Rack Basics: Everything You Need to Know Before You Equip Your Data Center

Executive Summary

When you're designing a data center, server room or network closet, deciding which racks to deploy and how to configure them should be at the top of your list. Just like building a house, the surface details may steal the spotlight, but it's the quality of the underlying foundation that makes the difference between success and frustration.

Racks organize IT equipment, such as servers and network switches, into standardized assemblies that make efficient use of space and other resources. Depending on the options you choose, they can also improve power protection, cooling, cable management, device management, physical security, mobility, ease of installation and protection from harsh environmental conditions.

Choosing the right racks and configuring them to match your needs will ensure that your IT equipment operates reliably and efficiently, saving your organization from costly downtime and other needless expenses.

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What is a rack and what does it do?

Rack Essentials

Racks organize IT equipment into standardized assemblies that make efficient use of space and other resources. At the most basic level, a rack consists of two or four vertical mounting rails and the supporting framework required to keep the rails in place. The rails and framework are typically made of steel or aluminum to support hundreds or over a thousand kilograms of equipment. The rails have square or round holes that allow you to mount rack equipment to them with screws. (In the case of the square mounting holes, the screws connect to removable cage nuts placed in the required locations.) Some equipment includes horizontal rails or shelves that you mount in the rack to provide extra support.

Rack Standards

The width of the rails, the horizontal and vertical spacing of the mounting holes, the size of the equipment cabinets and other measurements are standardized. This ensures that standard rack equipment will always be compatible with standard racks. Most IT equipment is nominally 19 inches (483 mm) wide (including mounting hardware) and follows a standard set by the Electronics Industry Alliance (EIA) and now maintained by the Electronic Components Industry Association (ECIA). The current 19-inch (483 mm) rack standard is called EIA-310-E, which is essentially equivalent to IEC-60297-3-100 or DIN 41494 in other regions. (There's also a standard for 23-inch/584 mm wide telecom equipment. The vast majority of IT applications use 19-inch/483 mm racks and equipment.)

Rack Units

Although 19-inch (483 mm) racks are always the same nominal width, the height and depth vary. The depth of the rack rails is usually adjustable to some degree. The height of the rack is divided into standardized segments called rack units. Each rack unit is 1.75 inches (44.5 mm) high, and the height of a rack or an equipment cabinet is expressed as the number of rack units followed by the letter "U". For example, a 42U rack contains 42 rack units. That does not mean the rack is exactly 42 x 1.75 inches (44.5 mm) high because racks usually include at least a little extra space at the top and bottom that isn't usable rack space. It does mean that the rack will accommodate any combination of standard rack equipment up to 42U—whether it's 42 x 1U switches, 14 x 3U servers or 21 x 1U switches with 7 x 3U servers. Remember that the rack also has to be deep enough for the equipment and rated to support the combined weight of all the equipment.

Rack Types

There are three primary types of racks: open frame racks, rack enclosures and wall-mount racks.

- **Open frame racks** are just that—open frames with mounting rails, but without sides or doors. They're typically used for applications where the rack does not need to control airflow or provide physical security. Open frame racks are good for network wiring closet and distribution frame applications that have high-density cabling because they provide convenient access and lots of open space for cable management. Open frame racks can have two or four vertical mounting rails (called "posts"). Two-post racks typically require less available depth than four-post racks, but they also support less weight. IT equipment that supports four-post mounting out of the box may require a special kit for two-post mounting, especially if it is designed to use all four vertical mounting rails for support.

Rack Types (continued)

- **Rack enclosures** have removable front and rear doors, removable side panels and four adjustable vertical mounting rails (posts). They're also called rack cabinets. The front and rear doors are typically ventilated to encourage ample airflow from front to back, through any installed equipment. Rack enclosures are ideal for applications that require heavier equipment, hotter equipment and higher wattages per rack. Since the doors and side panels lock, they also provide physical equipment security at the rack level (as opposed to the room level). Enclosures are a popular choice for high-density data centers and server rooms.

