveFromDrive

Use the `moveFromDrive` command to eject a single cartridge from a drive and move it to the home storage location. If the home storage location is unavailable, the `moveFromDrive` command moves the cartridge to the first empty slot. (If you want to eject a cartridge from the drive, and move it to a specific location, use the `moveToDrive` command.)

The command uses this syntax:

```
moveFromDrive -f# -c# -r#
```

The number sign (#) variables in the syntax specify the drive where the cartridge is located before you eject it. The variables have the following values:

`-f#`   Frame number of the moveFrom location
`-c#`   Column number of the moveFrom location
`-r#`   Row number of the moveFrom location

When the `moveFromDrive` command successfully executes, and the cartridge is successfully unmounted from the drive, the system returns output to your display. Example 5-41 instructs the system to eject the cartridge from the drive in frame 1, column 4, row 1, and place it in a storage slot.

Example 5-41   The moveFromDrive command

```
moveFromDrive -f1 -c4 -r1
The cartridge was ejected successfully
```

moveToDrive

Use the `moveToDrive` command to move a cartridge from a specified location to another specified location.

The command uses the following syntax:

```
moveToDrive F#,C#,R#,T# -f# -c# -r#
```

You must first specify the drive location of the cartridge that you want moved. Then, specify the destination where you want to move the cartridge.

The number sign (#) variables in the syntax have the following values:

`F#`   Frame number of the drive for the moveFrom location
`C#`   Column number of the drive for the moveFrom location
`R#`   Row number of the drive for the moveFrom location
`T#`   Tier number of the drive for the moveFrom location
`-f#`   Frame number of the drive for the moveTo location
`-c#`   Column number of the drive for the moveTo location
`-r#`   Row number of the drive for the moveTo location

Note: The CLI is not case-sensitive. In the `moveToDrive` command, uppercase and lowercase letters are used to distinguish between the moveFrom location and the moveTo location.

When the `moveToDrive` command successfully executes and the cartridge is successfully mounted in the new location, the system returns output to your display.

Example 5-42 shows the command that instructs the system to move the cartridge in drive `F1`, `C5`, `R1`, `T1` to the drive in `f1`, `c4`, `r1`. If the cartridge destination is in the same tier as the moveFrom location, you do not need to specify the tier number in the moveTo location.

Example 5-42   The moveToDrive command

```
moveToDrive F1,C5,R1,T1 -f1 -c4 -r1
The cartridge was mounted successfully
```

prestageDataCartridges

Use the `prestageDataCartridges` command to move cartridges from the high-density slots to cartridge cache locations, as specified in a text file or by using a list of VOLSERs. All data cartridges that are being prestaged must be in tier 3 or higher.

The command uses the following syntax:

```
prestageDataCartridges filename.txt or
prestageDataCartridges [VOLSER1],[VOLSER2],[VOLSERX],...
```

The `prestageDataCartridges` command can use a text file with one or more prestage operations as input. The *filename* variable specifies the file name of the input file.

The text file is in one of the following formats:

► From a storage location: [F,C,R,T]
► VOLSER: [VOLSER]

Each line in the text file is interpreted as a prestage operation. In the text file, the data cartridge location can be specified with the [F,C,R,T] location or the VOLSER.

Note: All cartridges that are being prestaged must be in tier 3 or higher.

Example 5-43 shows a `prestageDataCartridges` input file with the F,C,R,T reference.

Example 5-43   The prestageDataCartridges input file with the F,C,R,T reference

```
F1,C2,R8,T3
F1,C3,R18,T5
```

Example 5-44 shows the `prestageDataCartridges` input file with the VOLSER reference.

Example 5-44   The prestageDataCartridges input file with the VOLSER reference

```
UAA9RHL7
UBB9RHL7
```

When the `prestageDataCartridges` command executes successfully, the system returns output to your display.

Example 5-45 shows the command that instructs the system to prestage the data cartridges to the correct library location based on the information that is specified in the `prestage.txt` file.

Example 5-45   The prestageDataCartridges command

```
prestageDataCartridges prestage.txt
The cartridge [location] was moved successfully. Next element...

...
Done
```

removeDataCartridges

Use the **removeDataCartridges** command to remove the data cartridges from a storage location to the I/O station. If VIO is enabled for a particular cartridge, the **removeDataCartridges** command does not move the cartridge to the I/O station. It marks the cartridge as a cartridge that is ready for export. The cartridge appears as unassigned. If VIO is disabled, the cartridge moves to the I/O station.

The command uses the following syntax:

```
removeDataCartridges filename.txt
```

The **removeDataCartridges** command receives a text file with one or more remove operations as input. The text file is in the following format:

► [F,C,R,T]
► VOLSER

Each line in the text file is interpreted as a remove operation.

Example 5-46 shows a **removeDataCartridges** input file. In the first line of the text file, the data cartridge in storage slot location frame 1, column 2, row 8, tier 0 is moved to the I/O station. In the second line of the text file, the data cartridge in storage slot location frame 1, column 3, row 18, tier 5 is moved to the I/O station.

Example 5-46   The removeDataCartridges input file

```
F1,C2,R8,T0
F1,C3,R18,T5
UBB9RHL7
```

Example 5-47 shows the command that instructs the system to remove the data cartridges from a storage slot to the I/O station based on the information in the `todays_removes.txt` file. Example 5-47 shows the **removeDataCartridges** output.

Example 5-47   The removeDataCartridges output

```
removeDataCartridges todays_removes.txt
The cartridge [FCRT] has been removed successfully

...
Done
```

resetDrive

Use the **resetDrive** command to power-cycle a specific drive.

The command uses this syntax:

```
resetDrive -f# -c# -r#
```

The number sign (#) variables specify the location of the drive. They have the following values:

-f#   Frame number of the drive
-c#   Column number of the drive
-r#   Row number of the drive

When the **resetDrive** command executes successfully, the system returns output to your display, as shown in Example 5-48.

Example 5-48   The resetDrive command output

```
resetDrive -f1 -c4 -r1
The drive was reset
successfully
```

resetNodeCards

Use the **resetNodeCards** command to reset one or more specified node cards.

The command uses this syntax:

```
resetNodeCards node_name_1, node_name_2, . . .
```

The parameters for this command are items in a list of comma-separated names of nodes to reset.

The following list shows the possible values of node names:

► ALL
► ALLLCA
► ALLACC
► ALLSMC
► ALLXYC
► ALLPLUS
► XYCPLUS
► ACCPLUS
► LCAPLUS
► XYA
► XYB
► OPC1
► SMC[2-16]
► ACCA
► ACCB
► LCA[1-31]
► LCAB[1-31]

When the `resetNodeCards` command executes successfully, the system returns output to your display. Example 5-49 shows the command where the system is instructed to reset the node cards in nodes `LCA1`, `LCAB3`, and `ACCA`.

Example 5-49   The resetNodeCards command

```
resetNodeCards LCA1,LCAB3,ACCA
The command was executed successfully
```

restoreConfiguration

Use the `restoreConfiguration` command to restore the configuration database to the library. The configuration file (`configuration.db`) is uploaded to the library.

The command uses this syntax:

```
restoreConfiguration the_name_of_the configuration_file.db
```

You must specify the name of a configuration file to upload. The file name can be any name that you choose, but the file must have a `.db` extension. If the file is stored in the same directory where you are running the CLI, you do not need to enter a path name for the file. However, if the file is stored in a different directory, it is necessary to enter a path name for the file.

When the `restoreConfiguration` command executes successfully, the system returns the result of the operation to your display, as shown in Example 5-50.

Example 5-50   The restoreConfiguration command

```
restoreConfiguration myconfig.db
Name: myconfig.db
>>>Uploading file...
Done
..
The configuration database has been restored successfully.
```

saveConfiguration

Use the `saveConfiguration` command to save the configuration database to the user's computer. The configuration file (`configuration_backup.db`) is saved in the same directory where the CLI is running.

The command uses this syntax:

```
saveConfiguration
```

No parameters are necessary. Simply enter the command. When the `saveConfiguration` command executes successfully, the system returns the result of the operation to your display, as shown in Example 5-51.

