IBM FlashSystem A9000
Models 9836-415, 9838-415, 9836-425, 9838-425, and 9838-U25

Deployment Guide

Note

Before using this information and the product it supports, read the information in “Safety and environmental notices” on page xi and “Notices” on page 65.

Fourth Edition (November 2022)

This edition applies to IBM FlashSystem A9000 12.3.x . Newer document editions may be issued for the same product version in order to add missing information, update information, or amend typographical errors.

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Contents

Figures

Tables

Safety and environmental notices

Review the safety notices, environmental notices, and electronic emission notices for this product before you install and use the product.

Safety notices and labels

Review the safety notices and safety information labels before using this product.

IBM Systems safety notices and information

This publication contains the safety notices for the IBM Systems products in English and other languages. It also contains safety information labels found on the hardware in English and other languages. Anyone who plans, installs, operates, or services the system must be familiar with and understand the safety notices. Read the related safety notices before beginning work.

Environmental and safety notices (ibm.com®/docs/en/environmental-safety?topic=environmental-safety-notices)

The publication is organized into three sections:

Safety notices

Lists the danger and caution notices without labels, organized alphabetically by language.

The following notices and statements are used in IBM documents. They are listed in order of decreasing severity of potential hazards.

Danger notice definition
A special note that calls attention to a situation that is potentially lethal or extremely hazardous to people.

Caution notice definition
A special note that calls attention to a situation that is potentially hazardous to people because of some existing condition, or to a potentially dangerous situation that might develop because of some unsafe practice.

Labels
Lists the danger and caution notices that are accompanied with a label, organized by label reference number.

Text-based labels
Lists the safety information labels that might be attached to the hardware to warn of potential hazards, organized by label reference number.

Note: This product has been designed, tested, and manufactured to comply with IEC 60950-1, and where required, to relevant national standards that are based on IEC 60950-1.

Finding translated notices

Each safety notice contains an identification number. You can use this identification number to check the safety notice in each language. The list of notices that apply to this product are listed in the “Special caution and safety notices” on page xiv and “Environmental notices” on page xvi topics of this guide.

To find the translated text for a caution or danger notice:

1. In the product documentation, look for the identification number at the end of each caution notice or each danger notice. In the following examples, the numbers (D002) and (C001) are the identification numbers.

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DANGER: A danger notice indicates the presence of a hazard that has the potential of causing death or serious personal injury. (D002)

CAUTION: A caution notice indicates the presence of a hazard that has the potential of causing moderate or minor personal injury. (C001)

2. Open the Environmental and safety notices.
3. Under the language, find the matching identification number. Review the topics concerning the safety notices to ensure that you are in compliance.

To view a PDF file, you need Adobe Reader. You can download it at no charge from the Adobe website (get.adobe.com/reader/).

Danger notices for IBM FlashSystem A9000 systems

Ensure that you understand the danger notices for IBM FlashSystem A9000 systems.

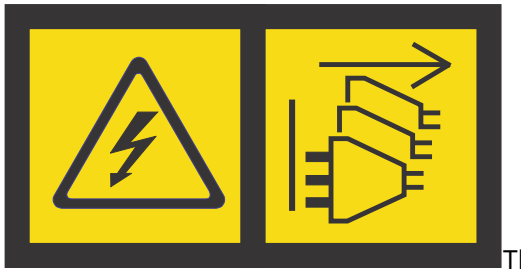
Danger notices

Use the reference numbers in parentheses at the end of each notice, such as (D001), to find the matching translated notice in *IBM Systems Safety Notices* .

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

DANGER: When working on or around the system, observe the following precautions:

Electrical voltage and current from power, telephone, and communication cables are hazardous. To avoid a shock hazard: If IBM supplied the power cord(s), connect power to this unit only with the IBM provided power cord. Do not use the IBM provided power cord for any other product. Do not open or service any power supply assembly. Do not connect or disconnect any cables or perform installation, maintenance, or reconfiguration of this product during an electrical storm.

-  The product might be equipped with multiple power cords. To remove all hazardous voltages, disconnect all power cords. For AC power, disconnect all power cords from their AC power source. For racks with a DC power distribution panel (PDP), disconnect the customer's DC power source to the PDP.
- When connecting power to the product ensure all power cables are properly connected. For racks with AC power, connect all power cords to a properly wired and grounded electrical outlet. Ensure that the outlet supplies proper voltage and phase rotation according to the system rating plate. For racks with a DC power distribution panel (PDP), connect the customer's DC power source to the PDP. Ensure that the proper polarity is used when attaching the DC power and DC power return wiring.
- Connect any equipment that will be attached to this product to properly wired outlets.
- When possible, use one hand only to connect or disconnect signal cables.
- Never turn on any equipment when there is evidence of fire, water, or structural damage.
- Do not attempt to switch on power to the machine until all possible unsafe conditions are corrected.
- When performing a machine inspection: Assume that an electrical safety hazard is present. Perform all continuity, grounding, and power checks specified during the subsystem installation procedures to ensure that the machine meets safety requirements. Do not attempt to switch power to the machine

until all possible unsafe conditions are corrected. Before you open the device covers, unless instructed otherwise in the installation and configuration procedures: Disconnect the attached AC power cords, turn off the applicable circuit breakers located in the rack power distribution panel (PDP), and disconnect any telecommunications systems, networks, and modems.

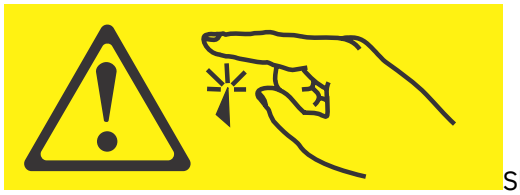
- Connect and disconnect cables as described in the following procedures when installing, moving, or opening covers on this product or attached devices.

  To Disconnect:

  1. Turn off everything (unless instructed otherwise).
  2. For AC power, remove the power cords from the outlets.
  3. For racks with a DC power distribution panel (PDP), turn off the circuit breakers located in the PDP and remove the power from the Customer's DC power source.
  4. Remove the signal cables from the connectors.
  5. Remove all cables from the devices.

  To Connect:

  1. Turn off everything (unless instructed otherwise).
  2. Attach all cables to the devices.
  3. Attach the signal cables to the connectors.
  4. For AC power, attach the power cords to the outlets.
  5. For racks with a DC power distribution panel (PDP), restore the power from the Customer's DC power source and turn on the circuit breakers located in the PDP.
  6. Turn on the devices.


Sharp edges, corners and joints may be present in and around the system. Use care when handling equipment to avoid cuts, scrapes and pinching. (D005)

DANGER: Heavy equipment — personal injury or equipment damage might result if mishandled. (D006)

DANGER: Professional movers are to be used for all relocation activities. Serious injury or death may occur if systems are handled and moved incorrectly. (D008)

DANGER: Serious injury or death can occur if loaded lift tool falls over or if a heavy load falls off the lift tool. Always completely lower the lift tool load plate and properly secure the load on the lift tool before moving or using the lift tool to lift or move an object. (D010)

Caution notices for IBM FlashSystem A9000 systems

Ensure that you understand the caution notices for IBM FlashSystem A9000 systems.

Caution notices

Use the reference numbers in parentheses at the end of each notice, such as (C001), to find the matching translated notice in *IBM Systems Safety Notices* .

CAUTION: Only trained service personnel may replace this battery. The battery contains lithium. To avoid possible explosion, do not burn or charge the battery.

Do Not:

- Throw or immerse into water
- Heat to more than 100 degrees C (212 degrees F)

- Repair or disassemble

Exchange only with the approved part. Recycle or discard the battery as instructed by local regulations. (C002)

CAUTION: The doors and covers to the product are to be closed at all times except for service by trained service personnel. All covers must be replaced and doors locked at the conclusion of the service operation. (C013)

CAUTION: This product is equipped with a 3-wire (two conductors and ground) power cable and plug. Use this power cable with a properly grounded electrical outlet to avoid electrical shock. (C018)

Special caution and safety notices

This information describes special safety notices that apply to FlashSystem A9000. These notices are in addition to the standard safety notices supplied and address specific issues relevant to the equipment provided.

Laser safety

When using an NVRAM5 or NVRAM6 cluster media converter, the storage system must be installed in a restricted access location.

CAUTION: This product contains a Class 1M laser. Do not view directly with optical instruments. (C028)

This equipment contains Class 1 laser products, and complies with FDA radiation regulations 21 CFR Subchapter J, international laser safety standard IEC 60825 parts -1 and -2, and relevant national standards based on these.

CAUTION:

Data processing environments can contain equipment transmitting on system links with laser modules that operate at greater than Class 1 power levels. For this reason, never look into the end of an optical fiber cable or open receptacle. (C027)

Attention: In the United States, use only SFP or GBIC optical transceivers that comply with the FDA laser registration, reporting and accessions per the Center for Devices and Radiological Health (CDRH) according to 21 CFR Subchapter J. Internationally, use only SFP or GBIC optical transceivers that comply with IEC standard 60825–1. Optical products that do not comply with these standards might produce light that is hazardous to the eyes.

Usage restrictions: The optical ports of the modules must be terminated with an optical connector or with a dust plug.

Fire suppression systems

A fire suppression system is the responsibility of the customer. The insurance underwriter, local fire marshal, or a local building inspector (or all three) must be consulted in selecting a fire suppression system that provides the correct level of coverage and protection.

IBM designs and manufactures equipment to internal and external standards that require certain environments for reliable operation. Because IBM does not test any equipment for compatibility with fire suppression systems, IBM does not make compatibility claims of any kind nor does IBM provide recommendations on fire suppression systems.

Power cables

Use only power cables that are IBM approved, certified, or both.

For your safety, IBM provides a power cable with a grounded attachment plug to use with this IBM product. To avoid electrical shock, always use the power cable and plug with a correctly grounded outlet. IBM power cables used in the United States and Canada are listed by Underwriters Laboratories (UL) and/or certified by the Canadian Standards Association (CSA).

For units intended to be operated at 115 volts: Use a UL-listed and CSA-certified cable set consisting of a minimum 18 AWG, Type SVT or SJT, three-conductor cable, a maximum of 15 feet in length and a parallel blade, grounding-type attachment plug rated 15 amperes, 125 volts.

For units intended to be operated at 230 volts (U.S. use), use a UL-listed and CSA-certified cable set consisting of a minimum 18 AWG, Type SVT or SJT, three-conductor cable, a maximum of 15 feet in length and a tandem blade, grounding-type attachment plug rated 15 amperes, 250 volts.

For units intended to be operated at 230 volts (outside the U.S.), use a cable set with a grounding type attachment plug. The cable set must have the appropriate safety approvals for the country in which the equipment is to be installed. IBM power cables for a specific country or region are usually available only in that country or region.

Connect all power cables to a correctly wired and grounded electrical outlet. Ensure that the outlets supplies correct voltage and phase rotation according to the system rating plate. Ensure that all customer facility outlets are protected with circuit breakers rated at maximum for 30 Amps. The power cable plugs operate as the system main-disconnection method.

Note: For power cables outside of the U.S., IBM might provide power cables with no connector. It is the client's responsibility to install the correct power plug with the aide of a certified electrician. For power requirements, see Power requirements.

Sound pressure

Hearing protection must be worn while you service the FlashSystem A9000 system.

Attention: Depending upon local conditions, the sound pressure might exceed 85 dB(A) during service operations. When working on the FlashSystem A9000 system while either the front or rear door is in the open position, hearing protection must be worn.

CAUTION:  Depending upon local conditions, the sound pressure might exceed 85 dB(A) during service operations. Hearing protection must be worn when you are in a room that has a FlashSystem A9000 system while either the front or rear door is open or when the front and rear doors are not installed.

Leakage current

The FlashSystem A9000 system incorporates electromagnetic interference filter capacitors that are required to prevent electrical noise from penetrating the power grid. A characteristic of filter capacitors, during normal operation, is a high amount of leakage current.

Depending on the storage configuration, this leakage current can reach 100 mA.

For the most reliable operation, do not use Ground Fault Circuit Interrupter (GFCI), Earth Leakage Circuit Breaker (ELCB), and Residual Current Circuit Breaker (RCCB) type circuit breakers with a FlashSystem A9000 system. The FlashSystem A9000 system is certified for safe operation and is compliant with IEC, EN, UL, CSA 60950-1 standards. However, if leakage detection circuit breakers are required by local electrical practice, the breakers must be sized for a leakage-current rating of 300 mA or greater to reduce the risk of server outage caused by erroneous and spurious tripping.

Site preparation

The IBM service representative can only minimally reposition the rack at the installation site, as needed to service the FlashSystem A9000 system. The customer is responsible for using professional movers or riggers in the case of equipment relocation or disposal.

Environmental notices

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

The Environmental and safety notices (ibm.com/docs/en/environmental-safety?topic=environmental-safety-notices) information includes statements on limitations, product information, product recycling and disposal, battery information, flat panel display, refrigeration and water-cooling systems, external power supplies, and safety data sheets.

About this guide

This guide provides information regarding the deployment, configuration, and preinstallation requirements for IBM FlashSystem A9000 models 9836-415, 9838-415, 9836-425, 9838-425, and 9838-U25. It is important to ensure that you meet all requirements to ensure a fast and reliable deployment and installation.

If you cannot meet the deployment and installation requirements explained in this document, notify your IBM representative in order to help devise an alternative solution.

Who should use this guide

This publication is for personnel that are involved in planning. Such personnel include IT facilities managers and individuals responsible for power, cooling, wiring, network, and general site environmental planning and setup.

CAUTION:  Servicing of this product or unit is to be performed by trained service personnel only. (C032)

Roles and responsibilities

Both IBM and the customer have roles and responsibilities that they must adhere to, in order to ensure proper workflow, timely successful installation, and properly configured Call Home and remote support, leading to a superior client experience.

Roles and responsibilities of the customer

- Review the product Deployment Guide.
- Enable and work with the Remote Support Center (RSC) remote support in performing remote data collection and support.
- Work with the IBM Planning Representative (IPR), Service Representative (SSR), Quality Practitioner (QPer), or other IBM personnel to fill out the Technical and Delivery Assessment (TDA) for an accurate and quicker initial installation.
- Provide and prepare a rack, adhering to the rack requirements, as specified in this guide.
- Provide adequate staffing/resources to support this solution.
- Provide sufficient bandwidth and host attachments to support this solution.
- Provide necessary Ethernet cabling.
- Provide all initial host Fibre Channel (FC) and iSCSI cabling.
- Provide proper power receptacles to match the requirements for the IBM FlashSystem A9000 ordered.
- Provide proper thermal dissipation, airflow and cooling, and environmental requirements.
- Provide proper floor space and clearance.
- Provide access for the IBM service representative (SSR), including notebook computer or PC access.
- Provide access for movers and vehicles.
- Allow firewall access to Call Home servers.
- Setup IP host network.
- Setup SAN host networking.
- Install the Management Server from Fix Central for IBM Hyper-Scale Manager UI use.

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- Perform logical configuration.
- Complete the host attachment plan.
- Prepare Fibre Channel (FC) connections.
- Prepare raised floor, if required.

Roles and responsibilities of IBM Service Support Representatives (SSRs)

- Complete Distant Learning (DL) education and hands-on education course.
- Enroll in a hearing conservation program.
- Perform product installation.
- Configure Call Home and remote support.
- Install software upgrades.
- Install hardware Engineering Change Notices (ECA) also known as Field Bill of Materials (FBM).
- Conduct product relocation, at customer request.
- Perform break/fix repairs.
- Handle the return of failed parts that are under warranty or have a Certified Spare Parts Value.
- Keep customers informed of service activities.
- Arrange time with customer/TA to facilitate upgrades.
- Assist with break/fix support as requested by Remote Support Center, Top Gun, or PFE team member.
- Complete accurate Quality Service Activity Reporting (QSAR) reporting.

Note: Additional information can be found in your *Enterprise Class Support for Storage* document, provided by your IBM representative.

Conventions used in this guide

These notices are used to highlight key information.

Tip: These notices provide important tips.

Note: These notices provide important guidance, or advice.

Important: These notices provide information or advice that might help you avoid inconvenient or difficult situations.

Attention: These notices indicate possible damage to programs, devices, or data. An attention notice is placed before the instruction or situation in which damage can occur.

CAUTION: These notices indicate a situation that is potentially hazardous to people because of some existing condition or where a potentially dangerous situation might develop because of some unsafe practice.

DANGER: These notices indicate a situation that is potentially lethal or hazardous to people. For example, after a computer side panel is removed, exposed high-voltage wires might be lethal.

Related information and publications

You can find additional information and publications related to IBM FlashSystem A9000 on the following information sources.

- IBM FlashSystem A9000 documentation (ibm.com/docs/en/flashsystem-a9000) – on which you can find the following related publications:
  - IBM FlashSystem A9000 – Release Notes
  - IBM FlashSystem A9000 – Product Overview

  - IBM FlashSystem A9000 – Command-Line Interface (CLI) Reference Guide
  - IBM FlashSystem A9000 and IBM FlashSystem A9000R – Application Programming Interface (API) Reference Guide
  - IBM XIV Remote Support Proxy – Release Notes
  - IBM XIV Remote Support Proxy – Installation and User Guide
- IBM FlashSystem A9000R documentation (ibm.com/docs/en/flashsystem-a9000r) – on which you can find the following related publications:
  - IBM FlashSystem A9000R – Release Notes
  - IBM FlashSystem A9000R – Product Overview
  - IBM FlashSystem A9000R – Deployment Guide
  - IBM FlashSystem A9000R – Command-Line Interface (CLI) Reference Guide
  - IBM FlashSystem A9000 and IBM FlashSystem A9000R – Application Programming Interface (API) Reference Guide
  - IBM XIV Remote Support Proxy – Release Notes
  - IBM XIV Remote Support Proxy – Installation and User Guide
- IBM Hyper-Scale Manager documentation (ibm.com/docs/en/hyper-scale-manager) – on which you can find the following related publications:
  - IBM Hyper-Scale Manager – Release Notes
  - IBM Hyper-Scale Manager – User Guide
  - IBM Hyper-Scale Manager – Representational State Transfer (REST) API Specifications
- IBM IT Infrastructure marketing website (ibm.com/it-infrastructure)
- IBM Storage Redbooks® website (redbooks.ibm.com/portals/storage)

Getting information, help, and service

If you need help, service, technical assistance, or want more information about IBM products, you can find various sources to assist you. You can view the following websites to get information about IBM products and services and to find the latest technical information and support.

- IBM website (ibm.com)
- IBM Support Portal (ibm.com/mysupport)
- IBM Directory of Worldwide Contacts website (ibm.com/planetwide)

IBM Publications Center

The IBM Publications Center is a worldwide central repository for IBM product publications and marketing material.

The IBM Publications Center website (ibm.com/resources/publications) offers customized search functions to help you find the publications that you need. You can view or download publications at no charge.

Sending comments

Your feedback is important in helping to provide the most accurate and highest quality information.

Procedure

To submit any comments about this publication or any other IBM storage product documentation:

- Send your comments by email to ibmdocs@us.ibm.com. Be sure to include the following information:
  - Exact publication title and version

- Publication form number (for example, GA32-1234-00)
- Page, table, or illustration numbers that you are commenting on
- A detailed description of any information that should be changed

Chapter 1. Overview

This guide defines deployment, planning, and preinstallation requirements for IBM FlashSystem A9000 storage systems. It is important to ensure that you meet all requirements to help achieve a fast and reliable installation.

IBM FlashSystem A9000 is a highly parallel all-flash solution for the cloud-scale business.

IBM FlashSystem A9000 provides predictable MicroLatency performance to meet service level agreements for data-intensive workloads. The system utilizes IBM MicroLatency modules, providing density, low latency, high I/O, and high availability by leveraging IBM-enhanced MLC flash in model 415, and 3D triple-level cell (3D TLC) flash in models 425 and U25. This storage system solution is designed to support service providers requiring highly efficient management as well as enterprises implementing their own private or hybrid clouds.

IBM FlashCore technology, which delivers market-leading storage response times for data-intensive workloads, forms the all-flash foundation of IBM FlashSystem A9000. Fundamental to this technology are many hardware-accelerated I/O features (redundant backplanes, non-blocking crossbar switching, and hardware-based RAID controllers) designed to deliver consistent microsecond latency with market-leading performance.

Because FlashSystem A9000 utilizes a grid architecture, the microsecond response times provided by FlashCore technology are consistent: even under variable workloads, the grid architecture ensures predictable high performance.

FlashSystem A9000 optimizes storage economics with comprehensive data reduction, including inline pattern removal, deduplication, and compression. It also comes fully integrated with a rich feature set of storage services built with IBM Spectrum Accelerate. A new management interface also saves time by greatly simplifying storage administration.

Figure 1. IBM FlashSystem A9000 storage system

IBM FlashCore technology keeps your data safe with enterprise-class data protection features like IBM Variable Stripe RAID technology, IBM-engineered error correction codes, overprovisioning capabilities, ultra-fast write buffers, and hardware-based data offloads.