  Although standard enclosures do not have as much room for cabling as open frame racks, wider and/or deeper cabinets are available to provide extra room. Enclosures can also be configured without doors and/or side panels for open frame applications where higher weight capacities are required. In addition to the vertical equipment mounting rails, enclosures often include additional rails to mount accessories like vertical cable managers and power distribution units (PDUs).

- **Wall-mount racks** are designed to be attached to the wall, saving floor space and fitting in areas where other racks can't. They can be open frame racks or enclosed cabinets. They're usually smaller than their floor-standing counterparts and can't support as much weight. The cabinets can be adapted to floor-standing applications by adding rolling casters.

What kind of equipment can you install in a rack?

IT Production Equipment

IT production equipment is the servers, storage, network switches, routers, telecommunications hardware and other devices that fulfill the primary purpose of the IT installation. (Racks also have applications that may not employ typical IT equipment, such as manufacturing, but the same general principles apply.)

Racks are designed to hold all standard 19-inch (483 mm) rack-mountable equipment, as long as it isn't too deep for the cabinet or too high to fit in the available rack spaces. The equipment often includes removable mounting brackets or "ears" that fasten to the vertical rack rails with screws. Heavier equipment may also include horizontal rails or shelves that mount in the rack to provide extra support. If the equipment isn't made for rack installation, you can install a rack shelf to hold it. Just make sure the equipment isn't too big or heavy for the shelf.

IT Infrastructure and Rack Accessories

Racks also accommodate IT infrastructure and rack accessories that support the operation of the production equipment. This includes equipment like UPS systems (uninterruptible power supplies), PDUs, cable managers, KVM switches, patch panels and shelves. Although most equipment is designed to fit in standard rack spaces, vertical PDUs and cable managers mount to vertical rails without using any rack spaces. Equipment that installs this way is referred to as 0U ("zero U").

How do you choose the right rack size?

Height

The height of the rack is one of the most important considerations because it determines how many rack spaces are available for your equipment. In fact, the height of the rack is expressed in the number of available rack spaces. (You can also find the external measurements to make sure the rack will fit through the doors in your facility.) Common heights for floor-standing racks and rack enclosures are 42U, 45U and 48U, with custom sizes up to 58U available for some high-density data center applications. You may also wish to leave extra space for horizontal cable managers, future expansion or other purposes, so keep that in mind when determining the height.

Width

Since the width of the rack's mounting rails and the rack equipment itself is standardized, that part is simple—just make sure your equipment and your rack both follow the your region's production standard. But you also need to consider the external width of the rack. The standard width for rack enclosures is 24 inches (600 mm), which corresponds to the standard for removable floor tiles in a raised-floor data center. Extra-wide 30-inch (750 mm) rack enclosures are also available, with or without extra depth. Enclosures with extra width have side channels that accommodate PDUs, high-density cabling and cable managers without obstructing airflow. This is especially helpful for network switches that have side-to-side airflow and forward-facing ports. Extra-wide rack enclosures may also have modified vertical mounting rails that include built-in cable channels. Some extra-wide racks can even be customized with extra rack spaces at the sides to fit as much equipment as possible.

Depth

The rack's depth is important because you need to make sure it will be deep enough for your equipment, including any cabling that extends past the equipment cabinet. You can usually adjust the depth of the vertical mounting rails in a four-post rack or rack enclosure, but only within certain limits. The standard depth for a rack enclosure is around 42 inches (1067 mm), but you can get extra-deep 48-inch (1219 mm) rack enclosures for deeper servers and blade chassis. The extra depth ensures that there's enough room for cabling, PDUs, cable managers and other accessories without blocking airflow or compromising serviceability. There are also racks that are shallower than the standard depth to save space. These are available as mid-depth 36-inch (914 mm) and shallow-depth 32-inch (813 mm) enclosures. Wall-mount rack cabinets are usually shallower than their floor-standing counterparts, with usable mounting depths around 12, 16, 20 or 32 inches (305, 406, 508 or 813 mm).