Example 5-51   The saveConfiguration command

```
saveConfiguration
Downloading... [completed] / [totalSize] has been downloaded.
..
The configuration file: configuration_backup.db has been downloaded.
```

setAccessorZones

This command is for use on Dual accessor libraries on and used to specify which tape drives and I/O stations (within sets of frames) are served by which accessor. This command can also be used to deactivate an accessor.

By default, each accessor is zoned to serve half of the frames in the library. So in a 12-frame library, Accessor A serves frames 1 through 6 and Accessor B serves frames 7 through 12.

You can view the current accessor zone settings with the `viewAccessorZones` command. You can also view these settings in the TS4500 management GUI on the **Settings** → **Library** → **Cartridges and Accessors** page. The Accessor Preferred Zones graphic is refreshed to reflect changes made both through the GUI and with the setAccessorZones command.

Elastic capacity settings made through the Cartridges and Accessors page are unaffected by zone changes made with the `setAccessorZones` command.

Use the **no** parameter to specify a different zone setting for an accessor, or to inactivate an accessor. Using this command to inactivate an accessor is the same as inactivating it in the Cartridges and Accessors GUI page.

The command uses this syntax:

`setAccessorZones no,[frameNumber|0|255]`

The parameters in the syntax have the following values:

► **no**: Do not use the default zone setting. Instead, use the setting specified here.

► **frame Number from 1 to 18**: This defines the last frame served by Accessor A. All remaining frames in the library will be served by Accessor B.

   – **0**: Inactivate Accessor A.
   – **255**: Inactivate Accessor B.

The example shown in Example 5-52 restricts Accessor A to frames 1, 2, 3, 4, and 5. Accessor B serves the rest of the frames in the library.

Example 5-52   setAccessorZones to frame 5

```
setAccessorZones No,5
The accessor zones was updated successfully
```

The example shown in Example 5-53 restricts Accessor A to frames 1, 2, 3, 4, and 5. Accessor B serves the rest of the frames in the library.

Example 5-53   setAccessorZones default

```
setAccessorZones Yes,255
The accessor zones was updated successfully
```

setAutoEjectCleaningCarts

Use the **setAutoEjectCleaningCarts** command to set the `enabled` or `disabled` flag for the auto eject expired cleaning cartridges function in the library.

The command uses this syntax:

`setAutoEjectCleaningCarts enabled or disabled`

Set the auto eject expired cleaning cartridges function flag:

- ▶ enabled = on
- ▶ disabled = off

When the **setAutoEjectCleaningCarts** command executes successfully, the system returns output to your display, as shown in Example 5-54.

Example 5-54   The setAutoEjectCleaningCarts command

```
setAutoEjectCleaningCarts enabled
The auto eject cleaning cartridges flag was set successfully
```

setDrivePortsId

Use the **setDrivePortsId** command to set the ports' IDs for a specified drive (Port 1 and Port 2).

The command uses this syntax:

```
setDrivePortsIdPort1ID,Port2ID -f# -c# -r#
```

The number sign (#) variables in the syntax have the following values:

-f#	Frame number of the drive that contains ports 1 and 2.
-c#	Column number of the drive that contains ports 1 and 2.
-r#	Row number of the drive that contains ports 1 and 2.

When the **setDrivePortsId** command executes successfully, the system returns the result of the operation to your display, as shown in Example 5-55.

Example 5-55   The setDrivePortsId command

```
setDrivePortsId 18,21 -f1 -c1 -r1
The ports IDs were updated successfully
```

setISCSI

The **setISCSI** command updates the network configuration settings for a single Ethernet drive and to optionally change the name and alias of the drive. Each port can be configured separately with this command, whereas network changes made through the TS4500 management GUI are always applied to both ports.

To look up a drive's current settings, use the **viewISCSI** command or refer to the **Drives** → **Ethernet Ports** GUI page

The command uses this syntax:

```
setISCSI -portxAddress DHCP|[ip-address] -subnet [subnet-mask] -gateway
[gateway-address] -name DEFAULT|[iSCSI-name] -alias [iSCSI-alias] -f# -c# -r#
```

The parameters have the following values:

portxAddress DHCP | [ip-address]

Both ports can be modified at the same time. portxAddress is either **port0Address** for port 0 or **port1Address** for port 1

DHCP enables DHCP for the port selected

[ip-address] disables DHCP and assigns this value as the IP address for the specified port. (IPv4 format). You can specify the settings for one port or both ports in the same command

subnet [subnet-mask]. This is required if DHCP is being disabled. This is the subnet mask for the specified port

gateway [gateway-address]. This is required if DHCP is being disabled.This is the gateway for the specified port.

name DEFAULT│[iSCSI-name]. This is optional. The name for the drive.

> **DEFAULT** restores the drive name to the system-assigned name.

> **SCSI-name** is the new name for the drive. A port ID is required when specifying this parameter, even though the name is applied to the drive. You can specify either port

alias [iSCSI-alias] is an optional parameter and sets a new alias for the drive. A port ID is required when specifying this parameter, even though the alias is applied to the drive. You can specify either port.

[-f# -c# -r#] Is a required field and is the location of the drive, where:

> **-f#** = frame number
> **-c#** = column number
> **-r#** = row number

The command in Example 5-56 enables DHCP for port 0 of the drive in F1C4R1 and renames the drive to new-drive-name.

Example 5-56   setISCSI default command

```
setISCSI -port0Address DHCP -name new-drive-name -f1 -c4 -r1
The iSCSI Drive Port Settings were updated.
```

The command in Example 5-57 disables DHCP for port 0 of the drive in F1C4R1. It assigns the address 9.1.2.4 to port 0 and also assigns the provided subnet mask and gateway to the port.

Example 5-57   setISCSI set IP command

```
setISCSI -port0Address 9.1.2.4 -subnet 255.255.255.0 -gateway 9.1.0.100 -f1 -c4
-r1
The iSCSI Drive Port Settings were updated.
```

The command in Example 5-58 enables DHCP for port 0 and disables DHCP for port 1 of the drive in F1C4R1, and changes the alias for the drive to new-drive-alias.

Example 5-58   setISCSI alias command

```
setISCSI -port0Address DHCP -port1Address 9.1.2.5 -subnet 255.255.255.1 -gateway
9.1.0.100 -alias new-drive-alias -f1 -c4 -r1
The iSCSI Drive Port Settings were updated.
```

setLibraryTime

The **setLibraryTime** command takes the date, time, and time zone in the server where the CLI is running and sets the library with those parameters.

The command uses this syntax:

```
setLibraryTime
```

No parameters are necessary. When the `setLibraryTime` command executes successfully, the system returns the result of the operation to your display, as shown in Example 5-59.

Example 5-59   The setLibraryTime command

```
setLibraryTime
The library date and time were updated successfully
```

setMacAddress

The `setMacAddress` command changes the MAC address for an Ethernet port (or both ports). To look up a port's current MAC address. To look up a port's current MAC address, use the `viewMacAddress` command or refer to the **Drives** → **Ethernet Ports** GUI page.

The command uses this syntax:

```
setMacAddress -portxAddress DEFAULT|[MAC-address]} -portxAddress
DEFAULT|[MAC-address] <-f# -c# -r#>
```

The parameters have the following values:

► **portxAddress**, Both ports can be modified at the same time. portxAddress is either **port0Address** for port 0 or **port1Address** for port 1

► **DEFAULT** returns the MAC address to its default setting

► [MAC-address] is the new MAC address, expressed as a 12-digit hexadecimal number. It can be entered either with or without colons for example, 00:1a:64:eb:04:83 and 001a64eb0483 are both acceptable

► **-f# -c# -r#** is required and is the location of the drive:
   - **-f#** is the frame number
   - **-c#** is the column number
   - **-r#** is the row number

When the `setMacAddress` command executes successfully, the system returns the result of the operation to your display, as shown in Example 5-60. This example shows both accepted formats of the MAC address.