IBM FlashSystem A9000 provides native implementation of IBM HyperSwap capability as well as Multi-site high availability and disaster recovery (HA/DR) capabilities. HyperSwap delivers active-active data access and transparent failover, per volume, across IBM FlashSystem® A9000 and IBM FlashSystem A9000R arrays and across data centers. Multi-site HA/DR supports high-availability with HyperSwap between two primary sites, and disaster recovery via simultaneous Asynchronous replication from the primary sites to a tertiary site.

The storage system delivers high performance and microsecond latency, helping your business improve data economics even further by increasing productivity and enabling consolidation of servers. Quality of Sevice (QoS) features help support secure multi-tenancy and mixed workloads.

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IBM FlashSystem A9000 is ready for Kubernetes container environments and integrates with a wide variety of hypervisor and virtualization software, including IBM Bluemix, VMware, OpenStack, Linux, and Microsoft.

Planning best practices and requirements

Use the planning information in this guide to place the FlashSystem A9000 system, plan power and environmental needs, plan for software and storage needs, and prepare for unique configurations that are based on how you plan to use the storage system.

Good planning is essential for the successful setup and use of your IBM FlashSystem A9000. It ensures that you have everything you need and that you meet all specified system prerequisites. It also helps minimize errors and speeds up the installation process.

It is imperative that you work with the IBM sales team, IBM representative, and IBM Service Representative (SSR) to capture information needed to install and configure the storage system. This information is collected during a Technical and Delivery Assessment (TDA) or installation planning meeting. This information must be collected prior to the commencement of the installation, or delays may occur.

CAUTION: Customers must prepare their environments to handle the FlashSystem A9000 system based on this planning information with assistance from an IBM representative. The final installation site within the computer room must be prepared *before* the equipment is delivered. If the site cannot be prepared before the delivery time, customers must make arrangements to have the professional movers return to finish the transportation later. Only professional movers can transport the equipment. The IBM service representative can minimally reposition the rack at the installation site, as needed to complete required service actions. Customers are also responsible for using professional movers in the case of equipment relocation or disposal.

If you cannot meet any of the installation requirements, notify your IBM service representative to help devise alternative solutions.

Additional product information

This guide only covers deployment and planning information for the IBM FlashSystem A9000 storage system.

Additional product information

- For planning information for the IBM FlashSystem A9000R integrated system, see *IBM FlashSystem A9000R Deployment Guide*, GC27-8565 on the IBM FlashSystem A9000R documentation (ibm.com/docs/en/flashsystem-a9000r).
- For information regarding the IBM Storage Utility Offering (SUO) (Model U25), see the IBM Storage Utility Offering at IBM Marketplace (ibm.com/common/ssi/cgi-bin/ssialias?htmlfid=TSS03238USEN).
- For information regarding management, automation, and access security, see the following documentation, which can be found on the IBM FlashSystem A9000 documentation (ibm.com/docs/en/flashsystem-a9000):
  - IBM FlashSystem A9000 Command-Line Interface (CLI) Reference Guide, SC27-8559
- For IBM Hyper-Scale Manager (HSM) information, see the following documentation, which can be found on the IBM Hyper-Scale Manager on IBM Knowledge Center (ibm.com/support/knowledgecenter/SSUMNQ).
  - *IBM Hyper-Scale Manager User Guide* , SC27-8560
  - *IBM Hyper-Scale Manager Release Notes*
  - *IBM Hyper-Scale Manager REST API Specifications* , SC27-6440

Chapter 2. System specifications

This section provides information about the general properties, performance, physical features, storage capacity features, and host connectivity for the different IBM® FlashSystem™ A9000 storage system models.

General properties

Element	Model 415	Models 425 and U25
Grid controllers	Three-way active grid controllers, each containing: • Two Intel Xeon E5 v3 8-core 2.4 GHz processors • 256 GB DDR4 memory • Redundant battery backup units and power supply units	Three-way active grid controllers, each containing: • Two Intel Xeon E5 12-core 2.2 GHz processors • 384 GB DDR4 memory • Redundant battery backup units and power supply units
Software	IBM FlashSystem A9000 and A9000R software v12.0.x or later	IBM FlashSystem A9000 and A9000R software v12.2.x or later
Models and warranties	• 9836-415: 1-year warranty • 9838-415: 3-year enterprise-class warranty Warranties include onsite service, same day 24×7	• 9836-425: 1-year warranty • 9838-425: 3-year enterprise-class warranty • 9838-U25: 3-year enterprise-class warranty Warranties include onsite service, same day 24×7
Data reduction and efficiency	• Pattern removal • Global, inline deduplication • Inline compression • Space-efficient snapshots • Thin provisioning	
Encryption	Hardware-based AES-XTS 256-bit with centralized key management	
Backplane interconnect	InfiniBand	
Client operating system support	For a current list of platforms supported, please visit the IBM System Storage Interoperation Center (SSIC) (ibm.com/systems/support/storage/ssic/interoperability.wss).	

Storage capacity features

Model 415

Element	Details		
Flash storage type	IBM-enhanced MLC		
	Flash enclosure-60	Flash enclosure-150	Flash enclosure-300
Effective capacity[1] (TB)	60	150	300

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Element	Details		
Maximum capacity[2] (TB)	1200	1200	1200
Raw capacity (TB)	21.4	52.8	105.6
IBM MicroLatency modules	12 × 1.2 TB	12 × 2.9 TB	12 × 5.7 TB
[1]Typical effective capacity is the available capacity after system overhead (including over-provisioning and RAID protection) and after the data reduction benefits of pattern removal, deduplication, and compression. This assumes data reduction of up to a multiple of 5.26 to 1. [2]Maximum capacity refers to the effective capacity provisioning limit.			

Models 425 and U25

Element	Details			
Flash storage type	IBM-enhanced 3D-TLC			
Effective capacity[1] (TB)	110[4]	180	425	900
Maximum capacity[2] (TB)	1200	1200	1200	1200
Physical capacity[3] (TB)	21.6	36	85	180
Raw capacity (TB)	36.9	55.3	129	258
IBM MicroLatency modules	8 × 3.6 TB[4]	12 × 3.6 TB	12 × 8.5 TB	12 × 18 TB
[1]Typical effective capacity is the available capacity after system overhead (including over-provisioning and RAID protection) and after the data reduction benefits of pattern removal, deduplication, and compression. This assumes data reduction of up to a multiple of 5 to 1. [2]Maximum capacity refers to the effective capacity provisioning limit. [3]Physical capacity is the available capacity after system overhead, including flash media over-provisioning and RAID protection. [4]The 8 x 3.6 TB (110 TB) configuration is only supported by model 425.				

Physical features (all models)

Physical feature	Details
Dimensions (height×width×depth)	356 mm (8U) cm × 483 mm × 930 mm (14 in. × 19 in. × 36.6 in.)
Front clearance	120 cm (47.2 in.)
Rear clearance	100 cm (39.4 in.)
Weight	125 kg (275.5 lbs)
Input voltage	200–240 V AC, 50/60Hz (+/-10% tolerance) via 30A–63A
Power usage	1.740 kW (typical); 2.625 kW (max) See “Power consumption” on page 21.

Operation environment (all models)

Environment	Details
Temperature range	10–35°C (50–95°F)
Maximum altitude	2134 m (7000 ft.)
Humidity	25–80% non-condensing

Host connectivity (all models)

Host connectivity feature		Details
Host system interfaces (per grid controller)	Storage systems with Fibre Channel (FC) capabilities	4 × 16 Gb Fibre Channel + 2 × 10 Gb iSCSI
	Storage systems with iSCSI (Ethernet) capabilities only	4×10 Gb iSCSI
Host connectivity for mirroring (per system)	Recommended minimum link bandwidth value	50 Mbps
	Recommended maximum round trip latency value for synch	250 ms
	Attaching IBM FlashSystem A9000 and A9000R systems for mirroring	The connection between two FlashSystem A9000 systems or between a FlashSystem A9000R and a FlashSystem A9000 system has to pass through: • Ethernet LAN for iSCSI connections • SAN for FC connections
Note: In model 415, synchronous remote mirroring is supported by version 12.0.1 and later.		

Chapter 3. Physical configuration options

Use these general guidelines for determining and ordering the feature codes that you need to customize your IBM FlashSystem A9000 system.

Procedure

Note: Contact your IBM representative to help determine which configuration options are best for your needs.

To determine the required ordering information, answer the following questions:

1. Which model best fits your warranty requirements?

   See full warranty information detailed on the IBM FlashSystem A9000 documentation (ibm.com/docs/en/flashsystem-a9000).
2. What are your capacity needs?

   See “Storage capacity features” on page 3 for full capacity specifications and see “Flash enclosure components and feature codes” on page 8 for flash enclosure information and feature codes.
3. What type of host connectivity do you need?

   See “Host connectivity (all models)” on page 5 for full host connectivity specifications and see “Grid controller components and feature codes” on page 10 for grid controller information and feature codes.

What to do next

See the following information about the various physical configuration options for your IBM FlashSystem A9000 storage system.

Components and interconnect

This section lists the components and interconnection options that are supplied with each IBM FlashSystem A9000 system.

Table 1. Components and interconnection options in IBM FlashSystem A9000

Component	Sub-components
Three grid controllers	Each grid controller includes: • Two hot-swap power supply units (PSUs). • Two internal battery modules. • Two data reduction hardware acceleration cards. • Two or three dual-ported host adapters, configuration according to customer request. Options include: – Two 16 Gb Fibre Channel dual ports and a 10 Gb Ethernet dual port adapter *or* – Two 10 Gb Ethernet dual port adapters • Network and host connectivity ports.

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Table 1. Components and interconnection options in IBM FlashSystem A9000 (continued)	
Component	**Sub-components**
One flash enclosure	• **Model 415:** 12 hot-swap 1.2, 2.9, or 5.7 TB IBM MicroLatency® modules **Models 425 and U25:** 12 hot-swap 3.6, 8.5, or 18 TB *or* 8 hot-swap 3.6, or 18, TB IBM MicroLatency modules **Note:** The 8 hot-swap 3.6 TB configuration is only available for model 425; the 8 hot-swap 18 TB configuration is only available for model 425 from system version 12.4.0. • Two internal battery modules
Complete set of internal cabling	

IBM FlashSystem A9000 configurations

IBM FlashSystem A9000 is made for racks with 8U capabilities.

For various configuration feature options and codes see:

- “Flash enclosure components and feature codes” on page 8
- “Grid controller components and feature codes” on page 10

IBM FlashSystem A9000 contains three grid controllers and one flash enclosure.

Figure 2 on page 8 shows the front and rear of a FlashSystem A9000 unit configuration.

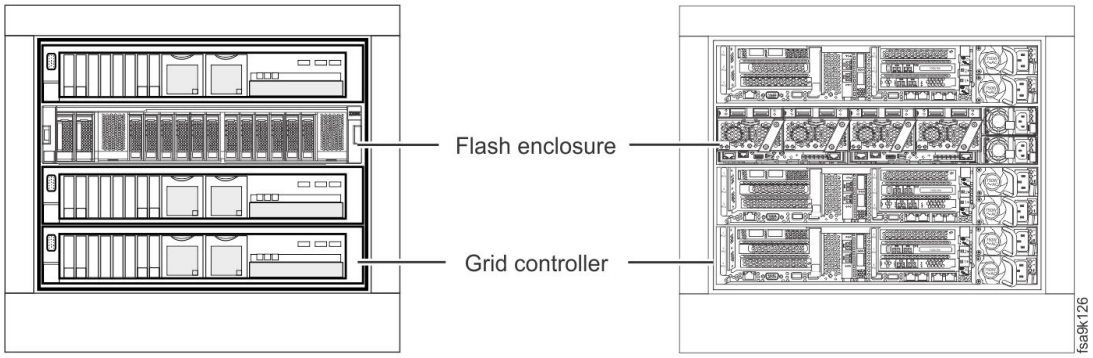
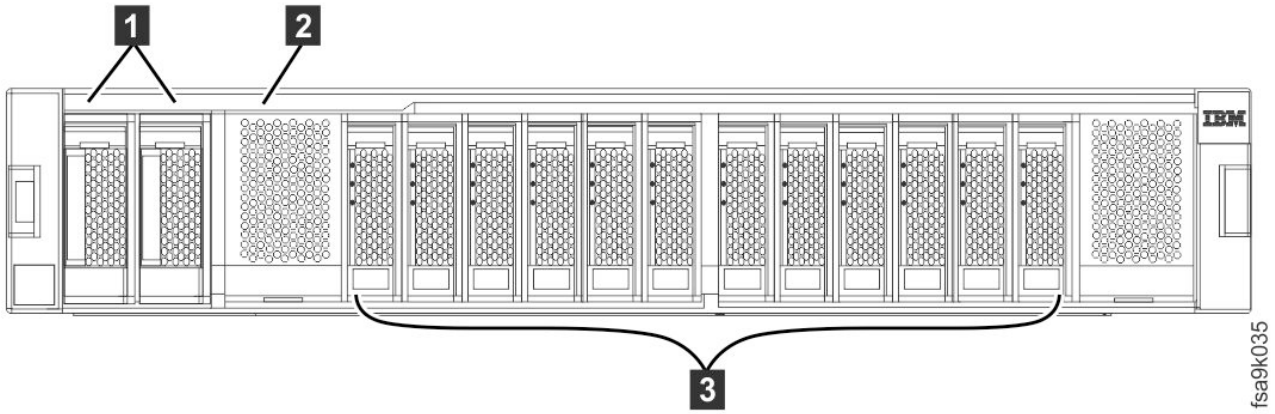


Figure 2. Configuration of an IBM FlashSystem A9000 unit

Flash enclosure components and feature codes

The flash enclosures are used for IBM FlashSystem A9000 storage functions.

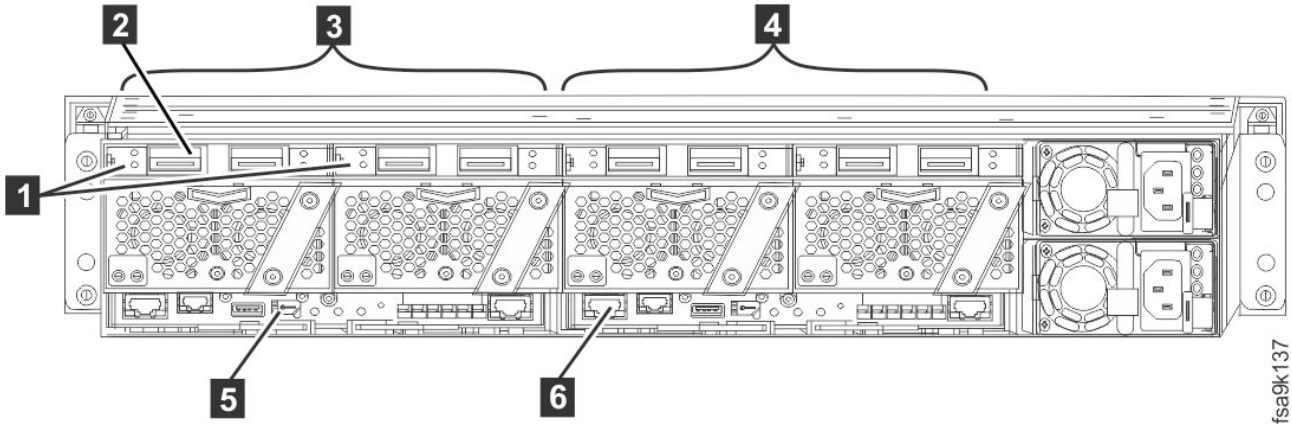
Figure 3 on page 9 shows the front view of a flash enclosure.



1 Battery modules
2 LED indicator panel
3 IBM MicroLatency modules

Figure 3. Front of a flash enclosure

Figure 4 on page 9 shows the rear view of a flash enclosure.



1 InfiniBand Adapters (two per canister)
2 Internal interconnect Infiniband ports
3 Canister 1
4 Canister 2
5 Maintenance ports (serial) (IBM technician access)
6 Management ports (Ethernet) (IBM technician access)

Figure 4. Rear of a flash enclosure

Model 415

Every flash enclosure contains 12 hot-swap 1.2 TB, 2.9 TB, or 5.7 TB IBM MicroLatency modules. Each IBM FlashSystem A9000 system contains one flash enclosure.

Figure 3 on page 9 and Figure 4 on page 9 illustrate the front and rear of the flash enclosure.

Table 2 on page 9 lists the feature codes for model 415.

Table 2. Feature codes for flash enclosures – model 415

Description	Feature code
Flash enclosure with 12 x 1.2 TB IBM MicroLatency modules	AFE1

Table 2. Feature codes for flash enclosures – model 415 (continued)	
Description	**Feature code**
Flash enclosure with 12 x 2.9 TB IBM MicroLatency modules	AFE2
Flash enclosure with 12 x 5.7 TB IBM MicroLatency modules	AFE3

Models 425 and U25

Every flash enclosure contains 12 hot-swap 3.6 TB, 8.5 TB, or 18 TB IBM MicroLatency modules. An 8 hot-swap 3.6 TB IBM MicroLatency module configuration is also available. Each IBM FlashSystem A9000 system contains one flash enclosure.

Figure 3 on page 9 and Figure 4 on page 9 illustrate the front and rear of the flash enclosure.

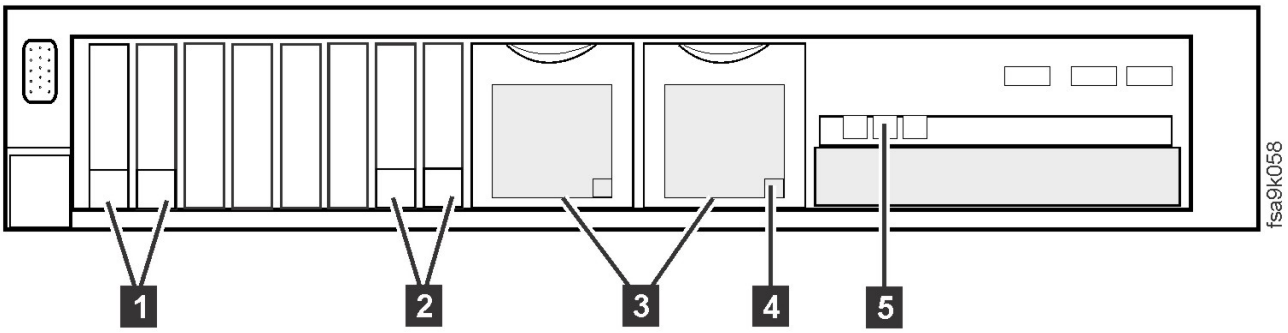
Table 3 on page 10 lists the feature codes for models 425 and U25.

Table 3. Feature codes for flash enclosures – models 425 and U25	
Description	**Feature code**
Flash enclosure with 12 x 3.6 TB IBM MicroLatency modules	AFE4
Flash enclosure with 12 x 8.5 TB IBM MicroLatency modules	AFE5
Flash enclosure with 12 x 18 TB IBM MicroLatency modules	AFE6
Flash enclosure with 8 x 3.6 TB IBM MicroLatency modules (Model 425 only)	AFE7

Grid controller components and feature codes

Each grid controller contains two hard disk drives (HDDs) and two solid state drives (SSDs) for IBM FlashSystem A9000 performance functions.

An IBM FlashSystem A9000 unit contains three (3) grid controllers. Figure 5 on page 10 illustrates the front of the grid controller. Figure 6 on page 11 and Figure 7 on page 11 illustrate the two rear options for the grid controller.



1 HDDs (two per grid controller)
2 SSDs (two per grid controller)
3 Battery modules (two per grid controller)
4 Battery module Fault LED (one per unit)
5 General battery module LEDs

Figure 5. Front of a grid controller

Attention: Do not use the power button / LED (not shown in Figure 5 on page 10) to turn off the machine. This can lead to a customer impact event (CIE).

For full information on how to properly shutdown a system, see the *IBM FlashSystem A9000 Command-Line Interface (CLI) Reference Guide* (SC27-8559).