Load Rating

The load rating (or weight capacity) of the rack is how much weight it can safely support. Remember that you also need to make sure that your facility's floor can support the weight of the rack and any equipment installed inside it. If you're installing a wall-mount rack, both the wall and the fasteners need to be able to support the combined weight. Racks usually list two different load ratings: a stationary/static load rating for when the rack is installed in place and a rolling/dynamic load rating for when the rack is rolled from place to place on its casters. (The stationary/static and rolling/dynamic load ratings may be equal if the rack has heavy-duty casters.)

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What are some of the basic rack options?

After deciding what type and size of rack you need, there are some basic configuration options to consider. Remember that not all of these options apply to every type of rack. (Floor-standing enclosures have the most options available.)

Doors
Floor-standing rack enclosures typically have front and rear doors that are ventilated to provide front-to-rear airflow, but they can also be configured without doors. Rear doors are usually split to reduce the clearance required to open them completely. The front door can be split too, though this is more unusual. The front door can be equipped with a Plexiglas® window, but this may reduce the airflow through the cabinet.

Side Panels
Floor-standing rack enclosures can be configured with or without side panels. Modular side panels that are split into two pieces on each side make it easier to service the rack enclosure. Side panels without vents improve cooling efficiency. They prevent hot air from recirculating through the sides of the rack and maintain direct front-to-rear airflow.

Roof
Floor-standing rack enclosures usually have a removable roof panel that includes several openings for cable access. The roof may also have attachment points for external cable managers, including cable ladders and cable troughs.

Casters and Levelers
Casters are wheels connected to the bottom of the rack. Floor-standing enclosures usually include casters that allow you to roll the cabinet over a short distance during installation. Once the cabinet is in place, sturdy feet called levelers support the weight of the cabinet and equipment in place of the casters. They also allow you to adjust and level the rack on uneven surfaces. Racks can also be equipped with larger, sturdier casters that support more weight and provide greater mobility. Wall-mount cabinets and four-post racks typically do not include casters, but you can usually add them if you need them. Casters adapt wall-mount racks to floor-standing and "roll-away" applications under desks, tables or counters.

Locks
Rack enclosure doors and side panels have keyed locks that you can replace with optional combination locks. Locking doors and side panels are required for some security standards, such as the credit card industry's data security standard (PCI DSS).

Hinged Wall Bracket
Some wall-mount rack cabinets include a hinged wall bracket. This allows the cabinet to open from the back, providing convenient access to equipment rear panels and cabling. A wall-mount rack with a hinged wall bracket requires more clearance than a similar model without the bracket, so decide whether you prefer increased access or reduced depth.

Mounting Holes
Two-post racks typically include round/threaded mounting holes. Four-post racks and enclosures typically include square holes, but some have round/threaded holes. Some vertical mounting rails include both types of holes on alternate sides.

Color
Most enclosures are black, but white enclosures are gaining popularity. They increase visibility, reduce lighting requirements and can reduce energy costs in large installations.

Toolless Mounting
Keyhole slots included on some racks allow you install compatible vertical PDUs and cable managers without fumbling with screws and mounting brackets. Toolless mounting saves a lot of time when you're installing and configuring multiple racks.

How should you plan for installation?

Room Attributes

As with any IT project, a little planning at the outset can prevent big headaches down the road. When choosing a room, make sure you have enough space for all the racks you'll need now and in the foreseeable future. And don't forget that you need to move the racks from the point of delivery to the final location. Your facility's doors must be tall enough, the floors must be sturdy enough and stairs should be avoided. The room's circuits must provide the correct voltages and sufficient amperage for all your equipment. There must be a way for cables to enter and exit the room. The room should be away from heat sources, whether they are inside or outside the building. And the room should have some way to get rid of the heat generated by your equipment. This may include heat dissipation through the walls and active or passive ventilation through ducts, raised flooring or dropped ceilings. Installations with higher wattage densities and heat production may also require dedicated computer room air conditioners (CRACs). Using "close-coupled" CRACs can increase efficiency compared to traditional perimeter CRACs.