Example 5-60   The setMacAddress command

```
setMacAddress -port0Address 00:1a:64:eb:04:83 -port1Address 001a64eb0484 -f1 -c4
-r1
MAC address(es) updated.
```

setMaximumVIOCartridges

Use the `setMaximumVIOCartridges` command to update the number of virtual I/O slots for the logical library. The command uses this syntax:

```
setMaximumVIOCartridges logical library name, value [32-255]
```

The maximum number of cartridges can be any value from 32 through 255. When this command executes successfully, the system returns the results of the `setMaximumVIOCartridges` operation to your display.

Example 5-61 shows the command to set the maximum virtual I/O cartridges in `Library1` to `200`.

Example 5-61   The setMaximumVIOCartridges command

```
setMaximumVIOCartridges Library1,200
The MAX VIO was updated successfully
```

setNMADetection

Use the **setNMADetection** command to set (on or off) the No Motion Allowed (NMA) detection flag in the library.

The command uses this syntax:

```
setNMADetection TRUE or FALSE
```

The parameter can have either of these values:

TRUE   NMA detection is on.
FALSE   NMA detection is off.

When the **setNMADetection** command executes successfully, the system returns the result of the operation to your display, as shown in Example 5-62.

Example 5-62   The setNMADetection command

```
setNMADetection TRUE
The NMA detection flag was updated successfully
```

setRolePermissions

Use the **setRolePermissions** command with the output from the **viewRolePermissions** command. This command instructs the system to change the permissions for a specified role.

The command uses this syntax:

```
setRolePermissions filename_of_role_permissions.txt -role role name
```

The **setRolePermissions** command receives a text file (which was created by the **viewRolepermissions** command) as input. Each line in the text file is interpreted as an instruction to set a permission. The text file can be edited to change any of the access levels for the listed pages.

The following access levels are valid:

Read only   The user has read-only access to the web page.
Modify   The user can run the edit operation for the web page.
No Access   The user cannot view the web page.

You can edit the text file to contain only the names of the web pages and permissions to change.

Example 5-63 shows the input file that was originally generated by the **viewRolePermissions** command. In this case, the input file is unchanged. However, you can edit the input file to contain only the specific permissions to change with the **setRolePermissions** command.

Example 5-63   The setRolePermissions input file

```
                         Action,   Access Level
                            AIT,    No Access
                      Cartridges,     Modify
    Cartridges by Logical Library,     Modify
            Cleaning Cartridges,       Modify
                 Debug Messages,    No Access
                         Drives,       Modify
        Drives by Logical Library,     Modify
             Email Notifications,    Read Only
                Email Recipients,    Read Only
              Encryption Internal,   Read Only
           Encryption Key Manager,     Modify
                  Ethernet Ports,       Modify
                         Events,       Modify
            Library Information,       Modify
            Licensed Functions,       Modify
              Logical Libraries,       Modify
         Management GUI Behavior,       Modify
                 Master Console,    No Access
                 Password Rules,       Modify
               Position Control,    No Access
           Remote Authentication,     Modify
                          Roles,       Modify
             SNMP Destinations,       Modify
            SNMP Notifications,       Modify
                    Scan Speed,    No Access
            Secure Socket Layer,       Modify
                  Service Port,    No Access
           Syslogs Notifications,     Modify
                        System,       Modify
                        System,       Modify
            System Date and Time,       Modify
                         Tasks,       Modify
                         Users,       Modify
                 VOLSER Ranges,       Modify
   VOLSER Ranges by Logical Library,     Modify
```

When the **setRolePermissions** command executes successfully, the system returns output to your display. Example 5-64 shows the command that instructs the system to set the role permissions for the administrator role, according to information in the `administrator_permissions.txt` file.

Example 5-64   The setRolePermissions command

```
setRolePermissions administrator_permissions.txt role administrator
The permissions were updated successfully
```

setScannerSpeed

Use the **setScannerSpeed** command to set the speed of the scanner.

The command uses this syntax:

```
setScannerSpeed speed
```

The following values for the *speed* variable are valid:

► 0 (nominal speed)
► 30
► 40
► 50
► 60
► 70
► 80
► 90
► 100

When the **setScannerSpeed** command executes successfully, the system returns output to your display. Example 5-65 shows the command that instructs the system to set the scanner speed to 100.

Example 5-65   The setScannerSpeed command

```
setScannerSpeed 100
The scanner speed was updated successfully
```

setSlotOffline

Use the **setSlotOffline** command to set a storage slot offline.

The command uses this syntax:

```
setSlotOffline -f# -c# -r#
```

The number sign (#) variables are defined in the following manner:

-f#   Frame number of the slot
-c#   Column number of the slot
-r#   Row number of the slot

> **Note:** When you use **r** =0, all rows for the specific column are set offline.

When the **setSlotOffline** command executes successfully, the system returns output to your display. Example 5-66 shows that the command was successful.

Example 5-66   The setSlotOffline command

```
setSlotOffline -f1 -c4 -r3
Storage Slot was set offline
```

setSlotOnline

Use the **setSlotOnline** command to set a storage slot online.

The command uses this syntax:

```
setSlotOnline -f# -c# -r#
```

The number sign (#) variables are defined in the following manner:

-f#   Frame number of the slot
-c#   Column number of the slot
-r#   Row number of the slot

> **Note:** When you use **r** =0, all rows for the specific column are set online.

When the `setSlotOnline` command executes successfully, the system returns output to your display. Example 5-67 shows that the command was successful.

Example 5-67   The setSlotOnline command

```
setSlotOnline -f1 -c4 -r3
Storage Slot was set online
```

setSSL

Use the `setSSL` command to set the Secure Sockets Layer (SSL) flag to `enabled` or `disabled`.

The command uses this syntax:

```
setSSL enabled or disabled
```

When the `setSSL` command executes successfully, the system returns output to your display. Example 5-68 shows the command that instructs the system to set the SSL flag to `enabled`.

Example 5-68   The setSSL command

```
setSSL enabled
The SSL flag was updated successfully
```

showQueuedExports

Use the `showQueuedExports` command to set a flag to show or hide the list of queued exports. This command is useful to view the status of your recent export jobs, cancel active jobs, or remove any of your recent jobs from the list.

The command uses this syntax:

```
showQueuedExports logical library name, flag value [true / false]
```

A flag value of `true` *shows* the queued exports list. A flag value of `false` *hides* the queued exports list.

When this command executes successfully, the system returns the results of the `showQueuedExports` operation to your display. Example 5-69 shows the command that shows the queued exports list for the `Library1` logical library.

Example 5-69   The showQueuedExports command

```
showQueuedExports Library1, true
Queued exports flag was updated successfully
```

startLibraryVerify

Use the **startLibraryVerify** command to start the library verification process for I/O stations. When the command completes, you will be prompted to open all I/O station doors and then run the **continueLibraryVerify** command. (Library verification is a three-step process in which the following commands must be run in this order: **startLibraryVerify**, **continueLibraryVerify**, and **continueCloseLibraryVerify**).

The command uses this syntax:

```
startLibraryVerify
```

When the **startLibraryVerify** command executes successfully, the system returns output to your display, as shown in Example 5-70.

Example 5-70   The startLibraryVerify command

```
startLibraryVerify
Library verify - IO stations - has started...Library verify in progress
...................................................................................
..........Done!
Next step: OPEN all IO doors , and then use "continueLibraryVerify" command to
continue the test
```

version

Use the **version** command to view the current version of the Gen 4 TS4500 Web Interface CLI program.

The command uses this syntax:

```
version
```

When the **version** command executes successfully, the system returns output to your display, as shown in Example 5-71.

Example 5-71   The version command

```
version
CLI GEN 4 Version: 1.29
Build: 05/15/2017
```

viewAccessor

Use the **viewAccessor** command to show the accessor's status and usage statistics. The **viewAccessor** command has no parameters.

When the **viewAccessor** command executes successfully, the system returns output to your display, as shown in Example 5-72.