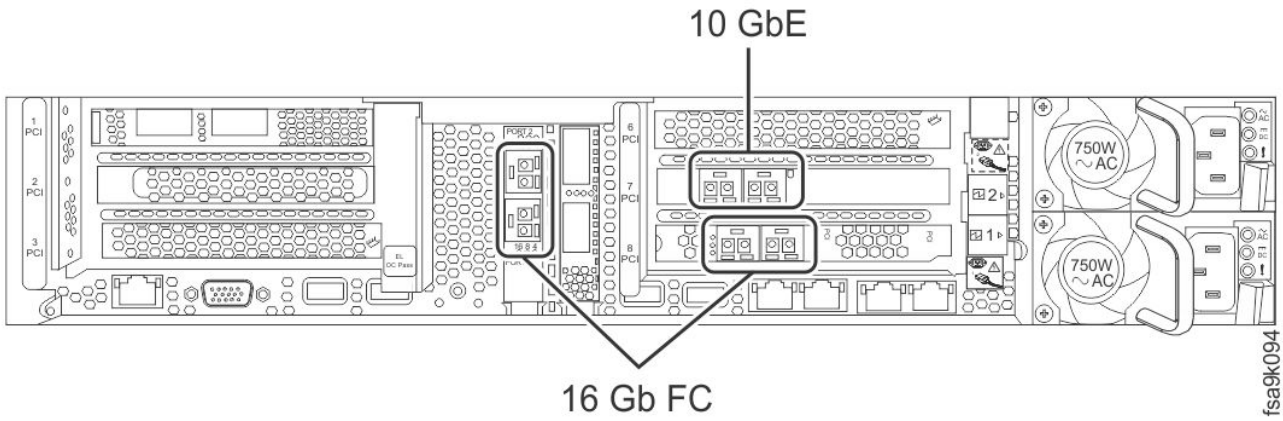


Figure 6. Rear of a grid controller with FC configuration

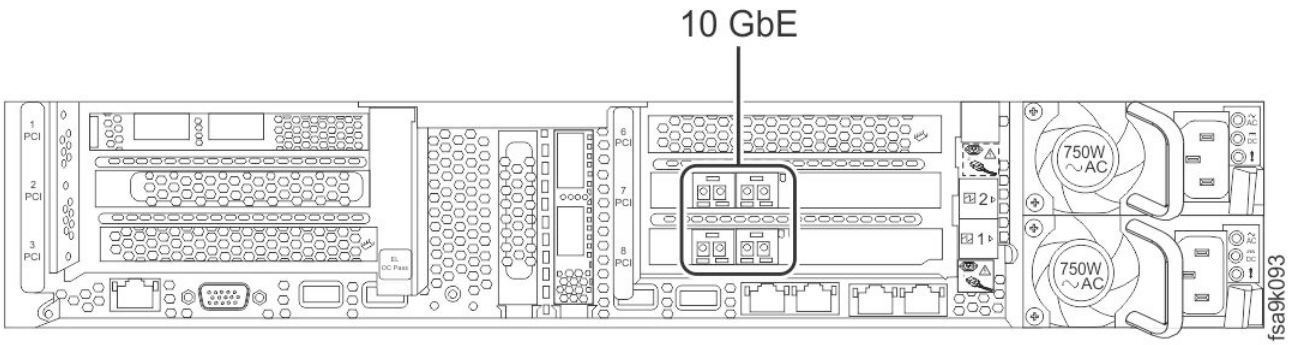


Figure 7. Rear of a grid controller with 10 Gb Ethernet configuration

Table 4 on page 11 lists the feature codes for model 415.

Table 4. Feature codes for grid controllers – model 415

Description	Feature code
Grid controller with 4 x 16 Gb Fibre Channel (FC) + 2 x 10 GbE iSCSI	5010
Grid controller with 4 x 10 GbE iSCSI	5011

Table 5 on page 11 lists the feature codes for models 425 and U25.

Table 5. Feature codes for grid controllers – models 425 and U25

Description	Feature code
Grid controller with 4 x 16 Gb Fibre Channel (FC) + 2 x 10 GbE iSCSI	5003
Grid controller with 4 x 10 GbE iSCSI	5004
Grid controller with 4 x 16 Gb Fibre Channel NVMe (FC-NVMe) ready + 2 x 10 GbE iSCSI	5005

Chapter 4. Physical installation site requirements

The location where you plan to install the storage system must meet all physical requirements.

Note: Contact your IBM representative to help determine which configuration options are best for your needs.

Prepare the site in advance so that professional movers or riggers can transport the equipment to the final site within the computer room. If the site cannot be prepared before the delivery time, you must make arrangements to have the professional movers return to finish the transportation later.

Attention: Only professional movers should transport the equipment.

See the following information about the various physical installation site requirements for your IBM FlashSystem A9000 storage system.

Planning for floor and space requirements

You must ensure that the location of the FlashSystem A9000 system meets floor and space requirements.

Procedure

Complete the following steps to ensure that the planned installation location meets floor-load and space requirements:

1. Determine whether the floor meets the floor-load requirements for the FlashSystem A9000 system. See "Floor-load requirements" on page 13.
2. Decide what type of rack you will need for your IBM FlashSystem A9000 configuration. See "Rack requirements" on page 14.
3. Determine whether the rack meets the floor-load and space requirements for the FlashSystem A9000 system. See "Rack requirements" on page 14.
4. Provide your IBM service representative with the following information before the installation:
   a) Whether under-floor or over-head power-cabling scheme is to be used.
   b) The distance of the rack from the power receptacles.

Floor-load requirements

You must ensure that the floor-load rating can support the weight of the FlashSystem A9000 system.

Floor reinforcement must support the weight of the FlashSystem A9000 system over a specific area, as shown in Table 6 on page 14. These measurements are of the FlashSystem A9000 system, and may vary based on customer rack.

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Table 6. Floor weight-support requirements		
IBM FlashSystem A9000 elements	**Floor reinforcement area**	**Total weight**
3 grid controllers and 1 flash enclosure	66 cm × 118 cm (26 in. × 46.5 in.)	125 kg (275.5 lbs)

To ensure that all requirements are met, obtain the service of a qualified structural engineer to prepare the floor.

Attention: If you do not know or are not certain about the floor-load rating of the installation site, you must check with the building engineer or another appropriate person.

Rack requirements

Use this information to help determine what rack you can use for your storage system.

Each of the IBM FlashSystem A9000 grid elements are 2U, and fit in 19-inch standard racks.

Be sure that you provide a rack with the following requirements:

__ 1. Minimum space of 8U (consecutive).

Important: Be sure that all space within this 8U area contains no other components. This area is to be left solely for the use of the IBM FlashSystem A9000 system and cabling components.

__ 2. Can support a weight of minimum 125 kg (275.5 lb).

__ 3. Provides two power distribution units (PDUs), ensuring that each is on a separate power source.

Rack installation specifications for racks not purchased from IBM

This section provides requirements and specifications for installing IBM® systems into 19-inch racks that were not purchased from IBM.

It is your responsibility, working with your rack manufacturer, to ensure that the rack chosen meets the requirements and specifications that are listed here. Mechanical drawings of the rack, if available from the manufacturer, are recommended for comparison against the requirements and specifications.

IBM maintenance services and installation planning services support IBM 7014-T00, 7014-T42, 7014-B42, 0551, and 0553 . These rack products comply with safety and regulatory requirements, and are verified to fit and function well with IBM products. When other racks must be used with IBM FlashSystem A9000, the customer is responsible to verify compliance with IBM specifications.

Rack requirements for non-IBM racks

The following rack requirements must be met for FlashSystem A9000 installation:

- The rack or cabinet must meet the EIA Standard EIA-310-D for 19-inch racks published August 24, 1992. The EIA-310-D standard specifies internal dimensions, for example, the width of the rack opening (width of the chassis), the width of the module mounting flanges, the mounting hole spacing, and the depth of the mounting flanges. The EIA-310-D standard does not control the overall external width of the rack. There are no restrictions on the location of side walls and corner posts relative to the internal mounting space.
- The front rack opening must be 450 mm wide + 0.75 mm (17.72 in. + 0.03 in.), and the rail-mounting holes must be 465 mm + 0.8 mm (18.3 in. + 0.03 in.) apart on center (horizontal width between vertical columns of holes on the two front-mounting flanges and on the two rear-mounting flanges).

  Figure 8 on page 15 shows the top view specification dimensions of a customer rack.

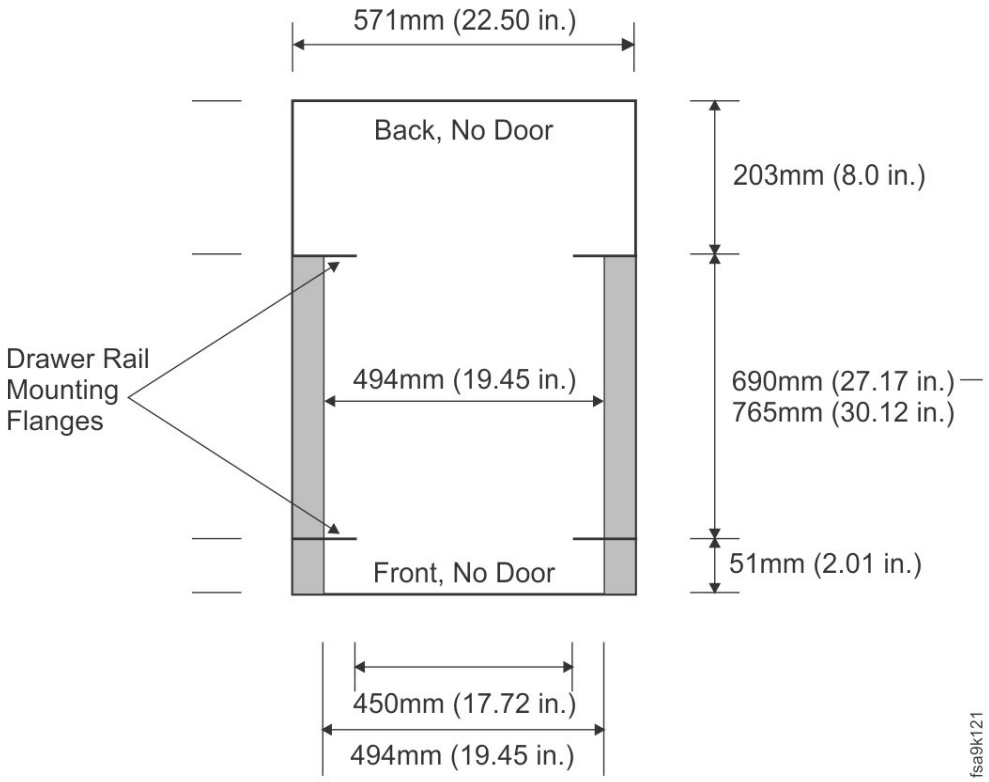
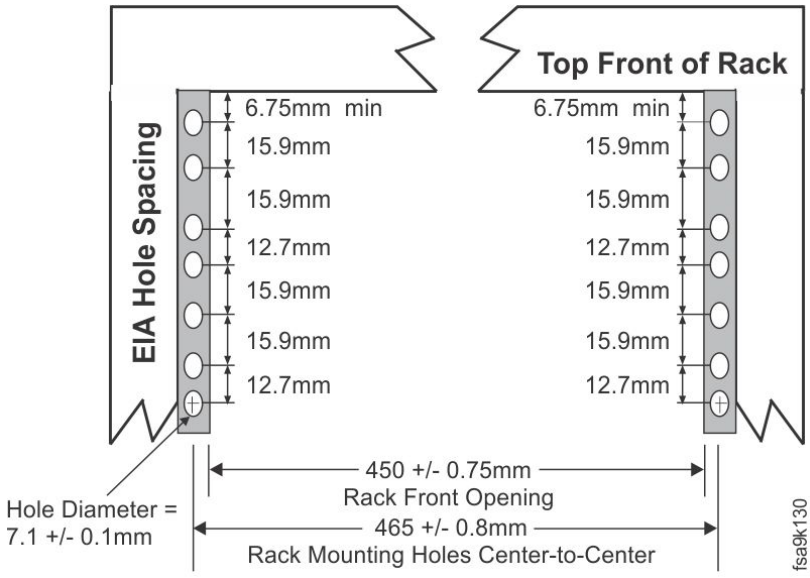
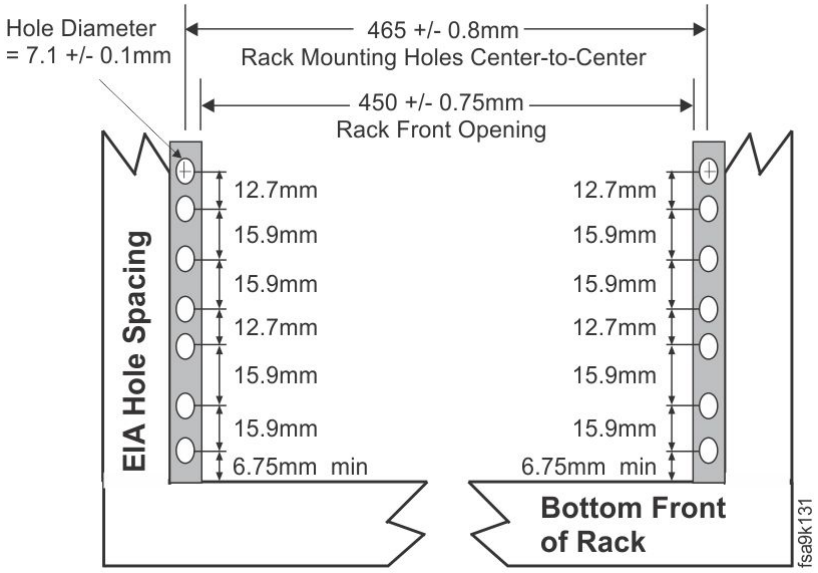


Figure 8. Customer rack – top view specification dimensions

The vertical distance between mounting holes must consist of sets of three holes spaced (from bottom to top) 15.9 mm (0.625 in.), 15.9 mm (0.625 in.), and 12.67 mm (0.5 in.) on center (making each three-hole set of vertical hole spacing 44.45 mm (1.75 in.) apart on center). The front and rear mounting flanges in the rack or cabinet must be 690 - 765 mm (27.17 - 30.12 in.) apart and the internal width that is bounded by the mounting flanges at least 494 mm (19.45 in.), for the IBM rails to fit in your rack or cabinet (see the following figure).





- The front rack opening must be 535 mm (21.06 in.) wide for dimension C (the width between the outsides of the standard mounting flanges, see Figure 9 on page 16). The back rack opening must be 500 mm (19.69 in.) wide for dimension C (the width between the outsides of the standard mounting flanges).

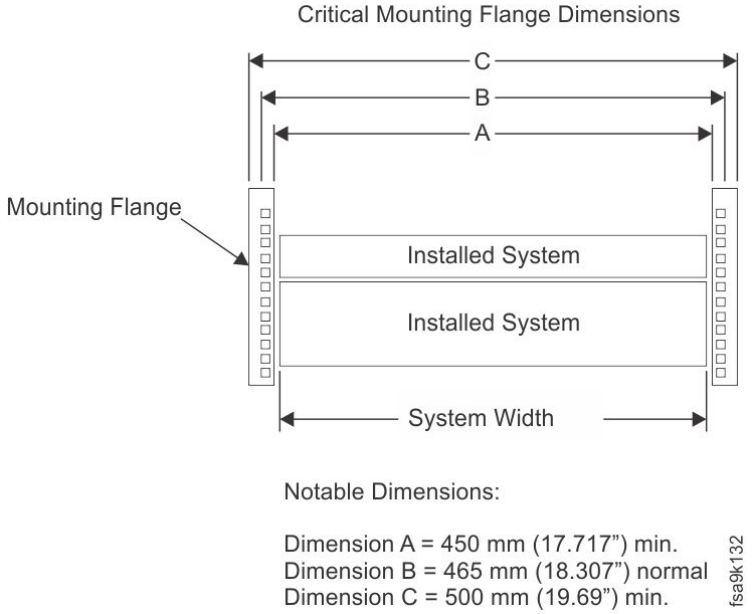


Figure 9. Critical mounting flange dimensions

- A minimum rack opening width of 500 mm (19.69 in.) for a depth of 330 mm (12.99 in.) is needed behind the installed system for maintenance and service. The depth can extend beyond the rack rear door. FlashSystem A9000 needs at least 254 mm (10 in.) of depth within the rack from the rear rack mount flange to the frame line. This space is necessary for cable management.

Note: Power distribution units (PDUs) should be mounted horizontally in the U space so that the additional width of the rack can also be used for the FlashSystem A9000 system cable management. If PDUs are mounted vertically, either 2U below the drawer or an extra 127 mm (5 in.) of depth within the rack from the rear rack mount flange to the frame line should be provided.

Figure 10 on page 17 shows the top-down view specification dimensions.

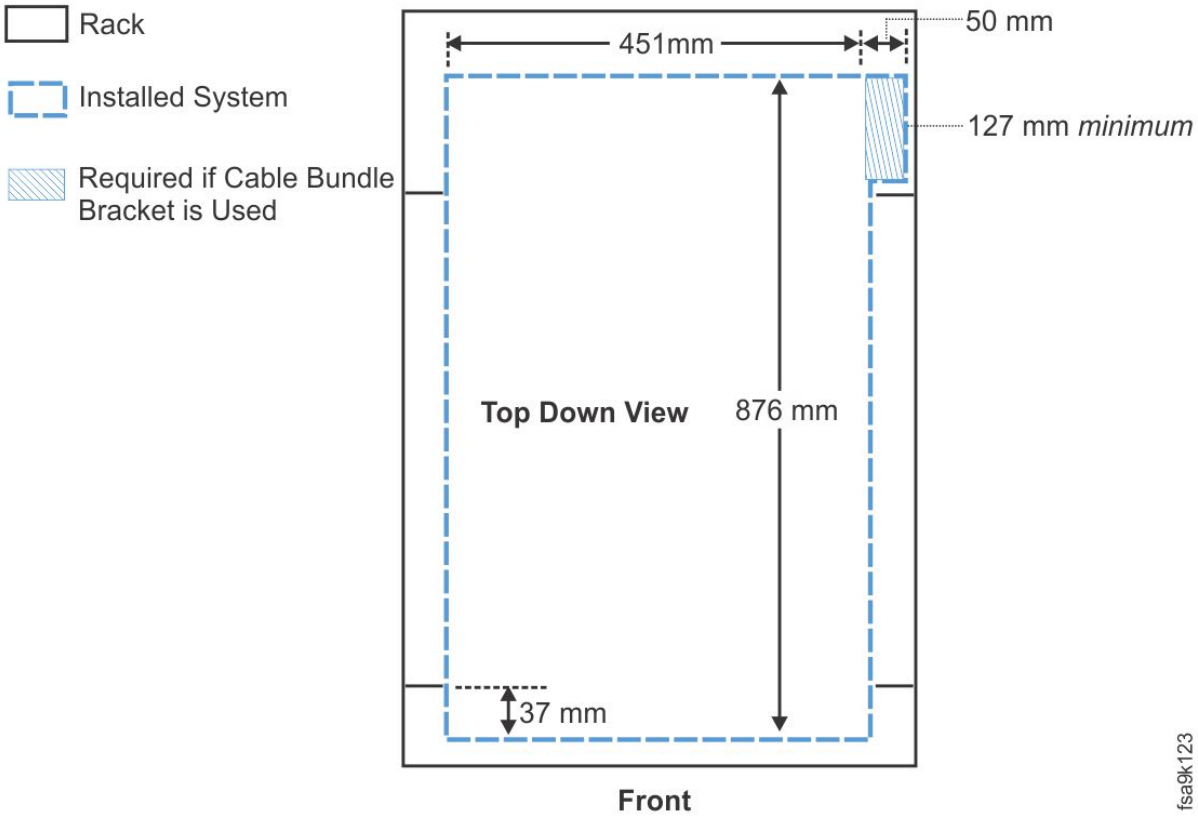


Figure 10. Customer rack – top-down view specification dimensions

- The rack or cabinet must be capable of supporting an average load of 15.9 kg (35 lb) of product weight per EIA unit.

  For example, a four EIA drawer has a maximum drawer weight of 63.6 kg (140 lb).

  The following rack hole sizes are supported for racks where IBM hardware is mounted:

  – 7.1 mm plus or minus 0.1 mm
  – 9.5 mm plus or minus 0.1 mm
- All parts that are shipped with the FlashSystem A9000 products must be installed.
- Only AC power drawers are supported in the rack or cabinet. It is strongly recommended to use a power distribution unit that meets the same specifications as IBM power distribution units to supply rack power. Rack or cabinet power distribution devices must meet the drawer voltage, amperage, and power requirements, as well as that of any additional products that are connected to the same power distribution device.

  The rack or cabinet power receptacle (power distribution unit, uninterruptible power supply, or multi-outlet strip) must have a compatible plug type for your drawer or device.
- The rack or cabinet must be compatible with the drawer-mounting rails. The rail-mounting pins and screws should fit securely and snugly into the rack or cabinet rail-mounting holes. It is strongly recommended that the IBM mounting rails and mounting hardware that are included with the product be used to install it in the rack. The mounting rails and mounting hardware that are provided with IBM products have been designed and tested to safely support the product during operation and service activities as well as to safely support the weight of your drawer or device. The rails must facilitate service access by allowing the drawer to be safely extended, if necessary, forward, backward, or both. Some rails, with IBM features for non-IBM racks, provide drawer-specific anti-tip brackets, rear lock-down brackets, and cable management guides that require clearance on the rear side of the rails.

Note: If the rack or cabinet has square holes on the mounting flanges, a plug-in hole adapter might be required.

- The rack or cabinet must have stabilization feet or brackets installed both in the front and rear of the rack, or have another means of preventing the rack/cabinet from tipping while the drawer or device is pulled into its extreme front or rear service positions.

  Note: Examples of some acceptable alternatives: The rack or cabinet might be securely bolted to the floor, ceiling or walls, or to adjacent racks or cabinets in a long and heavy row of racks or cabinets.

- There must be adequate front and rear service clearances (in and around the rack or cabinet). The rack or cabinet must have sufficient horizontal width clearance in the front and rear to allow the drawer to be fully slid into the front and, if applicable, the rear service access positions (typically this requires 914.4 mm (36 in.) clearance in both the front and rear).
- If present, front and rear doors must be able to open far enough to provide unrestrained access for service or be easily removable. If doors must be removed for service, it is the customer's responsibility to remove them before service.
- The rack or cabinet must provide adequate clearance around the rack drawer.
- There must be adequate clearance around the drawer bezel so that it can be opened and closed, according to the product specifications.
- Front or rear doors must also maintain a minimum of 51 mm (2 in.) front, 203 mm (8 in.) rear, door to mounting flange clearance, and 494 mm (19.4 in.) front, 571 mm (22.5 in.) rear, side-to-side clearance for drawer bezels and cables.
- The rack or cabinet must provide adequate front-to-back ventilation. For more information, see “Environmental requirements” on page 23).