Rack Layout

You should develop a blueprint for the placement of the racks in relation to the room, each other and important resources such as power circuits and cooling. Rack layout is especially important for cooling. Cooling will be more efficient and more effective if you prevent hot air from recirculating and mixing with the cold air supply. You should arrange rack enclosures in solid rows with hot aisles (where the racks are back-to-back) and cold aisles (where the racks are front-to-front). Arranging racks in a hot-aisle/cold-aisle layout can reduce energy use up to 20%. You should also "bay" rack cabinets by connecting them side-to-side. Baying creates a physical barrier between hot and cold air that discourages recirculation. Some enclosures include the baying hardware required to link them together.

Enclosures offer much more control over airflow. But even if you're using open frame racks, or if you have too few racks for more than a single row, it's important to pay attention to the arrangement of the racks. You should make sure the equipment in one rack isn't drawing in hot air from the equipment in another rack, or from any other obvious heat source.

Equipment Placement

The location of equipment in the rack is vital to the proper operation of servers and other equipment, to maximize the space inside the rack and to permit easy service. You should develop a detailed plan for equipment placement before you install it, including plans for future expansion. Naturally, you need to make sure each rack has enough rack spaces to accommodate all the equipment you plan to install.

The weight of your equipment must not exceed the rack's load rating. Always place the heaviest equipment, such as UPS systems and external battery packs, toward the bottom of the rack. This prevents the rack from becoming top-heavy and prone to tipping over—especially important if you plan to install equipment before rolling the rack to another location. (When rolling a rack, with or without installed equipment, you should always push it away from you—not pull it toward you. Push along its longest axis, which is almost always from front to back or back to front.) If sliding rails allow equipment to extend away from the rack horizontally, you should avoid placing this equipment too high in the rack. Also make sure it can't extend so far that it unbalances the rack.

Consider factors such as cable management when deciding where to install equipment in the rack. For applications that require high-density cabling, you may need 1U of horizontal cable management for every 1U of patch panels or switches. And if you plan to install a rack console or console KVM, you'll need to consider where the LCD monitor and keyboard will be at a comfortable height. You should also consider spreading blade servers and other high-density, high-wattage loads among multiple racks to prevent problematic hot spots.

How does a rack enclosure keep your equipment cool?

Some installations will be able to keep equipment cool without any special measures because of the lower wattages and smaller amounts of equipment involved. As computing needs grow, however, wattages and equipment density rise and increased heat production can reduce performance and cause shutdowns. A number of built-in and optional features help you keep equipment cool.

Basic Airflow

Open frame racks are great for some applications, but they offer very little control over airflow. The best racks for managing equipment cooling are floor-standing rack enclosures because they provide the most control over airflow. They also include a number of built-in and add-on features to keep hot air from recirculating and polluting the cold air supply. Make sure front-to-rear airflow is unrestricted by using enclosures with fully ventilated front and rear doors. If rack-level security isn't a concern, you can even remove the front and rear doors, or purchase enclosures without them.

Side Panels

Solid side panels prevent hot air from recirculating around the sides of the enclosure. It may seem like ventilated side panels would improve cooling, but they actually allow hot air to recirculate and cause cooling problems. (Ventilated side panels are used for wall-mount cabinets because they don't rely on front-to-rear airflow and usually have much lower heat loads.) Bayed enclosures should have solid side panels between them to prevent hot air from traveling from rack to rack inside the row.

Airflow Management

Blanking panels force cold air through your equipment and prevent hot air from recirculating through open spaces. Snap-in 1U blanking panels save significant installation time compared to screw-in models, and the 1U size always fills empty rack spaces evenly. You can also install brush strips, gaskets and grommets to block air leaks around cable channels and other gaps. If you have devices that use side-to-side airflow (common with network switches and routers because of their cabling requirements), you can install internal gaskets to accommodate them.