Example 5-72   The viewAccessor command

```
viewAccessor
Availability
                ,      Accessor A
         Accessor,    OK - Online
        Gripper 1,    OK - Online
        Gripper 2,    OK - Online
```

```
Usage Statistics
                          ,        Accessor A Component
                  Pivots,                          195
          Gripper 1 gets,                            5
          Gripper 1 puts,                            5
          Gripper 2 gets,                            1
          Gripper 2 puts,                            1
          Bar code scans,                         9355
      X travel (meters),                           112
      Y travel (meters),                           138
```

viewAccessorZones

Used the `viewAccessorZones` command to view which tape drives and I/O stations (within sets of frames) are being served by which accessor. You can also view these settings in the TS4500 management GUI on the **Settings** → **Library** → **Cartridges `and` `Accessors`** page.

The command uses this syntax:

```
viewAccessorZones > outputfilename.csv
```

Use the `viewAccessorZones > outputilename.csv` command to instruct the system to generate a .csv file from the output by typing a name, as a parameter to the command, for the file that is generated:

```
viewNodeCards > any_name_you_want.csv
```

The system generates the .csv file and stores it in the directory that contains the TS4500CLI.jar file. No message is returned to your display. To store the .csv file in another directory, specify the name of the directory in the command, as shown in Example 5-73.

Example 5-73   The viewAccessorZones command

```
viewAccessorZones
Accessor A: 1 - 12
Accessor B: 13 - 16
```

viewAdvancedEncryptionSettings

Used the `viewAdvancedEncryptionSettings` command to view high-level information for the encryption settings for a specific logical library.

The command uses this syntax:

```
viewAdvancedEncryptionSettings [Logical Library Name]
```

The `viewAdvancedEncryptionSettings` command displays information for all of the encryption settings for a specific logical library that is named Redbooks, as shown in Example 5-74.

Example 5-74   The viewAdvancedEncryptionSettings command

```
viewAdvancedEncryptionSettings Redbooks
            Name:                        Redbooks
  Advanced Method:          No advanced setting
  Advanced Policy:          No advanced setting
     Density Code:          No advanced setting
         Key Path:          No advanced setting
```

viewBEP

Use the `viewBEP` command to show a list of all VOLSER ranges that shows the bar code encryption policy (BEP) settings.

The `viewBEP` command has no parameters.

When the `viewBEP` command executes successfully, the system returns output to your display, as shown in Example 5-75.

Example 5-75   The viewBEP command

```
viewBEP
Index,Volser Start, Volser End,  Logical Library, Media Type,  KLM1, KLM2,  BEP
    1,      JK0000,     JK0009,         SLS_JAG1,       3592,     0,    0,    0
    2,      RBD000,     RBD099,   Redbooks_custom,      3592,     0,    0,    0
    3,      RBA000,     RBA999,     LTFS_redbooks,      3592,     0,    0,    0
    4,      DF0000,     DF9999,   Redbooks_custom,      3592,     0,    0,    0
```

viewCleaningCartridges

Use the `viewCleaningCartridges` command to view high-level information for all cleaning cartridges in a library.

The command uses this syntax:

```
viewCleaningCartridges
```

The `viewCleaningCartridges` command does not require any parameters. It instructs the system to display information for all of the cleaning cartridges in the library. When the `viewCleaningCartridges` command executes successfully, the system returns output to your display.

The output file sorts the names of the cleaning cartridges by VOLSER, as shown in Example 5-76.

Example 5-76   The viewCleaningCartridges command

```
viewCleaningCartridges
Volume Serial, Logical Library,Element Address, Media Type, Location(F,C,R),Cleans
remaining, Most Recent use
 CLN305L1,        255,      null,                      LTO,    Slot(F1,C6,R16,T0),
0,        04/25/2014 00:50:04
 CLN510L1,        255,      null,                      LTO,    Slot(F1,C6,R12,T0),
25,         05/08/2014 05:35:54
```

The same command can generate a `.csv` file that is downloaded into the directory of the `TS4500CLI.jar` file. Type a name, as a parameter to the command, for the file that is generated.

The command uses this syntax:

```
viewCleaningCartridges > any_name_you_want.csv
```

No message is returned to your display. To store the .csv file in another directory, specify the name of the directory in the command. Example 5-77 shows the command.

Example 5-77   Use viewCleaningCartridges to generate a .csv file

```
viewCleaningCartridges > C:\CLI\CVSFiles\cleaning_cartridges.csv
```

Note: All view commands can generate a .csv file by adding the **>** *any_name_you_want***.csv** parameter at the end of the command.

viewDataCartridges

Use the **viewDataCartridges** command to view the high-level information for all data cartridges in a library.

The command uses this syntax:

```
viewDataCartridges
```

The **viewDataCartridges** command does not require any parameters. It simply lists the information for all data cartridges in the library. When the **viewDataCartridges** command executes successfully, the system returns output to your display. The output file sorts the names of the data cartridges by VOLSER, as shown in Example 5-78.

Example 5-78   The viewDataCartridges command

```
viewDataCartridges
Volume Serial, Logical Library,Element Address, Media Type,
Location(F,C,R),Encryption, Most Recent use
IM1338L7,      Unassigned,      Unknown,             LTO, Slot(F1,C3,R1,T2),
Unknown,      04/24/2014 08:39:34
IM1364L7,      FC_LTO6_5856,              1054,      LTO,Slot(F4,C8,R38,T0), Not
Encrypted, 05/07/2014 15:24:24
IM1364L7,      FC_LTO6_5856,              1265,      LTO,Slot(F4,C8,R38,T0), Not
Encrypted, 05/07/2014 15:24:24
```

You can use the **viewDataCartridges** command to instruct the system to generate a .csv file from the output by typing a name, as a parameter to the command, for the file that is generated.

The command uses this syntax:

```
viewDataCartridges > any_name_you_want.csv
```

The system generates the .csv file and stores it in the directory that contains the TS4500CLI.jar file. No message is returned to your display. To store the .csv file in another directory, specify the name of the directory in the command, as shown in Example 5-79.

Example 5-79   The viewDataCartridges command with a .csv file

```
viewDataCartridges > C:\CLI\CVSFiles\todays_data_cartridges.csv
```

Note: All view commands can generate a .csv file by adding the **>** *any_name_you_want***.csv** parameter at the end of the command.

viewDriveDetails

The `viewDriveDetails` command provides a display of key information about the drive that is useful for troubleshooting. It displays the contents of the drive, name of the logical library, worldwide node numbers (WWNNs), port ID information, and so on.

The command uses this syntax:

```
viewDriveDetails -f# -c# -r#
```

The number sign (#) variables specify the location of the drive, and have the following values:

-f#   Frame number of the drive
-c#   Column number of the drive
-r#   Row number of the drive

When the `viewDriveDetails` command executes successfully, the system returns output to your display, as shown in Example 5-80.

Example 5-80   The viewDriveDetails command

```
viewDriveDetails -f 1 -c 4 -r  1
 Location(F,C,R)          F1, C4, R1
          State               ONLINE
           Type             3592-E07
Logical Library     Redbooks_custom
   Control Path             Enabled
       Contents               Empty
       Firmware                38A7
           WWNN     50050763001a000c
Element Address                  257
  Drive Display                   ND
         Port 0
        Loop ID                   13
           WWPN             005a000c
         Port 1
        Loop ID                   77
           WWPN             009a000c
```

The `viewDriveDetails` command can include a parameter that instructs the system to generate a .csv file from the output. Type a name, as a parameter to the command, for the file that is generated:

```
viewDriveDetails > any_name_you_want.csv
```

The system generates the .csv file and stores it in the directory that contains the `TS4500CLI.jar` file. No message is returned to your display. To store the .csv file in another directory, specify the name of the directory in the command, as shown in Example 5-81.

Example 5-81   The viewDriveDetails command with a .csv file

```
viewDriveDetails -f1 -c1 -r3 > C:\CLI\CVSFiles\drive_details.csv
```

Note: All view commands can generate a .csv by adding the **> *any_name_you_want*.csv** parameter at the end of the command.

viewDriveSummary

Use the `viewDriveSummary` command to show all of the drives in the library. This summary information is useful to network administrators who decide where to mount a cartridge. If you want to list detailed information about a specific drive, use the `viewDriveDetails` command.