General safety requirements for IBM products installed in a non-IBM rack or cabinet

The general safety requirements for IBM products that are installed in non-IBM racks are:

- Any product or component that plugs into either an IBM power distribution unit or mains power (via a power cord), or uses any voltage over 42 V AC or 60 V DC (considered to be hazardous voltage) must be Safety Certified by a Nationally Recognized Test Laboratory (NRTL) for the country in which it is installed.

  Some of the items that require safety certification might include: the rack or cabinet (if it contains electrical components integral to the rack or cabinet), fan trays, power distribution unit, uninterruptible power supplies, multi-outlet strips, or any other products that are installed in the rack or cabinet that connect to hazardous voltage.

  Examples of OSHA-approved NRTLs for the US:

  – UL
  – ETL
  – CSA (with CSA NRTL or CSA US mark)

  Examples of approved NRTLs for Canada:

  – UL (Ulc mark)
  – ETL (ETLc mark)
  – CSA

  The European Union requires a CE mark and a Manufacturer's Declaration of Conformity (DOC).

  Certified products should have the NRTL logos or marks somewhere on the product or product label. However, proof of certification must be made available to IBM upon request. Proof consists of such items as copies of the NRTL license or certificate, a CB Certificate, a Letter of Authorization to apply the NRTL mark, the first few pages of the NRTL certification report, Listing in an NRTL publication, or a copy of the UL Yellow Card. Proof should contain the manufacturers name, product type, and model, standard to which it was certified, the NRTL name or logo, the NRTL file number or license number, and a list of any Conditions of Acceptance or Deviations. A Manufacturer's Declaration is not proof of certification by an NRTL.

- The rack or cabinet must meet all electrical and mechanical safety legal requirements for the country in which it is installed. The rack or cabinet must be free of exposed hazards (such as voltages over 60 V dc or 42 V ac, energy over 240 VA, sharp edges, mechanical pinch points, or hot surfaces).
- There must be an accessible and unambiguous disconnect device for each product in the rack, including any power distribution unit.

  A disconnect device might consist of either the plug on the power cord (if the power cord is no longer than 1.8 m (6 ft)), the appliance inlet receptacle (if the power cord is of a detachable type), or a power on/off switch, or an Emergency Power Off switch on the rack, provided all power is removed from the rack or product by the disconnect device.

  If the rack or cabinet has electrical components (such as fan trays or lights), the rack must have an accessible and unambiguous disconnect device.
- The rack or cabinet, power distribution unit and multi-outlet strips, and products that are installed in the rack or cabinet must all be properly grounded to the customer facility ground.

  There must be no more than 0.1 Ohms between the ground pin of the power distribution unit or rack plug and any touchable metal or conductive surface on the rack and on the products that are installed in the rack. Grounding method must comply with applicable country's electric code (such as NEC or CEC). Ground continuity can be verified by your IBM service personnel, after the installation is completed, and should be verified before the first service activity.
- The voltage rating of the power distribution unit and multi-outlet strips must be compatible with the products plugged into them.

  The power distribution unit or multi-outlet strips current and power ratings are rated at 80% of the building supply circuit (as required by the National Electrical Code and the Canadian Electrical Code). The total load that is connected to the power distribution unit must be less than the rating of the power distribution unit. For example, a power distribution unit with a 30 A connection is rated for a total load of 24 A (30 A x 80 %). Therefore, the sum of all equipment that is connected to the power distribution unit in this example must be lower than the 24 A rating.

  If an uninterruptible power supply is installed, it must meet all the electrical safety requirements as described for a power distribution unit (including certification by an NRTL).
- The rack or cabinet, power distribution unit, uninterruptible power supply, multi-outlet strips, and all products in the rack or cabinet must be installed according to the manufacturer's instructions, and in accordance with all national, state or province, and local codes and laws.

  The rack or cabinet, power distribution unit, uninterruptible power supply, multi-outlet strips, and all products in the rack or cabinet must be used as intended by the manufacturer (per manufacturer's product documentation and marketing literature).
- All documentation for use and installation of the rack or cabinet, power distribution unit, uninterruptible power supply, and all products in the rack or cabinet, including safety information, must be available onsite.
- If there is more than one source of power in the rack cabinet, there must be clearly visible safety labels for `Multiple Power Source` (in the languages that are required for the country in which the product is installed).
- If the rack or cabinet or any products that are installed in the cabinet had safety or weight labels that are applied by the manufacturer, they must be intact and translated into the languages that are required for the country in which the product is installed.
- If the rack or cabinet has doors, the rack becomes a fire enclosure by definition and must meet the applicable flammability ratings (V-0 or better). Totally metal enclosures at least 1 mm (0.04 in.) thick are considered to comply.

  Nonenclosure (decorative) materials must have a flammability rating of V-1 or better. If glass is used (such as in rack doors) it must be safety glass. If wood shelves are used in the rack/cabinet, they must be treated with a UL Listed flame-retardant coating.
- The rack or cabinet configuration must comply with all IBM requirements for "safe to service" (contact your IBM Representative for assistance in determining if the environment is safe).

There must be no unique maintenance procedures or tools that are required for service.

Elevated service installations, where the products to be serviced are installed between 1.5- 3.7 m (5 - 12 ft) above the floor, require the availability of an OSHA- and CSA-approved nonconductive step ladder or ladders. If a ladder or ladders are required for service, the customer must supply the OSHA- and CSA-approved nonconductive step ladder (unless other arrangements have been made with the local IBM Service Branch Office). Some products can have rack installation limitations. Refer to the specific server or product specifications for any restrictions. Products that are installed over 2.9 m (9 ft) above the floor require a Special Bid to be completed before they can be serviced by IBM service personnel.

For products not intended for rack-mounting to be serviced by IBM, the products and parts that are replaced as part of that service must not weigh over 11.4 kg (25 lb). Contact your IBM Representative if in doubt.

There must not be any special education or training that is required for safe servicing of any of the products that are installed in the racks. Contact your IBM Representative if you are in doubt.

Power requirements

Ensure that your operating environment meets the AC-power and voltage requirements for IBM FlashSystem A9000 systems.

The FlashSystem A9000 system is designed with backup battery modules in order to maintain power to the storage system in the event of an AC-power loss.

The FlashSystem A9000 system has redundant power cables. For this type of redundant configuration, you must supply power from at least two independent sources of electricity.

Consult with an IBM service representative to discuss power source options.

Note: Removing all AC power from the FlashSystem A9000 system causes an emergency shutdown. All modified data is then saved to drives, and the system turns off within 5 minutes.

Customer responsibilities

The following are the customer responsibilities for ensuring that your operating environment meets all power requirements.

- You must supply enough branch circuits to prevent overloading from the equipment that you install.

  At least two separate power grids are necessary for each system.
- You must ensure that each electrical outlet is correctly wired and grounded to prevent an electrical shock.

IBM responsibilities

The following are the IBM responsibilities for ensuring that your operating environment meets all power requirements.

- The IBM service representative completes several checks, including voltage and grounding checks before the power to the FlashSystem A9000 system is connected.
- The IBM service representative connects the power cables, powering on the system.

Power outlet requirements

Ensure that the installation site has the required power outlets.

Two independent customer-supplied power distribution units (PDU) are required for the two power cords that are needed by each component in the system (total of eight outlets, four per PDU), as depicted in Figure 11 on page 21.

Important:

- To eliminate a single point of failure, the PDUs must be independent. This means that each PDU must use a separate power source and each power source must have its own wall circuit breaker (see Figure 11 on page 21).
- The minimum overcurrent protection device should be a 30 A breaker, with a recommendation that no more than 9.6 A nominal load per PDU when running in dual PDU configurations.
- Each component in the system must have one line cord to each PDU.

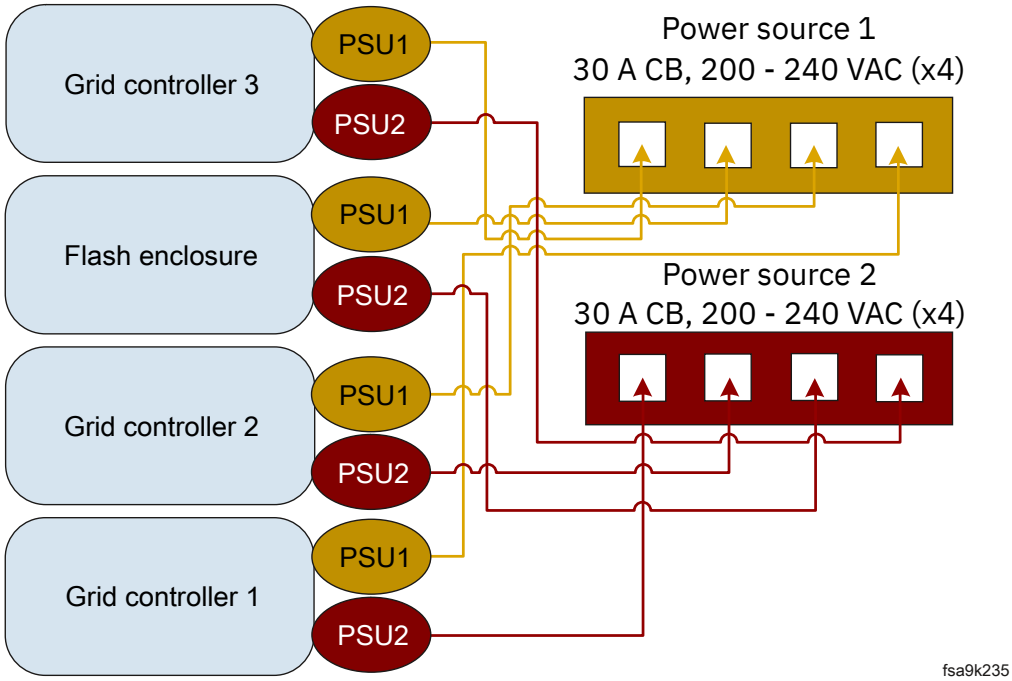


Figure 11. FlashSystem A9000 power sources

For the most reliable operation, do not use Ground Fault Circuit Interrupter (GFCI), Earth Leakage Circuit Breaker (ELCB), and Residual Current Circuit Breaker (RCCB) type circuit breakers with the FlashSystem A9000 system. The FlashSystem A9000 system is certified for safe operation and is compliant with IEC, EN, UL, CSA 60950-1 standards. However, if leakage detection circuit breakers are required by local electrical practice, the breakers must be sized for a leakage-current rating of 100 mA or greater to reduce the risk of server outage caused by erroneous and spurious tripping.

Power sources

Use this information to ensure proper power sources are provided for your storage system.

Each grid controller and flash enclosure in the system must be connected to two independent power sources, for a total of eight power outlets per storage system (four per power source).

A FlashSystem A9000 system requires two independent power sources, with minimum four (4) 10 A, 200 – 240 VAC outlets protected with a 30 A circuit breaker (as seen in Figure 11 on page 21).

For further details, see “Power outlet requirements” on page 20.

The FlashSystem A9000 system is protected from a power outage by internal backup battery modules. However, you can reduce the risk of a power outage by connecting the system to an external uninterruptible power supply, a backup generator, or both.

Power consumption

This section details the power consumption for your FlashSystem A9000 storage system.

The power consumption for pod configurations is the typical value and is provided only for reference purposes.

The measurements in the following tables have been taken in an environment with a room temperature of 18°C (64.4°F), all fans at nominal/idle speed, and battery modules not charging.

Table 7. Power consumption – model 415

MicroLatency module capacity	**Idle / light load power consumption**	
	kVA	**kW**
1.2 TB[1]	1.790	1.617
2.9 TB[1]	1.973	1.783
5.7 TB	2.173	1.963

[1]The numbers for power consumption of 1.2 TB and 2.9 TB MicroLatency modules are calculated estimates.

Table 8. Power consumption – models 425 and U25

MicroLatency module capacity	**Idle / light load power consumption**	
	kVA	**kW**
8 x 3.6 TB[1] (Model 425 only)	1.682	1.520
12 x 3.6 TB[1]	1.837	1.660
12 x 8.5 TB[1]	1.881	1.700
12 x 18 TB	1.925	1.740

[1]The numbers for power consumption of 3.6 TB and 8.5 TB MicroLatency modules are calculated estimates.

Input voltages and frequencies

This section lists the voltages or frequencies that are accepted by the FlashSystem A9000 system.

Table 9 on page 22 provides the voltages and frequencies that are accepted by the FlashSystem A9000 system. For more information, see Leakage current.

Table 9. Input voltages and frequencies

Characteristics	**Single-phase voltage or frequency**
Nominal rated input voltages	200 - 240 V AC
Minimum circuit ampacity	30 A
Minimum tolerant input voltage	180 V AC
Maximum tolerant input voltage	264 V AC
Maximum ground-leakage current	3.84 mA
Steady-state input frequencies	50±3 or 60±3 Hz
Power line disturbance (PLD) input frequencies	50±3 or 60±3 Hz

Environmental requirements

Ensure that the installation site meets all operating environment requirements for the IBM FlashSystem A9000 system.

Procedure

To ensure that the installation site meets the requirements, complete the following steps:

1. Use adequate ventilation, especially during the first 120 days of continuous operation. Ensure that there is an average room outdoor intake air rate of 0.4 air change per hour.
2. Keep the front and rear of the rack clear of obstruction.
3. Verify that you can meet the environmental operating requirements at the air intake locations.
4. Consider optimizing the air circulation and cooling for the rack by using a raised floor, adjusting the floor layout, and adding perforated tiles around the air intake areas.

   The following sections cover the environmental requirements for your FlashSystem A9000 system:

   - “Operating environment requirements” on page 23
   - “Air circulation and cooling” on page 24
   - “Contamination information” on page 26
   - “Acoustic declaration” on page 27
   - “Operating vibration requirements” on page 28

Operating environment requirements

You must verify that your operating environment is compatible with the required specifications.

The air that enters the front door of the FlashSystem A9000 system must meet the following requirements.

Operating (powered on)

- Temperature: 10°C to 35°C (50°F to 95°F)
- Relative humidity: 20% to 80%, non-condensing
- Maximum wet bulb temperature: 25°C (77°F)
- Maximum altitude: 2134 m (7000 ft)

Non-operating (powered off)

- Temperature: 5°C to 45°C (41°F to 113°F)
- Relative humidity: 20% to 80%, non-condensing
- Maximum wet bulb temperature: 27°C (80.6°F)

Shipping

- Temperature: -40°C to 60°C (-40°F to 140°F)
- Relative humidity: 5% to 95%, non-condensing
- Maximum wet bulb temperature: 29°C (84.2°F)

Important: A FlashSystem A9000 system that runs continuously must be within the specified operating environment. A FlashSystem A9000 system can operate at the maximum allowable temperature for only short durations, such as might occur during a disk drive module or power-supply unit replacement. Continuous operation above the maximum temperature increases the probability of component failure.

Air enters at the front of the rack and leaves at the back. To prevent the air that is leaving the rack from entering the intake of another piece of equipment, place racks in alternate rows, in a back-to-back, and front-to-front arrangement.

System environmental acclimation

Condensation is a normal and natural occurrence if packaging is removed at time of delivery, during extreme cold weather delivery times.

All IBM equipment has been tested in climate chambers duplicating shipping temperatures of -40°C to 60°C (-40°F to 140°F) and condensation and frost do not impact reliability of the product.

It is highly recommended that the device not be removed from the shipping package for at least 24 hours, in order to acclimate to the new temperature conditions. If there are still visible signs of condensation after the initial 24 hour wait period, acclimate the system without the shipping bag for an additional 12 - 24 hours, or until no further visible condensation remains. If package material removal is necessary, equipment should be placed in a location away from any air vents.

Air circulation and cooling

You can take steps to optimize the air circulation and cooling for your FlashSystem A9000 system.

Procedure

To optimize the cooling around your FlashSystem A9000 system, complete the following steps:

1. Install the FlashSystem A9000 system on a raised floor, which provides increased air circulation for better cooling.
2. Install perforated tiles in the front and back of each base rack and expansion rack as follows:
   a) For a stand-alone base rack, install two fully perforated tiles in front of the base rack and one partially perforated tile at the back of the base rack.
   b) For a row of racks, install a row of perforated tiles in front of the racks and one or two fully perforated tiles at the back of each two racks.
   c) For groupings of racks, where a hot aisle and cold aisle layout is used, use a cold aisle row of perforated tiles in front of all racks. For hot aisles, install a perforated tile per pair of racks.
3. Ensure that the installation site meets the cooling (thermal dissipation) requirements that are listed in one of the following:
   - **For model 415:** Table 10 on page 24
   - **For models 425 and U25:** Table 11 on page 24

Table 10. Thermal dissipation for FlashSystem A9000 system – model 415

Storage configuration	Thermal Dissipation kBTU/hour
3 grid controllers and 1 flash enclosures	9.9

Table 11. Thermal dissipation for FlashSystem A9000 system – models 425 and U25

Storage configuration	Thermal Dissipation kBTU/hour
3 grid controllers and 1 flash enclosures	6.7

4. Ensure that the installation site meets the airflow requirements that are listed in one of the following:
   - **For model 415:** Table 12 on page 25
   - **For models 425 and U25:** Table 13 on page 25

Table 12. Airflow requirements for FlashSystem A9000 system – model 415		
Storage configuration	**Cubic feet per minute (CFM)**	
	Nominal temperature (23°C) (73.4°F)	**Maximum temperature (35°C) (95°F)**
3 grid controllers and 1 flash enclosures	240	430

Table 13. Airflow requirements for FlashSystem A9000 system – models 425 and U25		
Storage configuration	**Cubic feet per minute (CFM)**	
	Nominal temperature (23°C) (73.4°F)	**Maximum temperature (35°C) (95°F)**
3 grid controllers and 1 flash enclosures	225	420

Temperature threshold and events

The storage system handles overheating by informing the administrator through warning events and initiating an automatic thermal shutdown as a last resort.

These event notifications indicate to the administrators if the system temperature is: normal, high, too high, and critically high; above which shutdown will be applied immediately. Table 14 on page 25 specifies the temperature thresholds and events received.

After a manual or automatic thermal shutdown due to thermal conditions, IBM support must be immediately contacted. Do not attempt to power up the system before contacting IBM support.

Table 14. FlashSystem A9000 system temperature thresholds and events		
Temperature threshold	**Event**	**Description**
27°C (80°F)	SYSTEM_TEMPERATURE_IS_OK_NOW	No action required. This event is generated only when the normal system temperature is recovered from a higher temperature.
28°C (82.4°F)	SYSTEM_TEMPERATURE_IS_ABOVE_NORMAL	System temperature is above normal temperature range.
30°C (86°F)	SYSTEM_TEMPERATURE_IS_HIGH	System should be closely monitored, and action to cool down the system is recommended.
32°C (89.6°F)	SYSTEM_TEMPERATURE_IS_TOO_HIGH	Actions to cool down the system must be taken immediately.
35°C (95°F)	SYSTEM_TEMPERATURE_IS_CRITICALLY_HIGH	Manually shutdown the system by using the **shutdown** command.
38°C (100.4°F)	SYSTEM_TEMPERATURE_IS_CRITICALLY_HIGH_SHUTTING_DOWN	Automatic system shutdown is in progress.

Contamination information

You must consider the air quality and contamination levels at your installation site.

Airborne particulates (including metal flakes or particles) and reactive gases acting alone or in combination with other environmental factors, such as humidity or temperature, might pose a risk to the FlashSystem A9000 system hardware. Risks that are posed by the presence of excessive particulate levels or concentrations of harmful gases include damage that might cause the system to malfunction or cease functioning altogether.

This specification describes limits for particulates and gases that are intended to avoid such damage. The limits must not be viewed or used as definitive limits because numerous other factors, such as temperature or moisture content of the air, can influence the impact of particulates or environmental corrosives and gaseous contaminant transfer.

In the absence of specific limits, implement practices that maintain particulate or gas levels that are consistent with the protection of human health and safety. If IBM determines that the levels of particulates or gases in your environment damaged the FlashSystem A9000 system, IBM might require implementation of appropriate remedial measures to mitigate such environmental contamination before providing repair or replacement of the storage system. Implementation of such remedial measures is a customer responsibility.

The following criteria must be met:

Gaseous contamination

Severity level G1 as per ANSI/ISA 71.04-1985[1], which states that the reactivity rate of copper coupons must be less than 300 Angstroms per month (Å/month, ≈ 0.0039 µg/cm^2-hour weight gain) [2]. In addition, the reactivity rate of silver coupons must be less than 300 Å/month (≈ 0.0035 µg/cm^2-hour weight gain) [3]. The reactive monitoring of gaseous corrosibleness must be conducted approximately 5 cm (2 in.) in front of the rack on the air inlet side at one-quarter and three-quarter frame height off the floor. For environments with special air handling equipment that alters the normal distribution of airflow into the rack, reactive monitoring of gaseous corrosibleness must be conducted at a location on the rack where air is entering at the highest rate.