Cable Management

Unmanaged cabling blocks airflow, preventing efficient cold air distribution under raised floors and trapping heat inside enclosures. In raised-floor environments, move under-floor cabling to overhead cable managers (ladders and/or troughs) that connect to racks. Inside enclosures, use horizontal and vertical cable managers to organize patch cables and power cords. Remember that a standard-size enclosure may not have enough room for all the cables required in a high-density network installation. An extra-wide and/or extra-deep enclosure may provide the extra breathing room you need.

Thermal Ducts

Overhead thermal ducts—like adjustable chimneys—route equipment exhaust directly to the HVAC/CRAC return air duct or plenum. Hot air is physically isolated, so there's no way for it to recirculate and pollute the cold air supply. Convection and the negative pressure of the return air duct draw heat from the enclosure, while the HVAC/CRAC system pumping air into the room creates positive pressure. The result is a highly efficient airflow path pushing cool air in and pulling hot air out. Enclosure-based thermal ducting is also compatible with hot-aisle/cold-aisle configurations and fire codes, so retrofitting an existing installation is relatively painless.

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Active Heat Removal

Active heat removal accessories assist passive heat removal with ventilation fans. You add fans to the roof of the enclosure or any rack space, with or without thermal ducts. Fans work with floor-standing or wall-mount enclosures.

Close-Coupled Cooling

Close-coupled cooling systems provide precise air conditioning suitable for IT equipment, yet they provide better efficiency than traditional perimeter and/or raised floor systems. They can also improve the efficiency of existing cooling systems by moderating hot spots without lowering the entire room's temperature setting. The modular nature of close-coupled cooling allows you to quickly reconfigure cooling to handle new equipment or overheating racks. Self-contained solutions can be installed by IT staff without outside help, reducing installation costs and disruption.

What other options and accessories should you consider?

Power Distribution

The equipment in your rack usually requires many power outlets, especially since most IT equipment has more than one cord and power supply. You also need a way to reach distant wall outlets from the rack. Power distribution units (PDUs) solve both problems. They're like industrial-strength power strips that provide the kind of rock-solid reliability required for high-availability IT applications. They can also provide features like current monitoring, remote management, automated alerts and individual outlet control. Vertical models may support convenient toolless mounting in compatible racks.

Battery Backup

Your equipment is only as reliable as your power. You cannot be certain that the power you receive from the local utility will be suitable for your equipment, or that it will always be available. And even when you are receiving good quality power from the utility, equipment inside your facility (such as electric motors) can introduce power problems.

A rack-mountable network/server UPS system conditions input power 24x7 to ensure that your equipment always receives reliable power and protection from damaging and disruptive power problems. It also supports your equipment during power failures, providing enough battery backup runtime to outlast shorter outages. During longer outages, the UPS system will provide enough runtime to save files and gracefully shut down or to ensure that equipment is powered until standby generators are ready to support the load. Battery backup runtime can be expanded to match any practical requirement. The UPS system may include enough outlets for the equipment it will support. For applications that require additional outlets, the UPS can connect to a PDU. You can manage power remotely through a UPS, a PDU or both.

Device Management

With IT installations of any size, you need an efficient way to manage devices at the rack and from remote locations. Rack-mountable KVM switches allow you to control dozens or even hundreds of servers from a single keyboard, monitor and mouse. Console KVMs combine the keyboard, monitor, mouse and KVM switch into a compact unit that folds like a laptop and slides into a 1U rack drawer when not in use. KVM switches can also include IP remote access, which allows you to access servers from any location. For applications that require in-band and out-of-band access, IP console servers allow you to manage hundreds of serial and network devices through a single IP address.