The command uses this syntax:

```
viewDriveSummary
```

This command does not require any parameters. It lists a summary of information for all drives in the library. When the `viewDriveSummary` executes successfully, the system returns output to your display, as shown in Example 5-82.

Example 5-82   The viewDriveSummary command

```
viewDriveSummary
Location(F,C,R), State,   Type, Contents, Firmware, Serial,  WWWNN,Element
Address,Logical Library
  F1, C4, R1,   ONLINE,3592-E07,  Empty,   38A7 , 0000013B008E, ,
257,Redbooks_custom
  F1, C4, R4,   ONLINE,3592-E07,  Empty,   38A7 , 0000013B006F, ,
258,Redbooks_custom
```

The `viewDriveSummary` command can include a parameter that instructs the system to generate a `.csv` file from the output. Type a name, as a parameter to the command, for the file that is generated:

```
viewDriveSummary > any_name_you_want.csv
```

The system generates the `.csv` file and stores it in the directory that contains the `TS4500CLI.jar` file. No message is returned to your display. To store the `.csv` file in another directory, specify the name of the directory in the command, as shown in Example 5-83.

Example 5-83   The viewDriveSummary command with a .csv file

```
viewDriveSummary > C:\CLI\CVSFiles\drive_summary.csv
```

viewDriveVPD

Use the `viewDriveVPD` command to show vital product data (VPD) information for all drives. The `viewDriveVPD` command is useful if an administrator or IBM service support representative (SSR) needs to see information, such as a product model number, product release level, or other information that is specific to the device type.

The command uses this syntax:

```
viewDriveVPD
```

The `viewDriveVPD` command does not require any parameters. It lists all of the vital product data for all of the drives in the library.

When the `viewDriveVPD` command executes successfully, the system returns output to your display, as shown in Example 5-84.

Example 5-84   The viewDriveVPD command

```
viewDriveVPD
Location(F,C,R), Drive Type,Firmware Version, Machine Type, Serial number
 F1, C4, R1,     3592-E07,      38A7 ,         3592,          00013B008E
 F1, C4, R4,     3592-E07,      38A7 ,         3592,          00013B006
```

The `viewDriveVPD` command can include a parameter that instructs the system to generate a .csv file from the output. Type a name, as a parameter to the command, for the file that is generated:

viewDriveVPD > *any_name_you_want*.csv

The system generates the .csv file and stores it in the directory that contains the TS4500CLI.jar file. No message is returned to your display. To store the .csv file in another directory, specify the name of the directory in the command, as shown in Example 5-85.

Example 5-85   The viewDriveVPD command with a .csv file

```
viewDriveVPD  > C:\CLI\CVSFiles\drive_VPD.csv
```

viewFibreChannel

Use the `viewFibreChannel` command to show the Fibre Channel settings for both ports in each drive. This command is useful to view the configuration of the ports for the Fibre Channel switch and to ensure that the ports are configured correctly to be compatible with the type of network in use.

The command uses this syntax:

viewFibreChannel

The `viewFibreChannel` command does not require any parameters. When the `viewFibreChannel` command executes successfully, the system returns output to your display. The output file sorts the information by drive name, as shown in Example 5-86.

Example 5-86   The viewFibreChannel command

```
viewFibreChannel
      Drive,Location(F,C,R),Logical Library,  Type,  Port(1,2), Link
Status,Configured Link Speed,Configured Topology,Actual Link Speed,Actual Topology
0000013B008E, F1, C4, R1,Redbooks_custom,  3592-E07, 13,        No light,
Auto,  Auto (L Port),          Auto,        L Port
        ,        ,              ,          , 77,        No light,
Auto,  Auto (L Port),          Auto,        L Port
0000013B006F, F1, C4, R4,Redbooks_custom,  3592-E07, 16,        No light,
Auto,  Auto (L Port),          Auto,        L Port
        ,        ,              ,          , 80,        No light,
Auto,  Auto (L Port),          Auto,        L Port
```

The `viewFibreChannel` command can include a parameter that instructs the system to generate a .csv file from the output. Type a name, as a parameter to the command, for the file that is generated:

viewFibreChannel > *any_name_you_want*.csv

The system generates the .csv file and stores it in the directory that contains the TS4500CLI.jar file. No message is returned to your display. To store the .csv file in another directory, specify the name of the directory in the command, as shown in Example 5-87.

Example 5-87   The viewFibreChannel command with a .csv file

```
viewFibreChannel > C:\CLI\CVSFiles\fibre_channel_settings.csv
```

viewIoStation

Use the `viewIoStation` command to view a summary of information for all cartridges in the I/O station.

The command uses this syntax:

```
viewIoStation
```

The `viewIoStation` command does not require any parameters. It simply lists the high-level information for all cartridges in the I/O station. When the `viewIoStation` command executes successfully, the system returns output to your display, as shown in Example 5-88.

Example 5-88   The viewIoStation command

```
viewIoStation
Volume Serial,Logical Library,Element Address,Media
Type,Location(F,C,R),Encryption
M000NTJL, Logical Library 1, 1046, JAG, I/O Slot(F1,C5,R4,T1), Not Encrypted
M001NTJL, Logical Library 1, 1294, JAG, I/O Slot(F1,C6,R29,T0), Not Encrypted
```

Use the `viewIoStation` command (and all `view` commands) to instruct the system to generate a .csv file from the output by typing a name, as a parameter to the command, for the file that is generated:

```
viewIoStation > any_name_you_want.csv
```

The system generates the .csv file and stores it in the directory that contains the TS4500CLI.jar file. No message is returned to your display. To store the .csv file in another directory, specify the name of the directory in the command, as shown in Example 5-89.

Example 5-89   The viewIoStation command with a .csv file

```
viewIoStation > C:\CLI\CVSFiles\viewIoStation.csv
```

viewISCSI

Use the `viewISCSI` command to configuration settings for a specific Ethernet drive.

The command uses this syntax:

```
viewISCSI -f# -c# -r#
```

The number sign (#) variables specify the location of the drive, and have the following values:

- **-f#**   Frame number of the drive
- **-c#**   Column number of the drive
- **-r#**   Row number of the drive

When the `viewISCSI` command executes successfully, the system returns output to your display, as shown in Example 5-90.

Example 5-90   The viewISCSI command

```
viewISCSI -f4 -c3 -r1
iSCSI name:    naa.032165478954
iSCSI alias:   Drive05
DHCP:          Disabled
Port 0 address: 9.1.2.3
Port 1 address: 9.1.2.4
Gateway:       9.1.0.100
Subnet mask:   255.255.255.0
```

viewKeyLabelMapping

Use the `viewKeyLabelMapping` command to view the list of available key labels. The command uses this syntax:

```
viewKeyLabelMapping
```

When the `viewKeyLabelMapping` command executes successfully, the system returns output to your display, as shown in Example 5-91.

Example 5-91   The viewKeyLabelMapping command

```
viewKeyLabelMapping
 Index,         Map From Key Label,     Key Mode,        Map To Key Label
   1,               REDB,           Wrapped-Hash,       END
   2,               REDB1,           Direct-Default-Set, 0
   3,               REDB1,          Direct-Specific,     Red1
```

The values in the Index column are referenced when you run the `editKeyLabelMapping` and `deleteKeyLabelMapping` commands.

viewLibraryVPD

Use the `viewLibraryVPD` command to show vital product data (VPD) for the library. This command is useful if an administrator or service engineer needs to see the model or serial number or other information specific to the library. This command requires a service user to run.

The command uses this syntax:

```
viewLibraryVPD
```

When the `viewLibraryVPD` command executes successfully, the system returns output to your display, as shown in Example 5-92.