Particulate contamination

Data centers must meet the cleanliness level of ISO 14644-1 class 8. For data centers without air-side economizers, the ISO 14644-1 class 8 cleanliness can be met by choosing one of the following filtration methods:

- The room air can be continuously filtered with MERV 8 filters.
- Air entering a data center can be filtered with MERV 11 or preferably MERV 13 filters.

For data centers with air-side economizers, the choice of filters to achieve ISO class 8 cleanliness depends on the specific conditions present at that data center. The deliquescence relative humidity of the particulate contamination must be more than 60% RH [4]. Data centers must be free of zinc whiskers [5].

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1 ANSI/ISA-71.04.1985. *Environmental conditions for process measurement and control systems: Airborne contaminants.* Instrument Society of America, Research Triangle Park, NC, 1985.

2 The derivation of the equivalence between the rate of copper corrosion product thickness growth in Å/month and the rate of weight gain assumes that Cu_2S and Cu_2O grow in equal proportions.

3 The derivation of the equivalence between the rate of silver corrosion product thickness growth in Å/month and the rate of weight gain assumes that Ag_2S is the only corrosion product.

4 The deliquescence relative humidity of particulate contamination is the relative humidity at which the dust absorbs enough water to become wet and promote corrosion, ion migration, or both.

5 Surface debris is randomly collected from 10 areas of the data center on a 1.5 cm (0.6 in.) diameter disk of sticky, electrically conductive tape on a metal stub. If examination of the sticky tape in a scanning electron microscope reveals no zinc whiskers, the data center is considered free of zinc whiskers.

Acoustic declaration

This information lists the acoustic (sound power) levels for the FlashSystem A9000 system.

CAUTION:

Depending upon local conditions, the sound pressure might exceed 85 dB(A) during service operations.

Hearing protection must be worn when you are in a room that has a FlashSystem A9000 unit while either the front or rear door is open or when the front and rear doors are not installed.

Note: Government regulations (such as those prescribed by OSHA or European Community Directives) may govern noise level exposure in the workplace and may apply to you and your server installation. The actual sound pressure levels in your installation depend upon a variety of factors, including the number of racks in the installation; the size, materials, and configuration of the room; the noise levels from other equipment; the room ambient temperature; and employees' location in relation to the equipment. Further, additional factors may be considered when reviewing noise exposures, including, but not limited to, exposure duration and the use of hearing protection. IBM recommends that you consult with a qualified expert in the acoustical noise field prior to operating this system.

Model 415

The acoustic levels are shown in Table 15 on page 27. All measurements are in conformance with ISO 7779 and declared in conformance with ISO 9296.

Note:

1. LWAd is the statistical upper-limit A-weighted sound-power level (rounded to the nearest 0.1 B).
2. LpAm is the mean A-weighted emission sound-pressure level that is measured at the 1-meter bystander positions (rounded to the nearest dB).
3. 10 dB (decibel) = 1 B (bel)

Table 15. Acoustic declaration – model 415

	Declared A-weighted sound power level, LWAd (B)	**Declared A-weighted sound pressure level, LpAm (dB)**
Operating	7.1	54
Idle	7.1	54

Models 425 and U25

The acoustic levels are shown in Table 16 on page 28. All measurements are in conformance with ISO 7779 and declared in conformance with ISO 9296.

Note:

1. LWAd is the statistical upper-limit A-weighted sound-power level (rounded to the nearest 0.1 B).
2. LpAm is the mean A-weighted emission sound-pressure level that is measured at the 1-meter bystander positions (rounded to the nearest dB).
3. 10 dB (decibel) = 1 B (bel)

Table 16. Acoustic declaration – models 425 and U25		
	Declared A-weighted sound power level, LWAd (B)	**Declared A-weighted sound pressure level, LpAm (dB)**
Operating	7.0	52
Idle	7.0	52

Operating vibration requirements

The vibration levels that are designed for the FlashSystem A9000 system comply with class V1L requirements included in the product classes for vibration.

The storage system is designed to operate under the vibration V1L levels that are described in Table 17 on page 28.

Table 18 on page 28 and Table 19 on page 28 provide additional information regarding random vibration PSD profile breakpoints and operational shock levels.

Table 17. Vibration levels		
Class	**grms**	***g* Peak Sine**
V1L	0.10	0.06 @ 50 & 60 Hz
Note: *g* is the peak *g* level of an approximate half-sine pulse.		

Table 18. Random vibration PSD profile breakpoints			
Class	**5 Hz**	**17 Hz**	**500 Hz**
V1L	2.0×10^{-7}	2.2×10^{-5}	2.2×10^{-5}
Note: All values in this table are in g^2/Hz.			

Table 19. Operational shock levels			
Class	**Axis**	**g^1**	**pw[2]**
S1	Vertical	3.5	3.0
Note: [1]*g* is the peak *g* level of an approximate half-sine pulse. [2]pw is the pulse width in milliseconds.			

Site security considerations

When installing an IBM FlashSystem A9000 storage system, you need to apply the same security practices that you apply to any other business critical IT system.

Note: A good reference on storage security can be found at the Storage Networking Industry Association (SNIA) website: http://www.snia.org/forums/ssif/programs/best_practices.

A common risk with storage systems is the retention of volatile caches. Your FlashSystem A9000 storage system is perfectly safe in regard to external operations and a loss of external power. If there is a power failure, the internal battery backup modules provide power to the system. These battery modules allow your storage system to gracefully shut down.

If desired, you can install your own uninterruptible power supply (UPS) unit(s) or generators in order to provide further power-failure protection.

However, if someone gains physical access to the equipment, physical contact with the machine presents the following security risks:

- Stealing of the machine or components
- Breaking components
- Manual shutdown of the machine or components by bypassing the preferred process

These cases could lead to losing the contents of the system and its volatile caches, resulting in loss of access.

Attention: Restricting physical access is especially critical when using local key management.

For more information on using local key management, see “Native user authentication” on page 46.

For more information on using external key management (LDAP), see “External authentication via Lightweight Directory Access Protocol (LDAP)” on page 46.

To eliminate or greatly reduce this risk, choose a rack with lockable doors, and/or a security kit.

Important: In addition to lockable doors on the system itself, it is highly advised to secure access to the room in which the physical storage system is kept.

Chapter 5. Network and host connectivity requirements

This section details the host SAN connections and requirements for IBM FlashSystem A9000 storage systems.

Network and host connectivity requirements are listed in the following sections:

Network connections for management

This section details the options used for network connectivity for the storage system.

Figure 12 on page 31 shows the customer port locations on a grid controller used for remote access, management, and VPN connections.

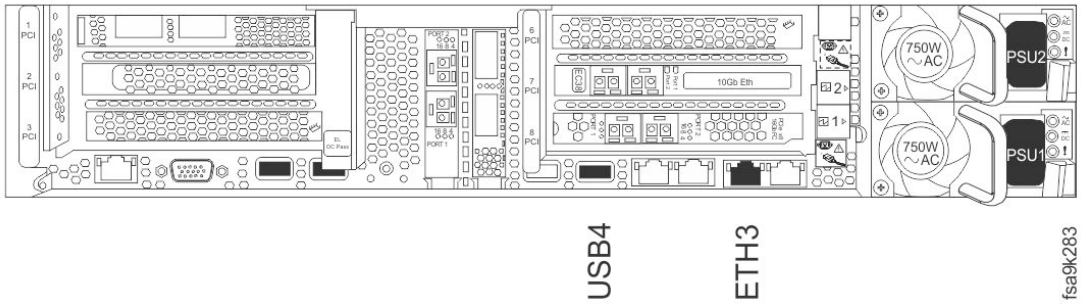

Figure 12. Customer port connections for management

Model 415

- For remote access and management connections, connect Ethernet cables to the ETH3 ports on grid controllers 1 and 3 (M1E3, M3E3).
- For VPN connections, use the USB4 connections on grid controllers 2 and 3, using a serial-to-USB adapter.
- For technician connections, technicians use the ETH3 port on grid controller 2 (M2E3) and the ETH4 port on grid controller 3 (M3E4).

Models 425 and U25

- For remote access and management connections, connect Ethernet cables to the ETH3 ports on grid controllers 1 and 2 (M1E3, M2E3).
- For VPN connections, use the USB4 connections on grid controllers 1 and 2, using a USB-to-Ethernet adapter.
- For technician connections, technicians use the USB2 port on grid controller 1 (M1U2) and the USB2 port on grid controller 2 (M2U2).

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Management port requirements

The management ports provide the connectivity required for the IBM Hyper-Scale Manager, the IBM FlashSystem A9000 command-line interface (CLI), and other management tools to monitor and control the FlashSystem A9000 system.

IP configuration

Use this information for system storage IP configuration.

The IBM FlashSystem A9000 storage system has two redundant management port IP addresses, via two Ethernet interfaces, in case of failure.

Each IP address is handled by different grid controllers.

Note: If you use only one path and the grid controller for that connection goes down, the ability to manage the system is lost.

For information about the IBM Hyper-Scale Manager, see the IBM Hyper-Scale Manager documentation (ibm.com/docs/en/hyper-scale-manager).

Management functions can be performed through any of the IP addresses. These addresses can be accessed simultaneously by multiple clients.

For each of the two management ports, provide the following information to the IBM service representative before starting the installation process:

- IP address of the port
- Net mask
- Default gateway IP
- Maximum transmission unit (MTU)

  Attention: Be careful when changing an Ethernet port MTU. If management connectivity is on, or a VPN is being used, this might break existing application connectivity unless the adjacent switch is configured properly.

  This would be the result of the switch using a fixed MTU size lower than the new size being defined on the system.

  For example, if the system sends 9000 byte packets while the switch can only receive packets up to 1500 bytes, the switch drops extra packets.

  Note:

  – All management IP interfaces must be connected to the same subnet and use the same network mask, gateway, and MTU.

  – MTU configuration is required if the network supports an MTU that is greater than the default 1536 bytes. The largest possible MTU supported is 9216 bytes.

- Virtual LAN (VLAN)

  VLAN tagging can be enabled or disabled for management and VPN ports. The ports can be configured as untagged (default) or tagged.

  Note:

  – A valid VLAN tag value can only be 1 - 4094.

  – All management or VPN ports with VLAN tagging enabled must belong to the same VLAN tag, one per port type.

In addition, provide the following system-level IP information:

Note: IPV6 is supported.

- IP address of the primary and secondary DNS servers

- IP addresses or DNS names of the SMTP servers
- IP addresses or DNS names of the NTP server
- IP addresses and port numbers of the Remote Support servers

Control (management) protocols

Communication to the system via Ethernet ports is divided into two: data Ethernet ports and control Ethernet ports. The control protocols are used for system management; monitoring; telemetry and support; and communication security. These control protocols are detailed in this section.

Note: For more information regarding the data Ethernet configurations, see "iSCSI network configurations" on page 40.

System management is carried out through the protocols detailed in Table 20 on page 33.

Note: *Inbound* protocol connections are initiated by external entities, such as IBM Hyper-Scale Manager and others. The *outbound* protocol connections are initiated by FlashSystem A9000.

Table 20. Control (management) protocols

Use	Protocol	TCP port	Inbound/ Outbound	Encrypted?	Enabled by default (Yes/No)	Comments
Management						
Command-line interface (CLI) (includes Hyper-Scale Manager)	<proprietary>	7778	Inbound	Yes	Yes	Storage system management portal and CLI act as the client and initiate the connection, while FlashSystem A9000 acts as the server.
Common Information Model (CIM) agent	CIM	5989	Inbound	Yes	No	Storage system uses CIM agent to reply to management commands.
Common Information Model (CIM)	SLP	427	Inbound	No	No	Service Location Protocol (SLP) used for service discovery in conjunction with the CIM protocol.
Time setting	NTP	123	Outbound	No	N/A	Storage system uses a Network Time Protocol (NTP) connection.
Monitoring						
SNMP requests	SNMP	161	Inbound	Yes	Yes	Storage system responds to SNMP requests when sending replies to SNMP managers.
SNMP traps/ notifications	SNMP	162	Outbound	No	N/A	Storage system initiates SNMP messages when sending traps/notifications to SNMP managers.
Syslog	UDP	514	Outbound	No	N/A	Storage system uses for collecting system logs.
Telemetry and Support						

Table 20. Control (management) protocols (continued)

Use	Protocol	TCP port	Inbound/ Outbound	Encrypted?	Enabled by default (Yes/No)	Comments
Outbound mail	SMTP	25	Outbound	No	N/A	Storage system initiates SMTP traffic when sending emails for either event notifications or for SMS gateways. **Note:** Closing this port disconnects the IBM Service Center.
XRSC (SSH)	TCP	22, 2222	Inbound	Need to enable	Yes	Storage system uses port for remote connectivity. **Note:** The management ports should be on a different subnet than the VPN ports that are used for remote access.
Secure technician access	TCP	443	Inbound	Yes	No	Technician Assistant tool uses for data management platform (DMP) connectivity.
Communication security and access						
Connectivity	IPSec	1293	Inbound	Yes	No	Storage system uses IPSec for management and VPN communication. **Note:** The management ports should be on a different subnet than the VPN ports that are used for remote access.
Domain Name System	DNS	53	Outbound	No	N/A	Storage system uses a Domain Name System (DNS) connection.
LDAP authentication	LDAP	389	Outbound	No	N/A	Storage system uses for LDAP authentication connectivity.
Other						
Key management	KMIP	5696	Outbound	Yes	N/A	Storage system communicates with key servers using the KMIP protocol.
Quorum Witness	<proprietary>	8460	Outbound	Yes	N/A	Storage system uses port with Quorum Witness for API communication (with a default Linux firewall).

Table 20. Control (management) protocols (continued)						
Use	**Protocol**	**TCP port**	**Inbound/ Outbound**	**Encrypted?**	**Enabled by default (Yes/No)**	**Comments**
Quorum Witness	<proprietary>	8461	Outbound	Yes	N/A	Storage system uses port with Quorum Witness for log retrieval (with a default Linux firewall).
Quorum Witness	<proprietary>	8462	Outbound	Yes	N/A	Storage system uses port with Quorum Witness for retrieval of Ngnix statistics (with a default Linux firewall).

Host network connectivity and multipathing configurations

Host systems can connect to an IBM FlashSystem A9000 over a Fibre Channel (FC) network by using the Small Computer System Interface (SCSI) protocol or over an Ethernet network by using the Internet Small Computer System Interface (iSCSI) protocol.

Important: A host must be attached to FlashSystem A9000 system through a Fibre Channel fabric or Ethernet switch.

While a host can connect through FC and iSCSI simultaneously, the same LUN can only be mapped through FC *or* iSCSI.

Host traffic can be directed to any of the grid controllers.

The administrator must ensure that multipathing is used. Multipathing is configured by ensuring the following:

- Host connections avoid single points of failure by applying redundant connections.
- All host workload is adequately balanced across the connections and grid controllers (ensuring system resource utilization is maximized).

  Review the balancing periodically and when connections or traffic patterns change.

Important: Always employ multipathing for data connections. If multipathing is not used, the Health widget on the Dashboard of the UI indicates that multipathing is not used.

For more information about host attachment support and connectivity, see Configuring host attachment. For supported interoperability configurations, see the System Storage® Interoperation Center website (ibm.com/systems/support/storage/config/ssic) .

Fibre Channel (FC) network configurations

Host systems can connect to the storage system over a Fibre Channel (FC) network. Use these important practices when configuring your Fibre Channel host port connections, in order to achieve high availability and high performance in your storage system.

Fibre Channel network configuration information is listed in the following sections:

- “Fibre Channel (FC) adapter types” on page 36
- “Fibre Channel host port configuration” on page 37
- “Fibre Channel connectivity requirements” on page 38
- “Fibre Channel best practices” on page 39
- “Fibre Channel zone types” on page 39

Fibre Channel (FC) adapter types

Use this information to learn about the FC adapter types being used in the IBM FlashSystem A9000 systems.

Both NVMe/FC and FC-FCP adapter types offer the same 16 Gb bandwidth.

The external physical difference between the two adapers is as follows:

- FC-FCP adapters are stamped with "PCIe x8 16GbFC".

  The FC-FCP port markings are stamped on each adapter.
- NVMe/FC adapters are stamped with "PCIe FC".

  The NVMe/FC port numbering is labeled on each adapter.

Figure 13 on page 36 shows the placement of the FC markings.

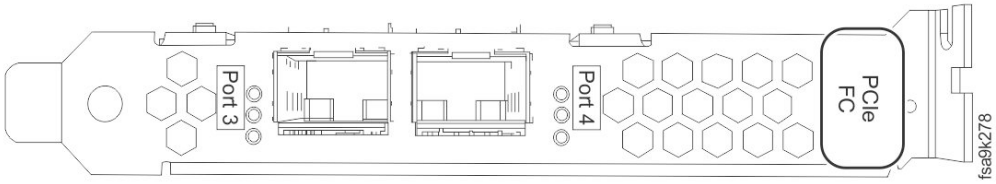


Figure 13. NVMe/FC adapter indication

Note: Figure 13 on page 36 shows an example of an NVMe/FC adapter in slot 8. The adapters in slot 4 looks slightly different, but all of the visual indicators described and shown in the image are present.

To determine which adapters are installed in your system, lookup the grid controller feature code, using the feature code information in “Grid controller components and feature codes” on page 10.

NVMe/FC adapters

NVM Express (NVMe) allows servers to leverage the native parallelism of today's SSD offerings, reduces overall I/O overhead, and increases bandwidth. NVMe/FC enables NVMe over a Fibre Channel (FC) network fabric, thus combining the benefits of all-flash SAN storage, with NVMe performance, over existing infrastructure.

Starting from system code level 12.2.1, all new orders of IBM FlashSystem A9000 models 425 and U25 systems (system code level 12.2.1 and higher) are shipped with an enhanced grid controller, with NVMe/FC ready adapters.

From system code level 12.4.0, all systems containing grid controller feature code 5005 have the ability to connect to either NVMe-based or SCSI-based (FCP) switches.

For systems with software versions prior to 12.4.0 and purchased prior to 12.2.1 release, the NVMe/FC adapters serve FC over SCSI only, just as the FC-FCP adapters currently do. In this type of FC configuration, a *system* may contain FC-FCP adapters; NVMe/FC adapters; or both. However, a *single grid controller* may contain only *one type* of adapter.

FC-FCP adapters

These adapters are used on grid controllers for model 415 and any model 425 that was proposed or ordered prior to 12.2.1.

Fibre Channel host port configuration

Use this information to properly configure your Fibre Channel host port connectivity.

Physical port connectivity

Be sure to connect port 1 of each grid controller in the system to switch 1 which belongs to fabric 1, and port 3 of each grid controller to switch 2 which belongs to fabric 2.

For more connectivity information regarding port connectivity, see “Fibre Channel connectivity requirements” on page 38. For a port–fabric connectivity example, see Figure 17 on page 40.

Connectivity for high performance

For high performance, follow these important practices:

- Spread grid controller port connections as evenly as possible.
- For high CPU utilization in each grid controller, use ports 1 and 3 for host connectivity and ports 2 and 4 for migration and mirroring activities (see Chapter 6, “Migration and mirroring connectivity,” on page 49).

Ensuring high availability of each host

In order to ensure high availability of each host, follow these important practices:

- Ensure that you have more than one path from the host to the system.
- Divide the paths between the two fabrics: half the paths connecting to fabric 1 and the other half connecting to fabric 2.
- Spread the paths across different grid controllers.
- Use different adapters within each of the grid controllers, as shown in Figure 14 on page 37.

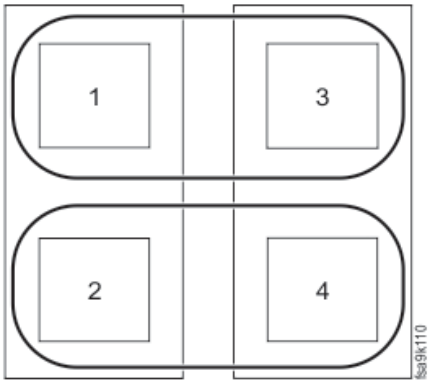
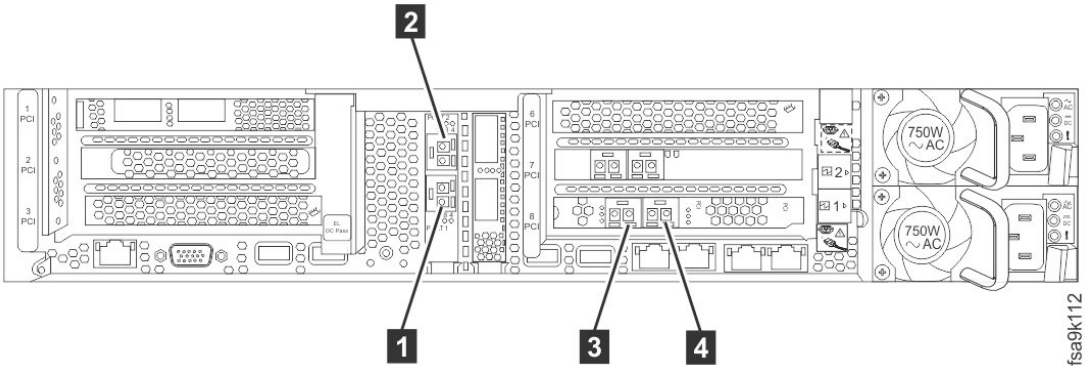


Figure 14. Crossing Fibre Channel grid controller ports

Important: It is important to use both Fibre Channel adapters for resiliency and high performance.