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Patch Panels

Patch panels provide space-saving, high-density cable connections. Using patch panels as part of a structured cabling system lowers maintenance costs and reduces installation and configuration errors.

Environmental Monitoring

Environmental sensors report temperature data remotely through networked UPS systems and PDUs. They can also record time-stamped logs and provide real-time warnings when temperatures exceed defined thresholds. Recording temperature data over the entire production cycle is helpful because some heat-related problems only reveal themselves when equipment is under heavy use or environmental conditions change. Although it may be impractical to measure every equipment intake, a representative sample will help you identify problem areas.

Security

Rack security doesn't end with locking doors. A number of accessories provide additional security and monitoring features, such as magnetic intrusion-detection switches. For service provider applications, colocation enclosures provide two or more separate, locking compartments. The compartments allow internal or external clients to keep equipment physically secure at a host location without "renting" an entire enclosure.

Shock Pallet

A shock pallet is a reinforced shipping pallet that allows you (or a reseller) to install equipment in an enclosure at one location and then ship it to a final installation location with the equipment inside.

Knockdown

Floor-standing cabinets usually ship assembled and ready to roll into place. However, there are some applications where it would be impossible to fit a cabinet through a doorway or stairwell. Or it may be too expensive to ship an assembled cabinet to a remote location. In that case, enclosures can be shipped flat in partially assembled sections that provide the required compactness without making assembly overly difficult or time-consuming.

Stability

Most floor-standing racks and rack enclosures can be bolted to the floor to provide extra resistance to tipping over. Floor plates and bolt-down kits are available to facilitate this process. Baying enclosures together also provides extra stability.

Environmental Protection

IT installations are usually kept clean, but this is not always possible. In some cases, equipment must be installed in damp or dirty environments like factory floors and warehouses. NEMA-rated enclosures are equipped with sealed cabinets and filtered airflow to protect equipment against environmental hazards. You can install equipment in a clean location, then roll the enclosure into place with the equipment already sealed inside. NEMA-rated enclosures may also include seismic protection (see below).

Seismic Protection

Seismic-rated enclosures include heavy-duty, torsion-resistant construction to withstand industrial vibrations and other severe movements—even earthquakes. They are subjected to a series of standardized tests that indicate the degree of violent motion they can withstand.

What if off-the-shelf models don't have everything you need?

Custom Racks

Off-the-shelf products aren't ideal for every application. A full-service manufacturer will be able to customize racks to match your technical specifications, cost requirements, facility, personnel and policies. Customization can be quite affordable, but it may require a minimum order. This will depend on the type and degree of customization you require.

Lead Time

One thing to watch out for when ordering a custom rack is the "lead time." This is the time required deliver your order after you place it. A manufacturer set up for local build-to-order manufacturing may be able to deliver your order in days. Other manufacturers may require months to retool production lines and receive cargo containers from overseas. Always ask for a firm lead time quote when placing a custom order, or even an off-the-shelf order. Otherwise, your project could experience significant and unexpected delays.

Where can you find more advice if you need it?

As you build, expand or reassess your IT infrastructure, don't overlook your equipment racks. It's an area for potentially significant cost savings, and it's vital to ensuring that your equipment operates reliably and efficiently. But choosing the right rack can be a complex task, especially since your organization may require different racks for different applications.

One of the best ways to understand the various options for your organization is to leverage the experience of a dependable partner. Get free advice from a reseller or manufacturer that offers racks suitable for the various applications you're likely to encounter. Tripp Lite manufactures a wide range of rack enclosures, open frame racks and wall-mount cabinets. Tripp Lite specialists are available to evaluate your needs, identify potential problems and recommend cost-effective solutions.

Tripp Lite also offers online resources to help you find the right rack:

- Detailed rack specifications at **www.tripplite.com/rack**
- Our interactive rack selector at **www.tripplite.com/rackfinder**
- Our Chicago-based support team at **www.tripplite.com/support**

Ready for expert help right now?

Contact Tripp Lite at
international@tripplite.com.

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