Example 5-92   The viewLibraryVPD command

```
viewLibraryVPD
     Location,       Machine Type,    Model,        Serial Number,Media Type
      Frame 1,             3584,       D25,            78CAFFF,       3592
      Frame 2,             3584,       L25,            78AAFFD,       3592
      Frame 3,             3584,       D55,            78DFFDS        LTO
```

The `viewLibraryVPD` command (and all `view` commands) can include a parameter that instructs the system to generate a .csv file from the output. Type a name, as a parameter to the command, for the file that is generated:

```
viewLibraryVPD > any_name_you_want.csv
```

The system generates the .csv file and stores it in the directory that contains the `TS4500CLI.jar` file. No message is returned to your display. To store the .csv file in another directory, specify the name of the directory in the command, as shown in Example 5-93.

Example 5-93   The viewLibraryVPD command with a .csv file

```
viewLibraryVPD > C:\CLI\CVSFiles\loglib_VPD.csv
```

viewLogicalLibraries

Use the `viewLogicalLibraries` command to list the high-level information for all logical libraries. If you need to list detailed information for a specific library, use the `viewLogicalLibraryDetails` command.

The command uses this syntax:

```
viewLogicalLibraries
```

The `viewLogicalLibraries` command does not require any parameters. It lists the information for all logical libraries. When this command executes successfully, the system returns output to your display, as shown in Example 5-94.

Example 5-94   The viewLogicalLibraries command

```
viewLogicalLibraries
Name,    Type, Assigned Cartridges,  Virtual I/O cartridges,    Drives,Encryption
Method, Queued Exports,VOLSER Reporting (6/8 characters)
LTFS_redbooks, 3592, 23, 0, 4, No, Show, 8
Redbooks_custom, 3592, 235, 0, 2, Application managed, Show, 8
SLS_JAG1, 3592, 197, 0, 3, No, Show, 8
```

> **Note:** The Queued Exports information and the VOLSER Reporting information are available only through the `viewLogicalLibraryDetails` command at the CLI. This information is not available through the TS4500 management GUI.

The `viewLogicalLibraries` command can include a parameter that instructs the system to generate a .csv file from the output. Type a name, as a parameter to the command, for the file that is generated:

```
viewLogicalLibraries > any_name_you_want.csv
```

The system generates the .csv file and stores it in the directory that contains the `TS4500CLI.jar` file. No message is returned to your display. To store the .csv file in another directory, specify the name of the directory in the command, as shown in Example 5-95.

Example 5-95   The viewLogicalLibraries command

```
viewLogicalLibraries > C:\CLI\CVSFiles\viewLogicalLibraries.csv
```

viewLogicalLibraryDetails

Use the **viewLogicalLibraryDetails** command to show the name, type, maximum number of cartridges, number of virtual I/O slot addresses, and number of drive addresses in a specified logical library.

The command uses this syntax:

```
viewLogicalLibraryDetails "logical library name"
```

> **Important:** Parameters for the **viewLogicalLibraryDetails** command must be enclosed in double quotation marks.

When the **viewLogicalLibraryDetails** command executes successfully, the system returns output to your display, as shown in Example 5-96.

Example 5-96   The viewLogicalLibraryDetails command

```
viewLogicalLibraryDetails "library 1"
Name, Type, Max Cartridges, Virtual I/O slot addresses,Drive Addresses,
Library1, 3592, 1000, 130(768-897), 68(257-321)
```

The **viewLogicalLibraryDetails** command (and all **view** commands) can include a parameter that instructs the system to generate a .csv file from the output. Type a name, as a parameter to the command, for the file that is generated:

```
viewLogicalLibraryDetails > any_name_you_want.csv
```

The system generates the .csv file and stores it in the directory that contains the TS4500CLI.jar file. No message is returned to your display. To store the .csv file in another directory, specify the name of the directory in the command, as shown in Example 5-97.

Example 5-97   The viewLogicalLibraryDetails command with a .csv file

```
viewLogicalLibraryDetails "library 1" > C:\CLI\CVSFiles\loglib_details.cs
```

viewMacAddress

Use the **viewMacAddress** command to look up the MAC addresses for a drive's Ethernet ports.

The command uses this syntax:

```
viewMacAddress -f# -c# -r#
```

The number sign (#) variables specify the location of the drive, and have the following values:

-f#   Frame number of the drive
-c#   Column number of the drive
-r#   Row number of the drive

When the **viewMacAddress** command executes successfully, the system returns output to your display, as shown in Example 5-98.

Example 5-98   The viewMacAddress command

```
viewMacAddress -f4 -c3 -r1
Port 0 MAC Address:  00:1a:64:eb:04:83
Port 1 MAC Address:  00:1a:64:eb:04:84
```

viewNodeCards

Use the `viewNodeCards` command to show a summary of information about the node cards.

The command uses this syntax:

```
viewNodeCards
```

The `viewNodeCards` command does not require any parameters. It simply lists the high-level information for all node cards in the system. When the `viewNodeCards` command executes successfully, the system returns output to your display, as shown in Example 5-99.

Example 5-99   The viewNodeCards command

```
viewNodeCards
                 Card name,  Location,Part number,Serial number, Firmware version
                 XY Card A, Accessor A,  95P8618,   YN11MA42NF87,
                 XY Card B, Accessor B,  95P8618,   YN11MA57SGZD,
Accessor Controller Card A, Accessor A,  46X5961,   YN10MA42WFLT,
Accessor Controller Card B, Accessor B,  46X5961,   YN10MA5AH03L,
                    LCC A,     Frame 1,  12X5001,   Y1Y0103CK628, 1.4.0.1-A02.00
                    LCC A,     Frame 2,  12X5001,   Y1Y01055B01N, 1.4.0.1-A02.00
                    LCC A,     Frame 3,  12X5001,   Y1Y01077761G, 1.4.0.1-A02.00
```

Use the `viewNodeCards` command to instruct the system to generate a .csv file from the output by typing a name, as a parameter to the command, for the file that is generated:

```
viewNodeCards > any_name_you_want.csv
```

The system generates the .csv file and stores it in the directory that contains the `TS4500CLI.jar` file. No message is returned to your display. To store the .csv file in another directory, specify the name of the directory in the command, as shown in Example 5-100.

Example 5-100   The viewNodeCards command with a .csv file

```
viewNodeCards > C:\CLI\CVSFiles\node_cards.csv
```

viewOfflineComponents

Use the `viewOfflineComponents` command to show a list of offline slots.

The command uses this syntax:

```
viewOfflineComponents
```

The `viewOfflineComponents` command does not require any parameters. It simply lists all offline storage slots. When the `viewOfflineComponents` command executes successfully, the system returns output to your display, as shown in Example 5-101.

Example 5-101   The viewOfflineComponents command

```
viewOfflineComponents
Frame,     Column ,Row , Status
   1 ,       3    , 1  , Offline
   1 ,       3    , 2  , Offline
   1 ,       3    , 3  , Offline
```

Use the `viewOfflineComponents` command to instruct the system to generate a .csv file from the output by typing a name, as a parameter to the command, for the file that is generated:

```
viewOfflineComponents > any_name_you_want.csv
```

The system generates the .csv file and stores it in the directory that contains the TS4500CLI.jar file. No message is returned to your display. To store the .csv file in another directory, specify the name of the directory in the command, as shown in Example 5-102.

Example 5-102   The viewOfflineComponents command with a .csv file

```
viewOfflineComponents > C:\CLI\CVSFiles\Offline_Slots.csv
```

viewRolePermissions

Use the `viewRolePermissions` command to display a list of all of the permissions for a specified role. The output shows a list of the web pages in the library that are available to that role, and the corresponding access level.

The command uses this syntax:

```
viewRolePermissions role name filename.txt
```

The **filename.txt** variable is optional. When you specify a file name, you instruct the system to generate a .txt file that can be used with the **setRolePermissions** command. The system generates the .txt file and stores it in the directory that contains the TS4500CLI.jar file. The text file can be edited to change any of the access levels for the listed pages.

The following access levels are valid:

Read only   The user has read-only access to the web page.
Modify   The user can execute the edit operation for the web page.
No Access   The user cannot view the web page.

When the `viewRolePermissions` command executes successfully, the system returns output to your display, as shown in Example 5-103.