Figure 15 on page 38 shows the port numbers for each of the FC ports on the rear of the grid controllers.



1 FC port 1
2 FC port 2
3 FC port 3
4 FC port 4

Figure 15. FC port numbering on the grid controllers

Only use non-redundant configurations when the risks of a single point of failure are acceptable, which is typically the case for test and development environments. Non-redundant configurations should generally not be used. For connectivity requirements, see "Fibre Channel connectivity requirements" on page 38.

Fibre Channel connectivity requirements

Use these connectivity requirements in order to ensure redundancy, further protecting your system data.

In a production environment, always connect Fibre Channel hosts to a **minimum** of two independent fabrics. Be sure to minimally have two separate grid controller connections, each path going to a separate fabric, as illustrated in Figure 16 on page 38.

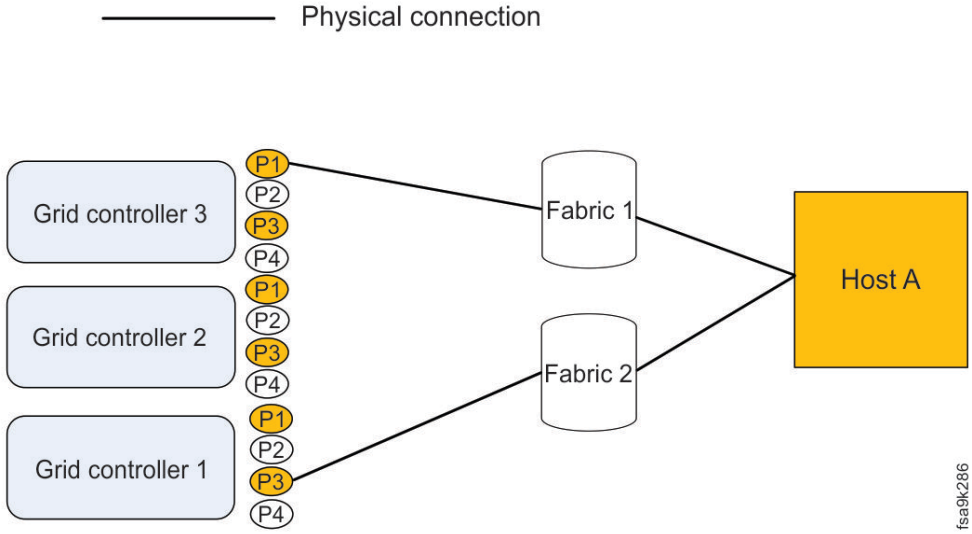


Figure 16. Minimum host connectivity

Important: Host multipath connectivity eliminates the risk of a single point-of-failure between the host and storage systems.

In Fibre Channel network configurations, there are two dual-port connections per grid controller. This setup contains a total of two paths (one path to each fabric), providing protection against single fabric failure or a failure of up to one grid controller.

Note:

- For best performance, use a 16 Gb Fibre fabric and HBA on the host.
- Host system can have as many HBAs as needed.
- In a FlashSystem A9000 with Fibre Channel configuration, each grid controller has two dual 16 Gb Fibre Channel ports.

Figure 15 on page 38 shows the port numbers for each of the FC ports on the grid controllers.

Several network configurations that use Fibre Channel are technically possible, and each configuration varies in terms of cost, flexibility, performance, and reliability.

Fibre Channel best practices

Use this information for FC host connectivity best practices.

Talk to your IBM representative to help optimally setup your host connections, according to your needs.

To achieve high performance, it is important to:

1. Spread the host connections to each grid controller evenly.
2. Utilize the CPU in each grid controller as much as possible. Use ports 1 and 3 for host connectivity and then ports 2 and 4 for migration and mirroring.

To achieve balancing, all hosts should be spread across all *zone types* evenly. The amount of *zone types* depends on the number of grid controllers in the system being used for connectivity.

For more information on *zone types*, see “Fibre Channel zone types” on page 39.

For supported interoperability configurations, see the System Storage Interoperation Center website (ibm.com/systems/support/storage/config/ssic) .

Fibre Channel zone types

A *zone type* is defined as a set of targets from a certain combination of grid controllers. Each zone defined in each fabric is based on a single *zone type*.

Zoning that follows the *zone type* configuration should guarantee the following:

- High availability of host connectivity.
- All grid controllers and ports are used evenly (as described in “Fibre Channel host port configuration” on page 37).

While Host A may be associated to Zone 1 and Host B may be associated to Zone 2, they are physically connected to the same system ports on different zones, therefore they have the same *zone type*. “Zone type examples” on page 39 shows an example of this type of zoning scheme.

For more information on *zone types*, zoning, connectivity during scale-out, and general host connectivity, see IBM FlashSystem A9000, IBM FlashSystem A9000R, and IBM XIV® Storage System: Host Attachment and Interoperability Redbook, SG24-8368 (www.redbooks.ibm.com/redbooks/pdfs/sg248368.pdf) .

Zone type examples

Use the following *zone type* examples to properly configure your Fibre Channel host connectivity.

Only use a single *zone type* in a FlashSystem A9000 per host in each switch. The single *zone type* includes all grid controllers in the system.

Physically, each grid controller is connected to two different fabrics through a single zone, being defined on both of the fabrics. This particular zone is based on a single *zone type*.

Table 21 on page 40 shows how all ports across all grid controllers are configured within the same *zone type* (Z123). Figure 17 on page 40 illustrates the port connections across the different hosts and fabrics, with zoning examples, where P1 and P3 are the port number connections.

Table 21. Map of ports according to zone type			
Zone type name	**Grid controller 1**	**Grid controller 2**	**Grid controller 3**
	Ports 1 and 3	**Ports 1 and 3**	**Ports 1 and 3**
Z123	✓		

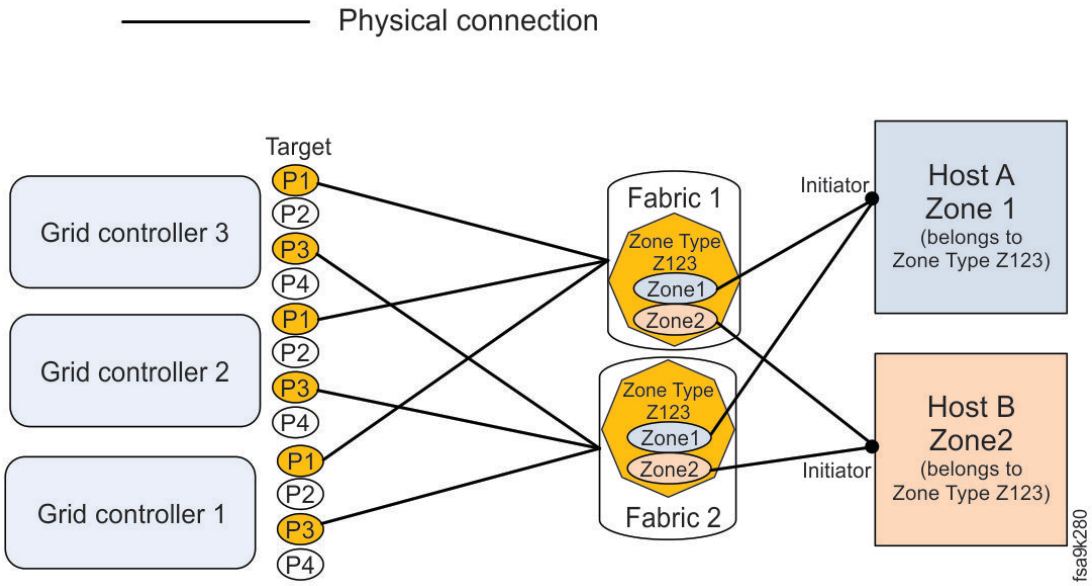


Figure 17. Zone type setup for FlashSystem A9000

iSCSI network configurations

Host systems can connect to a FlashSystem A9000 over an Ethernet network using the Internet Small Computer System Interface (iSCSI) protocol. Use these important recommendations when configuring your iSCSI host port connections, in order to achieve high availability and high performance in your storage system.

iSCSI network configuration information is listed in the following sections:

- "iSCSI host post configuration" on page 40
- "iSCSI connectivity requirements" on page 42
- "iSCSI best practices" on page 43

iSCSI host post configuration

Use this information to properly configure your iSCSI (Ethernet) host port connectivity.

Disabling and enabling Spanning Tree Protocol (STP) or Rapid Spanning Tree Protocol (RSTP)

When setting up your Ethernet switch for host port connectivity, disable the STP or RSTP for each port that is connected to the FlashSystem A9000 system on the switch. Keeping these enabled can cause loss of host connectivity to the FlashSystem A9000 during hot upgrade.

Your network administrator can disable and enable the STP or RSTP at any time.

The following are examples of how to disable and enable an STP on a specific interface, when using a Cisco Nexus 5000 Series Switch.

To disable the STP

```
switch# configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
switch(config)# interface Eth101/1/12
switch(config-if)# no spanning-tree port type edge trunk
switch(config-if)#
```

To enable the STP

```
switch# configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
switch(config)# interface Eth101/1/12
switch(config-if)# spanning-tree port type edge trunk
Warning: Edge port type (portfast) should only be enabled on ports connected to a single
 host. Connecting hubs, concentrators, switches, bridges, etc... to this
 interface  when edge port type (portfast) is enabled, can cause temporary bridging loops.
 Use with CAUTION
switch(config-if)#
```

Physical host port configuration

Be sure to connect port 1 of each grid controller in the system to switch 1 and port 3 of each grid controller to switch 2.

Connectivity for high performance

For high performance, follow these important practices:

- Try to spread all ports of grid controllers in the system evenly.
- Utilize the CPU in each grid controller, as much as possible, for high CPU utilization. To achieve this, it is recommended to use ports 1 and 3 for host connectivity and ports 2 and 4 for migration and mirroring activities (see Chapter 6, “Migration and mirroring connectivity,” on page 49).

Ensuring high availability of each host

In order to ensure high availability of each host, follow these important practices:

- Divide the paths between the two subnets: half the paths connecting to subnet 1 and the other half connecting to subnet 2.
- If possible, spread the paths across different grid controllers.
- Use different adapters within each of the grid controllers, as shown in Figure 18 on page 41.

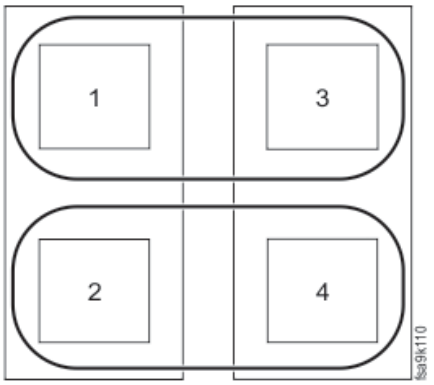
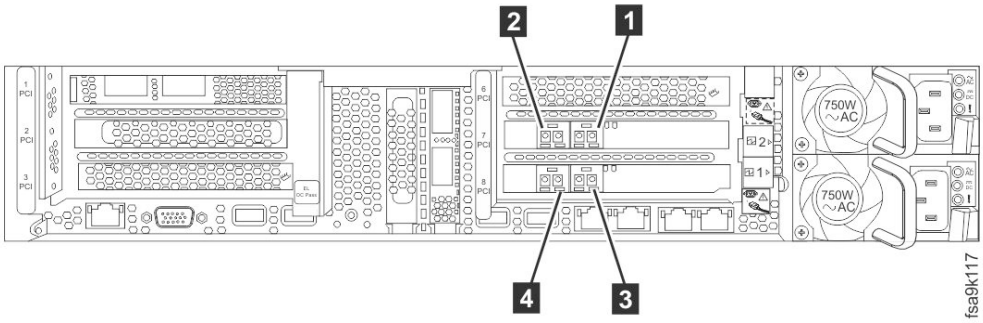


Figure 18. Crossing Fibre Channel grid controller ports

Important: It is important to use both Ethernet adapters for resiliency and high performance.

Figure 19 on page 42 shows the port numbers for each of the iSCSI ports on the grid controllers.



1 10 GbE port 1
2 10 GbE port 2
3 10 GbE port 3
4 10 GbE port 4

Figure 19. iSCSI port numbering on the grid controllers

Only use non-redundant configurations when the risks of a single point of failure are acceptable, which is typically the case for test and development environments. Non-redundant configurations should generally not be used. For connectivity requirements, see "iSCSI connectivity requirements" on page 42.

iSCSI connectivity requirements

Use these connectivity requirements in order to ensure redundancy, further protecting your system data.

In a production environment, always connect Ethernet hosts to a minimum of two separate Ethernet switches to provide redundancy. In Ethernet network configurations, there are two dual-port connections per grid controller.

Note:

- For best performance, use a 10 Gb Ethernet switch and HBA on the host to obtain maximum performance or throughput.
- Host system can have as many HBAs as needed to support the operating system, application, and overall performance requirements.
- In a FlashSystem A9000 system with iSCSI configuration, each grid controller has two dual 10 Gb Ethernet ports.

Several network configurations using Ethernet are technically possible, and each configuration varies in terms of cost, flexibility, performance, and reliability.

In the FlashSystem A9000 system, each iSCSI port is defined with its own IP address. Before you set up the iSCSI network, gather the following information for each iSCSI port:

- IP address
- Net mask
- Default gateway
- Maximum transmission unit (MTU)

Note the following when setting up your iSCSI network:

- If two or more iSCSI connections exist in your iSCSI network, iSCSI ports for mirroring must be defined on switches with flow control set to on.
- MTU configuration is required if the network supports an MTU that is greater than the default 1536 bytes.

  The maximum MTU value supported is 9216 bytes.

- Because the FlashSystem A9000 system acts as a TCP server for iSCSI connections, packets are always routed through the Ethernet port from which the iSCSI connection was initiated. The default gateways are required only if the hosts are not on the same layer-2 subnet as the FlashSystem A9000 system.
- If present, Ethernet VLANs and IP routers must be configured to enable connectivity between the host systems and the FlashSystem A9000 system.
- If present, IP routers must be configured to enable access between the hosts and the FlashSystem A9000 system.

Important: Link aggregation is not supported. Ports cannot be bonded.

For supported interoperability configurations, see the System Storage Interoperation Center website (ibm.com/systems/support/storage/config/ssic) .

iSCSI best practices

Use this information for iSCSI (Ethernet) host connectivity best practices.

Talk to your IBM representative to help optimally setup your host connections, according to your needs.

In order to achieve high performance, it is important to:

1. Spread the host connections to each grid controller evenly.
2. Utilize the CPU in each grid controller as much as possible; therefore, it is recommended to use ports 1 and 3 and then ports 2 and 4.

It is recommended to use half the ports in each grid controller (ports 1 and 3) and create a single subnet (an identical subnet in each switch).

Table 22 on page 43 is an example of how the host connections should be divided.

Table 22. Example of recommended Ethernet host connections

Switch	Subnet	Grid controllers	Port number
1	1	Grid controllers 1, 2, 3	1
2	1	Grid controllers 1, 2, 3	3

This configuration creates high availability, high performance, and balancing. In addition, all grid controllers are utilized for each host.

Network cable requirements

The customer is responsible for supplying cables host connection cables, including host attachment (Fibre Channel or iSCSI) cables, management cables, maintenance cables, and virtual private network (VPN) cables.

Table 23 on page 43 shows the various cable type requirements for your system.

Table 23. Required cable types

Cables	Required cable type
Fibre Channel	50 µm (micrometer) multimode Fibre Channel cables with LC/LC or LC/SC connectors (if applicable). **Note:** If you require 62.5-µm fibers, contact an IBM service representative for assistance.
Ethernet (iSCSI)	50 µm (micrometer) multimode optical cables with LC/LC or LC/SC connectors.

Table 23. Required cable types (continued)	
Cables	**Required cable type**
Management	Straight copper gigabit CAT5e-rated Ethernet cables with RJ-45 connectors.
Virtual private network (VPN)	Straight copper CAT5e-rated Ethernet cables with RJ-45 connectors.

Certain host connection cables may be ordered with the system. Talk to your IBM representative for ordering information.

Network and host connectivity security information

The storage system integrates various security features, to protect your network and host systems.

Use this information to help understand and plan for network and host connectivity security for your IBM FlashSystem A9000 storage system.

Network and host connectivity security information can be found in the following sections:

- "Internet Protocol Security (IPSec)" on page 44
- "Data-at-rest encryption" on page 44
- "User authentication and access control" on page 45
- "PCI DSS compliance" on page 48

Internet Protocol Security (IPSec)

Internet Protocol Security (IPSec) is a protocol suite that allows for enhanced security of IP communications through the authentication and encryption of IP packets.

The IBM FlashSystem A9000 system software and IBM management tools allow for the use of passkey or certificate authentication to establish IPSec connectivity between management workstations and the management or VPN ports of the storage system.

Configuration of the IPSec is done through the command-line interface (CLI). For IPSec configuration, see the *IBM FlashSystem A9000 Command-Line Interface (CLI) Reference Guide* , SC27-8559 on the IBM FlashSystem A9000 documentation (ibm.com/docs/en/flashsystem-a9000).

Data-at-rest encryption

The storage system secures all written data with industry-standard AES encryption for data-at-rest.

Encryption key management can be carried out through an external or an internal scheme.

Encryption can be enabled during the installation of the system or at any time later. While encryption is not enabled, the system might not meet customers or legal compliance standards and the data might not be protected against security issues. Encryption can be disabled only when no volumes are defined.

Encryption is configured through the CLI.

- For more information on data-at-rest encryption, see the *IBM FlashSystem A9000 Product Overview* , GC27-8583 on the IBM FlashSystem A9000 documentation (ibm.com/docs/en/flashsystem-a9000).
- For information regarding encryption CLI commands, see the *IBM FlashSystem A9000 Command-Line Interface (CLI) Reference Guide* (SC27-8559) on the IBM FlashSystem A9000 documentation (ibm.com/docs/en/flashsystem-a9000).

More about the different types of data-at-rest encryption options can be found in the following sections:

- "Internal data-at-rest encryption scheme" on page 45
- "External data-at-rest encryption scheme" on page 45

Internal data-at-rest encryption scheme

The internal encryption key management scheme generates and stores the encryption key locally, within the storage system.

The default encryption for your FlashSystem A9000 system is the internal encryption key management scheme.

With the internal encryption key management scheme, keys are not affected by software upgrades and remain available upon the failure of up to two grid controllers.

Because the encryption is internal, it contains more security risks if the system is physically accessed. (For steps of preventing physical access to your system, see “Site security considerations” on page 28).

In addition, further precautions are necessary during relocation of your system. The boot drives contain the encryption keys and must be shipped separately for the security of your system. For specific instructions on relocating with an internal encryption key management scheme, see “Relocation shipping requirements for systems with local encrypted schemes” on page 54.

External data-at-rest encryption scheme

An external encryption key management scheme stores the keys separately from the data, thereby presenting a secured and well-defined interface for key services.

The separation of key storage from data storage and key management is accomplished with external Key Management Interoperability Protocol (KMIP) compliant servers, such as IBM® Security Key Lifecycle Manager (SKLM) or Gemalto SafeNet KeySecure server.

The separation of the keys from the data provide another layer of security should your system be physically accessed (see “Site security considerations” on page 28).

Note: To protect against the possibility that all Security Key Lifecycle Managers (SKLMs) become unusable and unrecoverable (for example, following a disaster, or other difficulties during the relocation process), the system enables you to create a *recovery key*. With a recovery key, Security Administrators can unlock an IBM FlashSystem A9000 system without the involvement of a key server.

For more information regarding recovery keys and how to use them, see the Redbook publication Data-at-rest Encryption for the IBM Spectrum Accelerate Family: IBM XIV and IBM FlashSystem A9000 and A9000R (www.redbooks.ibm.com/redpapers/pdfs/redp5402.pdf).

For more information, and purchasing options, speak to your IBM representative.

User authentication and access control

Use this information to understand how to securely maintain your passwords.

The storage system features role-based authentication, either natively or through use of LDAP-based authentication.

Attention:

- Be careful when saving user credentials locally. This information can be accessed if site or system access is obtained.

  For more information, see “Site security considerations” on page 28.
- To properly ensure password safety, be sure to change passwords often to limit security risks.

- For more information on mirroring, see:
  - Chapter 6, “Migration and mirroring connectivity,” on page 49
  - *IBM FlashSystem A9000 Product Overview* , GC27-8583 on the IBM FlashSystem A9000 documentation (ibm.com/docs/en/flashsystem-a9000)
- For more information on user authentication and access control, see the *IBM FlashSystem A9000 Product Overview* , GC27-8583 on the IBM FlashSystem A9000 documentation (ibm.com/docs/en/flashsystem-a9000)

More about the different types of user authentication and access control can be found in the following sections:

- “Native user authentication” on page 46
- “External authentication via Lightweight Directory Access Protocol (LDAP)” on page 46

Native user authentication

Native user authentication is the default mode for authenticating users and user groups.