Example 5-103   The viewRolePermissions command

```
viewRolePermissions Redbooks name role.txt
                        Action,    Access Level
                           AIT,     No Access
                    Cartridges,       Modify
    Cartridges by Logical Library,    Modify
            Cleaning Cartridges,      Modify
                Debug Messages,     No Access
                        Drives,       Modify
        Drives by Logical Library,    Modify
            Email Notifications,      Modify
              Email Recipients,       Modify
            Encryption Internal,      Modify
         Encryption Key Manager,      Modify
                Ethernet Ports,       Modify
                        Events,       Modify
            Library Information,      Modify
            Licensed Functions,       Modify
              Logical Libraries,      Modify
        Management GUI Behavior,      Modify
                Master Console,     No Access
                Password Rules,       Modify
              Position Control,     No Access
          Remote Authentication,      Modify
                         Roles,       Modify
```

```
             SNMP Destinations,         Modify
             SNMP Notifications,        Modify
                     Scan Speed,     No Access
            Secure Socket Layer,        Modify
                   Service Port,     No Access
            Syslogs Notifications,      Modify
                         System,        Modify
            System Date and Time,        Modify
                          Tasks,        Modify
                          Users,        Modify
                  VOLSER Ranges,        Modify
 VOLSER Ranges by Logical Library,      Modify
```

viewRoles

Use the **viewRoles** command to display a list of all of the defined roles in the library.

The command uses this syntax:

```
viewRoles
```

The **viewRoles** command does not require any parameters. It instructs the system to display information for all roles in the library. When the **viewRoles** command executes successfully, the system returns output to your display, as shown in Example 5-104.

Example 5-104   The viewRoles command

```
viewRoles
              Role,Mapped users
     Administrator,        5
         Superuser,        0
           Service,        2
           Monitor,        1
           Custom1,        0
          Redbooks,        0
         RemoteAcc,        0
```

The **viewRoles** command can include a parameter that instructs the system to generate a .csv file from the output. Type a name, as a parameter to the command, for the file that is generated:

```
viewRoles > any_name_you_want.csv
```

The system generates the .csv file and stores it in the directory that contains the TS4500CLI.jar file. No message is returned to your display. To store the .csv file in another directory, specify the name of the directory in the command, as shown in Example 5-105.

Example 5-105   The viewRoles command with a .csv file

```
viewRoles > C:\CLI\CVSFiles\Roles.csv
```

viewSnapshots

Use the **viewSnapshots** command to display a list of all available snapshots in the library. The files in the list can be used with the **downloadSnapshot** command.

The command uses this syntax:

```
viewSnapshots
```

The **viewSnapshots** command does not require any parameters. It simply instructs the system to display information for all available snapshots in the library. When the **viewSnapshots** command executes successfully, the system returns output to your display, as shown in Example 5-106.

Example 5-106   The viewSnapshots command

```
viewSnapshots
1 - TS4500_SS_FA010_20140515124107.zip
2 - TS4500_SS_FA010_20140519105428.zip
3 - TS4500_SS_FA010_20140519105917.zip
4 - TS4500_SS_FA010_20140519110938.zip
5 - TS4500_SS_FA010_20140520213407.zip
6 - TS4500_SS_FA010_20140520213706.zip
```

The **viewSnapshots** command (and all **view** commands) can include a parameter that instructs the system to generate a .csv file from the output. Type a name, as a parameter to the command, for the file that is generated:

```
viewSnapshots > any_name_you_want.csv
```

The system generates the .csv file and stores it in the directory that contains the `TS4500CLI.jar` file. No message is returned to your display. To store the .csv file in another directory, specify the name of the directory in the command, as shown in Example 5-107.

Example 5-107   The viewSnapshots command with a .csv file

```
viewSnapshots > C:\CLI\CVSFiles\Snapshots.csv
```

viewSystemSummary

Use the **viewSystemSummary** command to view the physical library system summary. The **viewSystemSummary** command is useful for users who need to view information about each frame, or see a summary of the total storage capacity.

The command uses this syntax:

```
viewSystemSummary
```

The **viewSystemSummary** command does not require any parameters. It lists the information about each frame in ascending order by frame number. When the **viewSystemSummary** command executes successfully, the system returns output to your display, as shown in Example 5-108.

Example 5-108   The viewSystemSummary command

```
viewSystemSummary
                    Frame:                 1
                    State:     Door Closed
               Media Type:              3592
          Data Cartridges:                 0
            Storage Slots:               660
                   Drives:                 2
                      MTM:           3584L25
                      S/N:           13FA010
-------------------------------------------
                    Frame:                 2
                Accessors:     OK - Online
                    State:     Door Closed
               Media Type:              3592
          Data Cartridges:                15
            Storage Slots:               875
                   Drives:                 0
                      MTM:           3584D25
                      S/N:           13FA107
-------------------------------------------
       Total storage slots:              1535
   Total storage cartridges:               15
            Total IO slots:                 0
        Total IO cartridges                13
              Total Drives:                 2
               Total Frames                 2
```

The **viewSystemSummary** command can instruct the system to generate a .csv file from the output. Type a name, as a parameter to the command, for the file that is generated:

```
viewSystemSummary > any_name_you_want.csv
```

The system generates the .csv file and stores it in the directory that contains the TS4500CLI.jar file. No message is returned to your display. To store the .csv file in another directory, specify the name of the directory in the command, as shown in Example 5-109.

Example 5-109   The viewSystemSummary command with a .csv file

```
viewSystemSummary > C:\CLI\CVSFiles\system_summary.csv
```

viewSystemSummaryDetails

Use the **viewSystemSummaryDetails** command to view detailed information about a specified frame. The **viewSystemSummaryDetails** command does not instruct the system to list summary information about all frames in the library. If you need to view summary information about all frames in the library, use the **viewSystemSummary** command. The command uses this syntax:

```
viewSystemSummaryDetails frame#
```

The pound sign (#) variable in the command specifies the frame number of the frame for which you want details. If the input frame is not available in the library, the system displays an error message.

When the `viewSystemSummaryDetails` command executes successfully, the system returns output to your display, as shown in Example 5-110.

Example 5-110 The viewSystemSummaryDetails command

```
viewSystemSummaryDetails 2
                    Frame:              2
                    State:      Door Closed
               Media Type:           3592
          Data Cartridges:            206
            Storage Slots:            550
                   Drives:              4
       Upper IO cartridges:             0
       Upper IO door slots:            16
   Upper IO door media type:         3592
       Lower IO cartridges:             0
       Lower IO door slots:            16
   Lower IO door media type:         3592
                      MTM:         3584D25
                      S/N:         78D3746
```

The `viewSystemSummaryDetails` command can instruct the system to generate a .csv file from the output. Type a name, as a parameter to the command, for the file that is generated:

`viewSystemSummaryDetails > `*`any_name_you_want`*`.csv`

The system generates the .csv file and stores it in the directory that contains the `TS4500CLI.jar` file. No message is returned to your display. To store the .csv file in another directory, specify the name of the directory in the command, as shown in Example 5-111.

Example 5-111 The viewSystemSummaryDetails command with a .csv file

`viewSystemSummaryDetails > C:\CLI\CVSFiles\system_summary_Detail.csv`

Note: The system does not display any information about accessors if the specified frame does not have accessors.

viewUsers

Use the `viewUsers` command to display a list of all of the users in the library.

The command uses this syntax:

`viewUsers`

The `viewUsers` command does not require any parameters. It instructs the system to display information for all users in the library. When the `viewUsers` command executes successfully, the system returns output to your display, as shown in Example 5-112.

Example 5-112 The viewUsers command

```
viewUsers
   Name,Locked,      State,          Role, Email,      Last login
  admin, , Disconnected,  Administrator,,Wednesday, May 14, 2014, 06:20:16 AM MST
 admin2, , Disconnected,  Administrator,, Tuesday, April 8, 2014, 07:02:48 AM MST
```

```
LocalGUI, , Disconnected,        Monitor,,  Tuesday, May 20, 2014, 02:43:50 PM MST
 Redbooks, , Connected,  Administrator,,Wednesday, May 21, 2014, 09:33:06 AM MST
 Service, , Disconnected,        Service,,  Tuesday, May 20, 2014, 02:42:36 PM MST
```

The `viewUsers` command can include a parameter that instructs the system to generate a
.csv file from the output. Type a name, as a parameter to the command, for the file that
is generated:

```
viewUsers > any_name_you_want.csv
```

The system generates the .csv file and stores it in the directory that contains the
TS4500CLI.jar file. No message is returned to your display. To store the .csv file in another
directory, specify the name of the directory in the command, as shown in Example 5-113.

Example 5-113   The viewUsers command with a .csv file

```
viewUsers  > C:\CLI\CVSFiles\viewUsers.csv
```

viewVolserRanges

Use the `viewVolserRanges` command to list all of the VOLSER ranges in the physical library.
To list all of the VOLSER ranges that are assigned for each logical library, use the
`viewVolserRangesByLL` command.

The command uses this syntax:

```
viewVolserRanges
```

The `viewVolserRanges` command does not require any parameters. It lists the information for
all of the VOLSER ranges in the physical library. When the `viewVolserRanges` command
executes successfully, the system returns output to your display, as shown in Example 5-114.

Example 5-114   The viewVolserRanges command

```
viewVolserRanges
  Volser start - Volser end,Logical Library,  Media Type,Number of cartridges
          DF0000 - DF9999,Redbooks_custom,     3592,          0
          JK0000 - JK0009,    SLS_JAG1,        3592,          2
          RBA000 - RBA999,LTFS_redbooks,       3592,          0
          RBD000 - RBD099,Redbooks_custom,     3592,          0
```

The `viewVolserRanges` command can include a parameter that instructs the system to
generate a .csv file from the output. Type a name, as a parameter to the command, for the file
that is generated:

```
viewVolserRanges > any_name_you_want.csv
```

The system generates the .csv file and stores it in the directory that contains the
TS4500CLI.jar file. No message is returned to your display. To store the .csv file in another
directory, specify the name of the directory in the command, as shown in Example 5-115.

Example 5-115   The viewVolserRanges command with a .csv file

```
viewVolserRanges > C:\CLI\CVSFiles\volser_ranges.csv
```

viewVolserRangesByLL

Use the `viewVolserRangesByLL` command to list all of the VOLSER ranges for each logical library in the physical library. To list all of the VOLSER ranges for the physical library, use the `viewVolserRanges` command.

The command uses this syntax:

```
viewVolserRangesByLL
```

The `viewVolserRangesByLL` command does not require any parameters. It simply lists the information for all of the VOLSER ranges in each logical library in the physical library. When the `viewVolserRangesByLL` command executes successfully, the system returns output to your display, as shown in Example 5-116.

Example 5-116   The viewVolserRangesByLL command

```
viewVolserRangesByLL
Logical Library,  Cartridges,  Media Type
  LTFS_redbooks,              0,            3592
RBA000 - RBA999,             0
Redbooks_custom,             0,            3592
DF0000 - DF9999,             0
RBD000 - RBD099,             0
       SLS_JAG1,              0,            3592
 K0000 - JK0009,             2
```

Use the `viewVolserRangesByLL` command to instruct the system to generate a .csv file from the output by typing a name, as a parameter to the command, for the file that is generated:

```
viewVolserRangesByLL > any_name_you_want.csv
```

The system generates the .csv file and stores it in the directory that contains the `TS4500CLI.jar` file. No message is returned to your display. To store the .csv file in another directory, specify the name of the directory in the command, as shown in Example 5-117.

Example 5-117   The viewVolserRangesByLL command with a .csv file

```
viewVolserRangesByLL > C:\CLI\CVSFiles\volser_ranges_by_ll.csv
```

Related publications

The publications listed in this section are particularly suitable for a more detailed discussion of the topics covered in this book.

IBM Redbooks

The following IBM Redbooks publications provide additional information about the topic in this document. Note that some publications referenced in this list might be available in softcopy only.

► *IBM Tape Library Guide for Open Systems*, SG24-5946

► *IBM Spectrum Archive Enterprise Edition V1.2.5.1 Installation and Configuration Guide*, SG24-8333

► *IBM Linear Tape File System Installation and Configuration*, SG24-8090

► *Implementing IBM Tape in Linux and Windows*, SG24-6268

► *Implementing IBM Tape in UNIX Systems*, SG24-6502

You can search for, view, download or order these documents and other Redbooks, Redpapers, Web Docs, draft and additional materials, at the following website:

ibm.com/redbooks

Other publications

These publications are also relevant as further information sources:

► *IBM Tape Device Drivers Installation and User's Guide*, GC27-2130

http://www.ibm.com/support/docview.wss?uid=ssg1S7002972

► *IBM TS4500 Introduction and Planning Guide,* SC27-5990

http://www.ibm.com/support/docview.wss?uid=ssg1S7005016

► *IBM TotalStorage Enterprise Tape System 3592 Introduction and Planning Guide,* GA32-0555

http://www.ibm.com/support/docview.wss?uid=ssg1S7005233

► *IBM TotalStorage LTO Ultrium Tape Drive SCSI Reference (LTO-5 through LTO-8)*, GA32-0928

http://www.ibm.com/support/docview.wss?uid=ssg1S7003556

► *IBM 3592 SCSI Reference*, GA32-0562

https://www.ibm.com/support/docview.wss?uid=ssg1S7003248

► *IBM Tape System Library Manager User's Guide*, GA32-2208

http://www.ibm.com/support/docview.wss?uid=pub1ga32220802

Online resources

These web pages are helpful for more information:

- ► IBM System Storage Interoperation Center (SSIC)

  https://www.ibm.com/systems/support/storage/ssic/interoperability.wss

- ► IBM Spectrum Archive Library Edition (LE) documentation, IBM Knowledge Center

  http://www.ibm.com/support/knowledgecenter/STZMZN/com.ibm.storage.hollywood.doc
  /ltfs_le_ichome.html

- ► IBM Spectrum Archive Enterprise Edition documentation, IBM Knowledge Center

  http://www.ibm.com/support/knowledgecenter/ST9MBR

- ► Library and drive firmware packages in IBM Fix Central

  http://www.ibm.com/support/fixcentral

- ► IBM Security Identity Manager V6.0.0 documentation, IBM Knowledge Center

  http://www.ibm.com/support/knowledgecenter/SSRMWJ_6.0.0/com.ibm.isim.doc_6.0/ic
  -homepage.htm

- ► IBM Security Key Lifecycle Manager product ordering and resources website

  http://www.ibm.com/software/products/en/key-lifecycle-manager

- ► IBM Security Key Lifecycle Manager V2.5 documentation section in IBM Knowledge Center

  http://www.ibm.com/support/knowledgecenter/SSWPVP_2.5.0/com.ibm.sklm.doc_2.5/we
  lcome.htm?lang=en

- ► IBM tape storage products for data protection and long-term retention

  http://www.ibm.com/systems/storage/tape

- ► IBM Linear Tape File System (LTFS)

  http://www.ibm.com/systems/storage/tape/ltfs

- ► TS4500 documentation

  http://www.ibm.com/support/knowledgecenter/STQRQ9/com.ibm.storage.ts4500.doc/ts
  4500_ichome.html

- ► TS4500 product overview

  http://www.ibm.com/systems/storage/tape/ts4500

- ► ISV matrix, which is available to download as a PDF file from the "Independent Software Vendor Matrix (ISV) for IBM TotalStorage 3592 tape drives and LTO" from the TS4500 product web page under Resources link

  https://www.ibm.com/common/ssi/cgi-bin/ssialias?subtype=WH&infotype=SA&appname=
  STGE_IV_IV_USEN&htmlfid=IVL12347USEN&attachment=IVL12347USEN.PDF

- ► IBM Data Protection & Retention (DP&R) System Connectivity and Security

  http://www.ibm.com/support/techdocs/atsmastr.nsf/WebIndex/WP102531

Help from IBM

IBM Support and downloads

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IBM Global Services

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