In this mode, users and groups are authenticated against a database locally on the system. The authentication is based on the submitted username and password, which are compared to user credentials defined and stored on the storage system.

The authenticated user must be associated with a user role that specifies the system access rights.

Note: Technicians use a different form of native user authentication. For more information regarding technician authentication, see “Support and software maintenance security information” on page 62.

External authentication via Lightweight Directory Access Protocol (LDAP)

IBM FlashSystem A9000 systems offer the capability to use LDAP server-based user authentication.

Note:

- For supported LDAP server products, see “Product selection” on page 47.
- For more detailed information about LDAP products, role mapping, defining on your storage system, and more, speak to your IBM representative and refer to:
  - *IBM Hyper-Scale Manager for IBM Spectrum Accelerate Family* Redbook, SG24-8376
  - *Enabling LDAP for IBM FlashSystem A9000 and A9000R* with Microsoft Active Directory Redpaper

There are three user-authentication options:

LDAP only
Requires that all users must be granted LDAP credentials in order to gain access. This mode does not allow concurrent native user authentication.

Native user authentication (internal users)
Grants access only to internal users (such as technicians, Admin users, and so on) who do not use LDAP authentication.

Mixed
Allows concurrent use of LDAP authentication and native-user authentication protocols.

Important: As a preferred practice, the LDAP server and the FlashSystem A9000 storage system should have their clocks synchronized to the same time source, be registered, and be configured to use the same DNS servers.

LDAP authentication must be set up separately, as the native user authentication mode (for internal users) is the default. For more information about native user authentication, see “Native user authentication” on page 62.

Managing multiple systems in LDAP authentication mode and single sign-on (SSO)

The task of managing multiple IBM FlashSystem A9000 and A9000R systems can be simplified by using LDAP authentication mode.

As a result of all user credentials being stored centrally in the LDAP directory, it is no longer necessary to synchronize user credentials among multiple storage systems. After a user account is registered in LDAP, multiple storage systems can use credentials stored in the LDAP directory for authentication.

Note: LDAPs are all located externally, posing less risk should the system be physically accessed by unwanted persons.

For more information about the physical security of your system, see “Site security considerations” on page 28.

Because the user's password is stored in the LDAP directory, all connected storage systems authenticate the user with the same password. If the password is changed, all storage systems automatically accept the new password.

This mode of operation is often referred to as *single sign-on* (SSO). This approach is especially useful in remote mirroring configurations, where the storage administrator is required to frequently switch from source to target system. For more information about remote mirroring, see the *IBM FlashSystem A9000 Product Overview* , GC27-8583 on the IBM FlashSystem A9000 documentation (ibm.com/docs/en/flashsystem-a9000).

Product selection

LDAP authentication of the storage system supports three LDAP server products:

- Microsoft Active Directory
- Oracle Directory Server Enterprise Edition
- OpenLDAP

The current skill set of your IT staff is always an important consideration when choosing any products for centralized user authentication. If you have skills in running a particular directory server, it might be a wise choice to standardize on this server because your skilled people will best be able to customize and tune the server. Your experts will be able to provide the most reliable and highly available implementation for the LDAP infrastructure.

Security LDAP with Secure Sockets Layer (SSL)

In any authentication scenario, information is exchanged between the LDAP server and your storage system where access is being sought. SSL can be used to implement secure communications between the LDAP client and server. LDAP over SSL (LDAPS), the secure version of the LDAP protocol, allows a setup where user passwords are never transferred in clear text.

SSL provides methods for establishing identity using X.509 certificates and ensuring message privacy and integrity using encryption.

To create an SSL connection, the LDAP server must have a digital certificate signed by a trusted certificate authority (CA). Companies have the choice of using a trusted CA from another vendor or creating their own certificate authority.

To be operational, SSL must be configured on both the client (IBM FlashSystem A9000 or FlashSystem A9000R storage system) and the LDAP server. Server configuration includes generating a certificate request, obtaining a server certificate from a CA, and installing the server and CA certificates.

Important: When defining the LDAP server with a security certificate in the storage system, the fully qualified name of the LDAP server must match the "issued to" name in the client's certificate.

LDAP registration in the server can be done either through the UI or through the CLI. LDAP registration through the UI can be done with a simple file upload. When using the CLI, Windows users can drag and drop the certificate into the XCLI utility window. Other uses need to copy and paste a long string containing the certificate, noting the correct formatting.

Maintaining SSL certificates

New SSL certificates must be installed before the existing ones expire.

PCI DSS compliance

The Payment Card Industry Data Security Standard (PCI DSS) is the global information security standard, for organizations that process, store, or transmit data with any of the major credit card brands. IBM FlashSystem A9000 systems comply with PCI DSS standards.

Table 24 on page 48 describes how IBM FlashSystem A9000 complies with these standards.

Table 24. PCI-DSS Support

Requirement	PCI-DSS Section	FlashSystem A9000 solution
Encrypt all non-console administrative access	2.3	All management connections are secured via IPSec.
Implement a data retention and disposal policy that includes...Processes for secure deletion of data when no longer needed	3.1.1	FlashSystem A9000 provides data-at-rest encryption by use of SED capabilities of the flash enclosure IBM MicroLatency modules and by encrypting the SSD vault devices.
Disk encryption and key management requirements	3.4.1, 3.5, 3.6	Key management using IBM's SKLM key server services, using KMIP key exchange protocol. Disks are encrypted using AES256 in XTS mode.
Render all passwords unreadable during transmission and storage on all system components using strong cryptography	8.4	XIV stores secure and irreversible hashes of user passwords
Enable accounts used by vendors for remote access only during the time period needed. Monitor vendor remote access accounts when in use.	8.5.6	**`xiv_support_enable`**/**`disable`** is used to temporarily enable remote access
Change user passwords at least every 90 days	8.5.9	Enforcement of password expiration may be provided using LDAP servers, as configured by the system administrator. **Note:** Password expiration rules do not apply to the storage admin user.
Minimum password length ... passwords containing both numeric and alphabetic characters ... Limit repeated access attempts ... Set the lockout duration to a minimum of 30 minutes	8.5.10 - .14	Enforcement of password rules may be provided using LDAP servers, as configured by the system administrator. **Note:** Password enforcement rules do not apply to the storage admin user.
If a session has been idle for more than 15 minutes, require the user to re-authenticate	8.5.15	Supported by IBM Hyper-Scale Manager UI and XCLI utility.
Audit trails	10.5.1- .7	The audit trails are supported through the syslog (Service Center) server.

Chapter 6. Migration and mirroring connectivity

Use this information in order to plan for physical connectivity for data migration and mirroring.

This section covers only the important physical connection setup required for migration and mirroring. For more in-depth information, see the following relevant publications:

- *IBM FlashSystem A9000 Product Overview* , GC27-8583

  This publication can be found on the IBM FlashSystem A9000 documentation (ibm.com/docs/en/flashsystem-a9000).
- IBM FlashSystem A9000 and A9000R Business Continuity Functions Redbook, REDP-5401 (www.redbooks.ibm.com/abstracts/redp5401.html?Open)

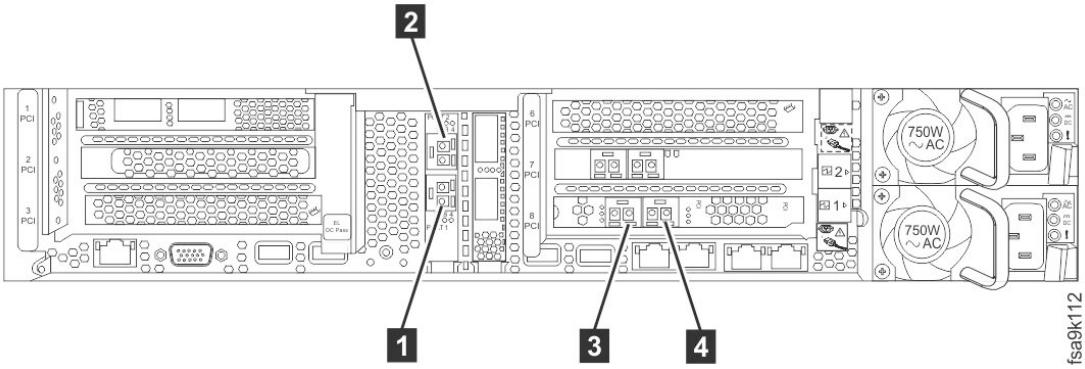
Physical connectivity for mirroring and migration using Fibre Channel

Be sure to use ports 2 and 4, 4 being the initiator, when conducting mirroring or migration using FC connectivity.

Ports 1 and 3 are used for host connectivity. For more information, see “Host network connectivity and multipathing configurations” on page 35.

For more information about FC adapters, see “Fibre Channel (FC) adapter types” on page 36.

Figure 20 on page 49 shows the port numbers for each of the FC ports on the grid controllers.



1 FC port 1
2 FC port 2
3 FC port 3
4 FC port 4

Figure 20. FC port numbering on the grid controllers

For more information about grid controller feature codes and connectivity options, see “Grid controller components and feature codes” on page 10.

Physical connectivity for mirroring and migration using iSCSI

Port connectivity for mirroring and migration using the Ethernet ports depends on the grid controller type being used in the system.

Ports 1 and 3 are used for host connectivity. For more information, see “Host network connectivity and multipathing configurations” on page 35.

iSCSI on grid controllers containing FC ports

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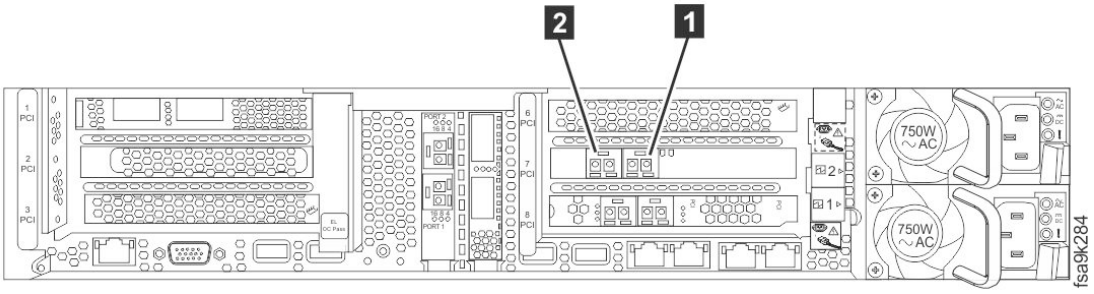
(feature codes 5010, 5003, 5005)

Important: In this grid controller setup, migration can **only** be done via FC port connections (see “Physical connectivity for mirroring and migration using Fibre Channel” on page 49).

When conducting mirroring using Ethernet port connectivity, use ports 2 and 4 (where applicable).

Ports 1 and 3 are used for host connectivity. For more information, see “Host network connectivity and multipathing configurations” on page 35.

Figure 21 on page 50 shows the port numbers for each of the Ethernet ports on the grid controllers.



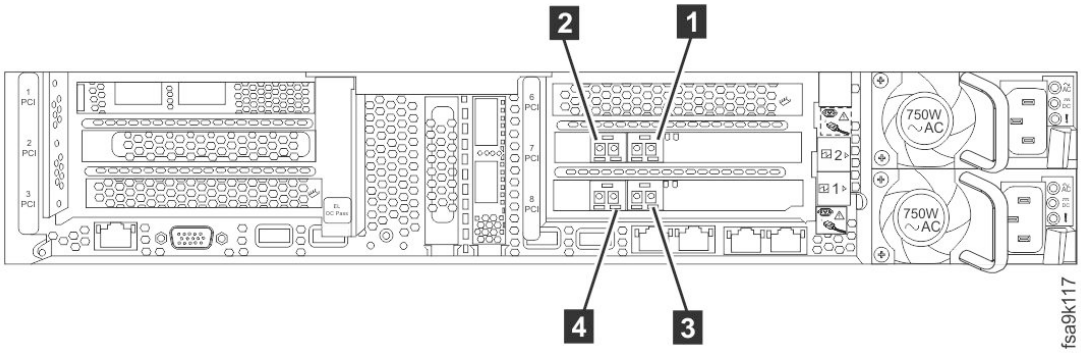
1 10GbE port 1
2 10GbE port 2

Figure 21. Ethernet (10 Gb) port numbering on the grid controllers (mixed FC and iSCSI configuration)

iSCSI on grid controllers containing full iSCSI connectivity (feature codes 5011, 5004)

When conducting mirroring or migration using Ethernet port connectivity, use ports 2 and 4.

Figure 22 on page 50 shows the port numbers for each of the Ethernet ports on the grid controllers.



1 10GbE port 1
2 10GbE port 2
3 10GbE port 3
4 10GbE port 4

Figure 22. Ethernet (10 Gb) port numbering on the grid controllers (full iSCSI connectivity)

Migration and mirroring best practices

Use this information in order to achieve high availability and high performance in your storage system when performing migration and mirroring.

Talk to your IBM representative to help optimally setup any migration and mirroring connectivity, according to your needs.

To achieve high availability and performance, it is important to:

- Spread all ports being used for migration or mirroring connectivity over multiple grid controllers, evenly distributing the mirroring load.
- Use both Fibre Channel or iSCSI adapters within each of the grid controllers, as shown in Figure 23 on page 51.

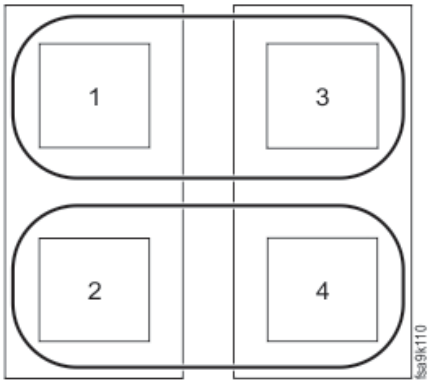


Figure 23. Crossing grid controller adapter ports

- Divide the paths between the two switches or subnets: half the paths connecting to switch/subnet 1 and the other half connecting to switch/subnet 2.

  When possible, P2 connects to switch/subnet 1 and P4 connects to switch/subnet 2.

The administrator must ensure that:

- Host connections avoid single points of failure by applying redundant connections.
- All host workload is adequately balanced across the connections and grid controllers, ensuring system resource utilization is maximized.

Be sure to follow these **minimum** connectivity requirements:

Fibre Channel connections

Use a minimum of two FC ports configured as *initiator* and an additional two FC ports configured as *target* on each system. Each pair of FC ports (one initiator and one target) must reside on separate grid controllers, in order to provide redundancy and sustain a grid controller failure.

Using bi-connections additional FC ports helps improve performance.

Ethernet connections

Use a minimum of two bi-directional Ethernet connections, using two iSCSI ports on each system. Each Ethernet connection must reside on a separate grid controller, in order to provide redundancy and sustain a grid controller failure.

Using additional bi-connections iSCSI ports helps improve performance.

Chapter 7. Planning for physical shipment

Ensure that your environment meets the standard delivery clearance and weight requirements for the IBM FlashSystem A9000 system.

Prepare for equipment delivery so that professional movers or riggers can transport the equipment to the final installation site. If you cannot complete preparations at the time of delivery, you must make your own arrangements for the professional movers to complete transportation later.

Important: Use only professional movers to transport the equipment.

The IBM service representative can minimally reposition the rack at the installation site, as required.

The following information describes how to plan for the physical shipment of your storage system:

Planning to receive delivery

The professional movers or riggers are responsible for delivering and unloading the IBM FlashSystem A9000 system as close to its final destination as possible.

Planning for relocation

When unpacking your storage system delivery, be sure to keep the original packaging material, in case it is needed for relocation at a later date.

Important: Whenever IBM FlashSystem A9000 units need to be physically moved to another location, the relocation must only be performed by an IBM service provider.

Customer responsibilities

When relocating systems, the customer is responsible for the following:

- Informing their IBM representative what packing requirements are necessary for their relocation (based off of machine type, model, and encryption type)
- **For locally encrypted systems only:** Shipping the drive packages

IBM responsibilities

When relocating systems, IBM is responsible for the following:

- Ordering the packaging material for the customer (at customer expense)
- **For locally encrypted systems only:** Packaging and labeling the location of the boot drives
- **For locally encrypted systems only:** Reinstalling the boot drives at the new customer location

Relocation shipping requirements for systems with external encryption schemes

IBM FlashSystem A9000 systems that are encrypted with external key management schemes must have access to key servers with the original key upon restart.

About this task

Only use this procedure for systems that are encrypted with external key management schemes. For systems encrypted with local key management schemes, see "Relocation shipping requirements for systems with local encrypted schemes" on page 54.

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Procedure

Use the following procedures on systems using external key encryption before relocation.

1. Ensure that you have any new IP addresses needed for the new location (ie. system IP, network component IPs, SMTP GW, and any other IP addresses).
2. Give the new IP address to your service technician before system shutdown, for use when connecting the system upon relocation.

   Important: If these steps are not taken for externally encrypted systems, the system will not be able to restart.

   To protect against the possibility that all Security Key Lifecycle Managers (SKLMs) become unusable and unrecoverable (for example, following a disaster, or other difficulties during the relocation process), the system enables you to create a *recovery key*. With a recovery key, Security Administrators can unlock an FlashSystem A9000 system without the involvement of a key server.

   For more information regarding recovery keys and how to use them, see the Redbooks publication Data-at-rest Encryption for the IBM Spectrum Accelerate Family: IBM XIV and FlashSystem A9000 and A9000R (www.redbooks.ibm.com/redpapers/pdfs/redp5402.pdf).

Relocation shipping requirements for systems with local encrypted schemes

Shipping systems that contain encrypted data, with the encryption keys, outside of secure customer premises, increases the risk of confidential data exposure.

To ensure the safety of your system, it is strongly recommended to perform the following during relocation of locally encrypted systems:

- Separate the data (system) and the encryption keys (boot media devices) prior to relocation. This action can only be performed by IBM.
- Ship the boot media devices separately from the rest of the data.
- Ship the boot media devices in separate packages.

  The shipments should be a *minimum* of two (2) separate packages.

  Note: In order to avoid risk of loss of access to system data, all drives labeled 0 should be shipped in a separate shipment and using a different carrier than drives labeled 1.

Shipment weights and dimensions

Use this information to help you plan for the delivery of your IBM FlashSystem A9000.

The IBM FlashSystem A9000 storage system is shipped with each grid element packaged separately.

Delivery weight and dimensions

The following are the delivery weight and dimensions of each grid element, including all packing materials:

Grid controller

- Height: 26.7 cm (10.5 in.)
- Depth: 99 cm (39 in.)
- Width: 58.4 cm (23 in.)
- Weight: approximately 31 kg (68 lb)

Flash enclosure

- Height: 27.3 cm (10.75 in.)
- Depth: 100.3 cm (39.5 in.)
- Width: 58.4 cm (23 in.)

- Weight: approximately 40 kg (88 lb)

Chapter 8. Planning for remote support, on-site service, and maintenance

This section provides you with information to help prepare you for optimal support and software maintenance.

Remote support, on-site service, and maintenance planning considerations are listed in the following sections:

Planning for remote support connection

IBM Remote Support Center (RSC) is a management system used by authorized IBM service representatives to provide remote support and problem-determination assistance over a secure network interface.

The remote support connection is used either before or after parts are called out by the internal diagnostic tests of the storage system. IBM authorized personnel use remote support connections to perform real-time problem analysis and isolation.

Remote support access is obtained over a dedicated network connection. When using this method, the storage system is connected to the RSC through one of the virtual private network (VPN) ports or management ports on one of the three grid controllers. For more connectivity information, see "Network connections for management" on page 31.

The RSC has three components:

Software that is installed on the storage system and handles remote support connectivity.
It relies on a single outgoing TCP connection and is not able to receive inbound connections of any kind. The remote support client is controlled by using the command-line interface (CLI) commands and starts a connection, terminates a connection (due to timeout or customer request), and attempts to reconnect when the connection is terminated unexpectedly.

***Front servers* that serve as a hub at which the storage system and the remote-support back server connect.**
The front servers are located in an IBM demilitarized zone (DMZ) and receive and maintain connections from the remote support client and the back server. The front servers are strictly inbound and do not initiate any outbound communication.

No sensitive information is stored on the front server, and all data passing through the front server from the client to the back server is encrypted, so the front server or a malicious entity in control of a front server cannot access this data.

One or more *back servers* are located within the IBM intranet.
Only IBM service representatives that are authorized to perform remote support of the storage system can access these servers.

The back server authenticates the IBM service representative, provides the IBM service representative with a user interface through which to choose a system to support, and manages the remote support session as it progresses. The IBM service representative connects to the back server by using a Secure Shell (SSH) client or an HTTPS connection with any browser.

Requirement: To perform remote support through the Remote Support Center, your storage system must be able to initiate an outbound SSH connection to IBM. If the system does not have direct access to the Internet (for example, due to a firewall), you can use the IBM Remote Support Proxy (RSP) to

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facilitate the connection to IBM. For more information, see the *IBM XIV Remote Support Proxy User Guide* (GA32-0795).

Figure 24 on page 58 illustrates the remote support components.

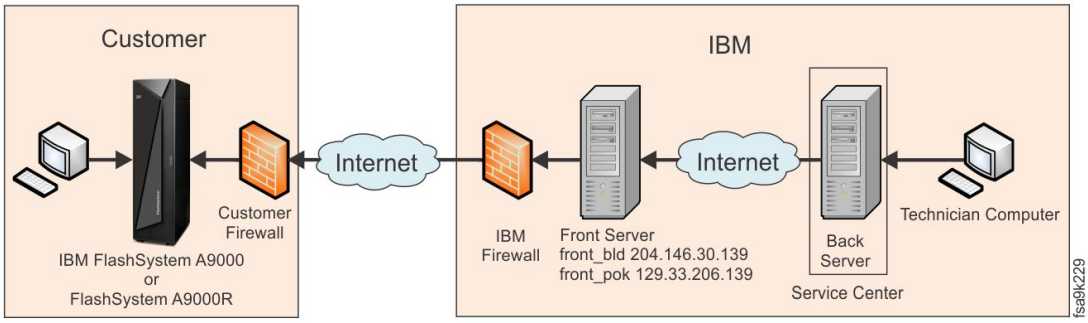

Figure 24. Remote support components

The RSC uses the Secure Shell (SSH) protocol for transporting data. The encryption used by SSH provides confidentiality and integrity of the transferred data even over insecure mediums.

To conduct a remote support session, the IBM service representative must explicitly connect to the RSC back server. The following secure remote connection process occurs when a support session is opened:

1. The customer initiates an Internet SSH connection to the RSC.
2. The RSC identifies the storage system and marks it as connected.
3. The IBM service representative connects to the RSC using SSH.
4. The RSC authenticates the IBM service representative.
5. The IBM service representative is shown a list of currently connected storage systems that correspond with the defined permissions, or the IBM service representative manually enters the serial number to view the system.
6. The IBM service representative chooses the storage system to support. Only permitted systems are displayed, and all activity is logged.
7. The fully recorded support session commences.
8. The IBM service representative terminates the support session.
9. The system disconnects from the RSC.

While a support session is in progress, the storage system displays the system status on the IBM Hyper-Scale Manager user interface (UI). You can view the process of phasing out a component or the restart of customer-visible system services as it happens. The customer has full control over whether to proceed with a support session by using mechanisms such as timeout or force-disconnect. If a session disconnects unexpectedly, the IBM service representative can resume the session when the storage system next connects to the RSC.

Remote support for severe system conditions

A remote support connection may be established automatically, when activated, if severe system conditions (critical issues) are seen in the system and access to the machine is blocked to the host. Immediate action is necessary so that waiting for session connection is not necessary. This function is also known as "XRSC on severe system conditions."

Important: Enabling the remote support for severe system conditions is strongly recommended in order to keep system repair time to a minimum and in order to resume connectivity to hosts as fast as possible. This allows an IBM service representative to access the system remotely and start the repair action immediately.

Note: XRSC on severe system conditions (XRSC) is compliant with General Data Protection Regulation (GDPR) EU 2016/679. For more information, refer to http://ibm.biz/gdpr-storage-paper.

Remote support for severe system conditions permits a remote support access without the need for the customer to initiate the SSH session towards the RSC. It also eliminates the need to dispatch an IBM service representative to the customer site in order to initiate this session to do so.

The remote support for severe system conditions can be configured by the IBM service representative at the time of the storage system installation. This information is communicated through the Technical and Delivery Assessment (TDA) checklist and worksheets.

If automatic remote support activation is not enabled at the time of installation, you can enable these actions at any time, using the XCLI utility. Use the **support_center_config** command to configure the automatic connection to a support center, setting **automatically_connect** to **yes**.

For more detailed information, see **IP configuration commands** > **Configuring the support center connection to enable automatic connect on restart** in the *IBM FlashSystem A9000 Command-Line Interface (CLI) Reference Guide* (SC27-8559).

Planning for Call Home

Using Call Home, you can set up the IBM FlashSystem A9000 system to automatically send pre-failure or failure notifications to the IBM Troubleshooting Ticketing System in the IBM Service Center. You can also configure the storage system to automatically send alerts directly to you.

Note: Call Home is compliant with General Data Protection Regulation (GDPR) EU 2016/679. For more information, refer to http://ibm.biz/gdpr-storage-paper.

Call Home cannot accept incoming communication, which means that the IBM Service Center cannot contact the FlashSystem A9000 system using Call Home.

When certain events occur in the FlashSystem A9000 system, Call Home sends a notification to the IBM Service Center. After receiving the notification, IBM service personnel analyze the problem promptly and take appropriate action. If the problem requires service, an IBM service representative is sent to your site with any necessary replacement parts. With access to the FlashSystem A9000 system, IBM service personnel can perform service tasks, such as viewing error logs and problem logs or initiating trace and dump retrievals.

Call Home proactively reduces problem handling efforts and provides more efficient self-service solutions. This ensures success when using IBM products and services, reducing critical situation events. This will also help you save time and money while maintaining your IT environment.

Call Home notifications are sent through email from an SMTP server. You must have an SMTP email system available that the FlashSystem A9000 system can use to send outgoing Call Home emails to IBM.

If required, the customer email gateway can be configured to send Call Home information to IBM only via a secured channel. For more information, see Monitoring and Troubleshooting > Encrypting Call Home and heartbeat notifications in IBM FlashSystem A9000 and IBM FlashSystem A9000R: Architecture, Implementation and Usage Redbook, SG24-8345 on the IBM Redbooks website (www.redbooks.ibm.com) .

Call Home information is configured by the IBM service representative at the time of storage system installation. This information is communicated through the Technical and Delivery Assessment (TDA) checklist and worksheets.

Customer responsibility

As the customer, it is your responsibility to configure the SMTP email system to enable the FlashSystem A9000 system to send outgoing emails for the Call Home function. The email configuration rules must not inhibit call home emails from being sent in real time. Emails with "Importance" or "X-Priority" in the email header must not be delayed.

For example, FlashSystem A9000 emails must not be placed in a queue for later delivery or filtered for priority. The administrator must verify correct configuration and function of the email system before installation. Failure to verify the email system might delay the successful installation or repair of the FlashSystem A9000 system.

Table 25 on page 60 lists requirements that must be met to configure the Call Home function.

Table 25. Call Home configuration information

Call Home configuration requirement	**Value**	**Comment**
Customer SMTP port	25	The customer SMTP server must be reachable on port 25 from the customer-provided management IP address.
Customer SMTP address	IP address	This IP address is supplied by the customer.
Email destination address	xiv-callhome-eastern-hemisphere@vnet.ibm.com or xiv-callhome-western-hemisphere@vnet.ibm.com	Customer SMTP server must allow relaying to the following IBM email addresses based on geographical location: • **East:** EMEA, Asia, Australia, Africa, and the rest of the world • **West:** USA, Canada, Latin America, and the Caribbean Islands
Email source address	xiv@il.ibm.com or customer-defined	The default email address from which the email is sent. This email address can be customer-defined to conform to the customer email relay rules.

Planning for Call Home Web

Call Home Web allows you to view online support information for one or more IBM storage systems in a consistent and consolidated manner.

The standard Call Home option (see “Planning for Call Home” on page 59) allows you to set up the system to automatically send pre-failure or failure notifications to the IBM Troubleshooting Ticketing System in the IBM Service Center. This information can help IBM Support to better diagnose issues with your systems and proactively assist in identifying them and in developing an action plan for their fast resolution.

While the standard Call Home information is accessible to IBM Support only, you can now view the information online through Call Home Web on the IBM Support Portal (support.ibm.com). The information is presented in a consistent and consolidated manner. It includes descriptive events, generated by the standard Call Home, an exportable system summary, software levels, and your system information.

Additional features allow you to view such details as the last automated problem report received, maintenance contract expiration date, last inventory received, and last heartbeat received. When configured to send notifications, Call Home web notifies you via email upon receipt of an event from Call Home.

Figure 25 on page 61 shows the flow between IBM Call Home and Call Home Web.

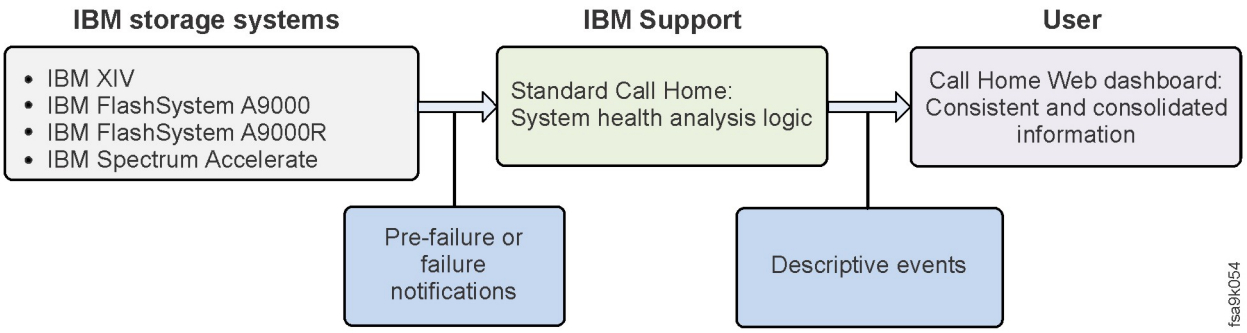

Figure 25. IBM Call Home and Call Home Web

Attention: To use Call Home Web, you must first enable the standard Call Home option on your system, as explained in "Planning for Call Home" on page 59.

Note: Call Home Web is only available for systems under warranty or maintenance contract.

After Call Home has been enabled, you can add your system to Call Home Web. This operation is authorized for the following FlashSystem A9000 user roles:

- Storage integration administrator
- Storage administrator
- Application administrator

To add your system to Call Home Web, one of the above storage system users must issue the custom event similar to the following, but with properly substituted information values:

```
custom_event custom_event_description= "Connect System to Web Call Home" [severity = <INFORMATIONAL ]
Contact Name = 'Your Name': Contact Phone Number = '555-555-5555':
Contact Email Address = 'jdoe@company_name.com': ICN= '1234567'"
```

Upon receiving this event, the IBM Service Center generates a test event and establishes an association with your system.

To disconnect a storage system from Call Home Web:

- Go to the **System Details** page and click **Remove System from Call Home Web**.

Note: You can only remove a system that is fully added (activated and confirmed). If you need to remove a system that was accidentally added or cannot be confirmed, click **Feedback** and request that the system be removed.

For comprehensive information about Call Home Web, see the Call Home Web tab on the IBM Support Site assistance webpage (ibm.com/support/home/widgets/siteAssistance/siteAssistance.html).

Required support information

Use this information to help prepare for support requests.

Have the following information on hand when calling for a support request for a storage system:

- Phone number of machine location
- Machine serial number

Figure 26 on page 62 depicts the location of the serial number on the front of a FlashSystem A9000.

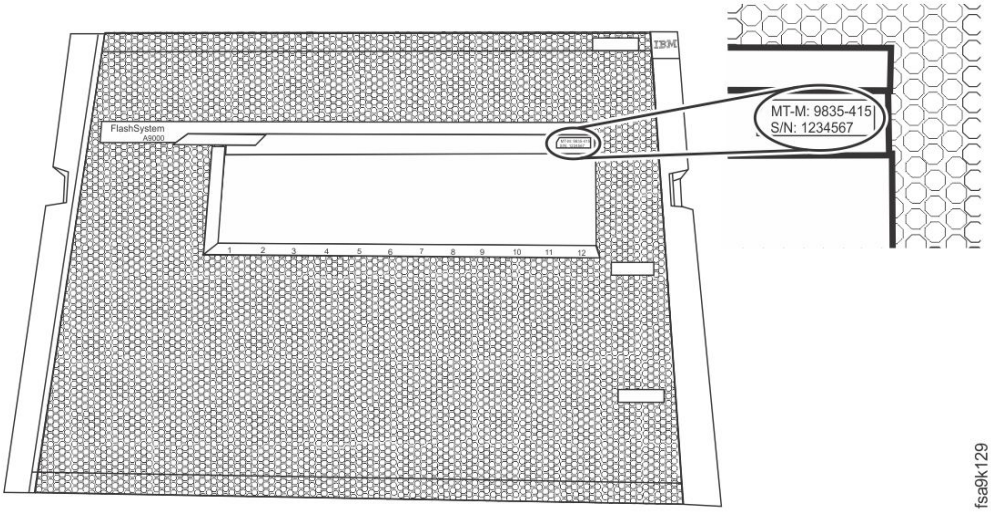

Figure 26. Machine type and model, and serial number on front of FlashSystem A9000

Support and software maintenance security information

The IBM Remote Support Center (RSC) provides a high level of security for a remotely supported FlashSystem A9000 system through encryption, authentication, authorization, auditing, and field-proven security components.

On-site service security

Service representatives need a valid time certificate in order to connect to any given system.

Native user authentication

To prevent unauthorized access to the configuration of the storage system and ultimately to the information stored on its volumes, the IBM FlashSystem A9000 storage system uses various forms of user authentication.

Customer user authentication
Customer's use password-based user authentication.

Note: For more information on customer user authentication, see “User authentication and access control” on page 45.

Technician user authentication
Service technicians have a challenge-response authentication protocol, establishing the authenticity of the technician.

This is done with a question (challenge) and comparing the answer (response) with information stored in a credential repository.

Local credential repository

By default, the IBM FlashSystem A9000 storage system is configured to use native (FlashSystem A9000 system managed) user authentication. Native user authentication uses the credential repository stored locally on the storage system. The FlashSystem A9000 local credential repository maintains the following information:

- User name
- User password
- User role
- User group

- Optional account attributes (such as email and phone numbers)

For more information about these role definitions and how to use them, see **Security** > **Native user authentication** > **Local credential repository** in IBM FlashSystem A9000 and IBM FlashSystem A9000R: Architecture, Implementation and Usage on the IBM Storage Redbooks website (www.redbooks.ibm.com/portals/storage) .

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IBM Deutschland GmbH
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CNS 13438

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此為甲類資訊技術設備，
於居住環境中使用時，可
能會造成射頻擾動，在此
種情況下，使用者會被要
求採取某些適當的對策。

CNS 15936

警告：為避免電磁干擾，本產品不應安裝或使用於住宅環境。

IBM Taiwan Contact Information:

United Kingdom Notice

This product may cause interference if used in residential areas. Such use must be avoided unless the user takes special measures to reduce electromagnetic emissions to prevent interference to the reception of radio and television broadcasts.

United States Federal Communications Commission (FCC) Notice

This equipment has been tested and found to comply with the limits for a Class A digital device, pursuant to Part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference when the equipment is operated in a commercial environment. This equipment generates, uses, and can radiate radio frequency energy and, if not installed and used in accordance with the instruction manual, may cause harmful interference to radio communications. Operation of this equipment in a residential area is likely to cause harmful interference, in which case the user will be required to correct the interference at his own expense.

Properly shielded and grounded cables and connectors must be used in order to meet FCC emission limits. IBM is not responsible for any radio or television interference caused by using other than recommended cables and connectors, or by unauthorized changes or modifications to this equipment. Unauthorized changes or modifications could void the user's authority to operate the equipment.

This device complies with Part 15 of the FCC Rules. Operation is subject to the following two conditions:

(1) this device might not cause harmful interference, and (2) this device must accept any interference received, including interference that might cause undesired operation.

Responsible Party:
International Business Machines Corporation
New Orchard Road
Armonk, NY 10504
Contact for FCC compliance information only: fccinfo@us.ibm.com

Electromagnetic compatibility Class B notices

The following Class B statements apply to features designated as electromagnetic compatibility (EMC) Class B in the feature installation information.

When attaching a monitor to the equipment, you must use the designated monitor cable and any interference suppression devices supplied with the monitor.

Canada Notice

CAN ICES-3 (B)/NMB-3(B)

European Community and Morocco Notice

This product is in conformity with the protection requirements of Directive 2014/30/EU of the European Parliament and of the Council on the harmonization of the laws of the Member States relating to electromagnetic compatibility. IBM cannot accept responsibility for any failure to satisfy the protection

requirements resulting from a non-recommended modification of the product, including the fitting of non-IBM option cards.

Germany Notice

Deutschsprachiger EU Hinweis: Hinweis für Geräte der Klasse B EU-Richtlinie zur Elektromagnetischen Verträglichkeit

Dieses Produkt entspricht den Schutzanforderungen der EU-Richtlinie 2014/30/EU zur Angleichung der Rechtsvorschriften über die elektromagnetische Verträglichkeit in den EU-Mitgliedsstaatenund hält die Grenzwerte der EN 55022/ EN 55032 Klasse B ein.

Um dieses sicherzustellen, sind die Geräte wie in den Handbüchern beschrieben zu installieren und zu betreiben. Des Weiteren dürfen auch nur von der IBM empfohlene Kabel angeschlossen werden. IBM übernimmt keine Verantwortung für die Einhaltung der Schutzanforderungen, wenn das Produkt ohne Zustimmung von IBM verändert bzw. wenn Erweiterungskomponenten von Fremdherstellern ohne Empfehlung von IBM gesteckt/eingebaut werden.

Deutschland: Einhaltung des Gesetzes über die elektromagnetische Verträglichkeit von Geräten

Dieses Produkt entspricht dem “Gesetz über die elektromagnetische Verträglichkeit von Geräten (EMVG)“. Dies ist die Umsetzung der EU-Richtlinie 2014/30/EU in der Bundesrepublik Deutschland.

Zulassungsbescheinigung laut dem Deutschen Gesetz über die elektromagnetische Verträglichkeit von Geräten (EMVG) (bzw. der EMC Richtlinie 2014/30/EU) für Geräte der Klasse B

Dieses Gerät ist berechtigt, in Übereinstimmung mit dem Deutschen EMVG das EG-Konformitätszeichen - CE - zu führen.

Verantwortlich für die Einhaltung der EMV Vorschriften ist der Hersteller:
International Business Machines Corp.
New Orchard Road
Armonk, New York 10504
Tel: 914-499-1900

Der verantwortliche Ansprechpartner des Herstellers in der EU ist:
IBM Deutschland GmbH
Technical Relations Europe, Abteilung M456
IBM-Allee 1, 71139 Ehningen, Germany
Tel: +49 (0) 800 225 5426
email: HalloIBM@de.ibm.com

Generelle Informationen:

Das Gerät erfüllt die Schutzanforderungen nach EN 55024 und EN 55032 Klasse B

Japan Electronics and Information Technology Industries Association (JEITA) Notice

（一社）電子情報技術産業協会　高調波電流抑制対策実施
要領に基づく定格入力電力値：IBM Documentationの各製品の仕様ページ参照

This statement applies to products less than or equal to 20 A per phase.

高調波電流規格 JIS C 61000-3-2 適合品

These statements apply to products greater than 20 A, single phase.

高調波電流規格 JIS C 61000-3-2 準用品

本装置は、「高圧又は特別高圧で受電する需要家の高調波抑制対策ガイドライン」対象機器（高調波発生機器）です。
- 回路分類：６（単相、ＰＦＣ回路付）
- 換算係数：０

This statement applies to products greater than 20 A per phase, three-phase.

高調波電流規格 JIS C 61000-3-2 準用品

本装置は、「高圧又は特別高圧で受電する需要家の高調波抑制対策ガイドライン」対象機器（高調波発生機器）です。
- 回路分類：５（３相、ＰＦＣ回路付）
- 換算係数：０

Japan Voluntary Control Council for Interference (VCCI) Notice

この装置は、クラスB機器です。この装置は、住宅環境で使用することを目的としていますが、この装置がラジオやテレビジョン受信機に近接して使用されると、受信障害を引き起こすことがあります。
取扱説明書に従って正しい取り扱いをして下さい。 **VCCI ー B**

Taiwan Notice

IBM Taiwan Contact Information:

United States Federal Communications Commission (FCC) Notice

This equipment has been tested and found to comply with the limits for a Class B digital device, pursuant to Part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference in a residential installation. This equipment generates, uses, and can radiate radio frequency energy and, if not installed and used in accordance with the instructions, may cause harmful interference to radio communications. However, there is no guarantee that interference will not occur in a particular installation. If this equipment does cause harmful interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one or more of the following measures:

- Reorient or relocate the receiving antenna.
- Increase the separation between the equipment and receiver.
- Connect the equipment into an outlet on a circuit different from that to which the receiver is connected.
- Consult an IBM-authorized dealer or service representative for help.

Properly shielded and grounded cables and connectors must be used in order to meet FCC emission limits. Proper cables and connectors are available from IBM-authorized dealers. IBM is not responsible for any radio or television interference caused by using other than recommended cables and connectors or by unauthorized changes or modifications to this equipment. Unauthorized changes or modifications could void the user's authority to operate the equipment.

This device complies with Part 15 of the FCC Rules. Operation is subject to the following two conditions: (1) this device might not cause harmful interference, and (2) this device must accept any interference received, including interference that might cause undesired operation.

Responsible Party:
International Business Machines Corporation
New Orchard Road
Armonk, NY 10504
Contact for FCC compliance information only: fccinfo@us.ibm.com

Index

G

H

I

L

M

N

O

P

R

S

T

V

W

X

Z

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