

How to Choose an IT Rack

White Paper 201

Revision 1

by Pearl Hu and Wei Zhou

Executive summary

In data centers with 1-3kW/rack, the most popular IT racks have been 600 mm (24 inches) wide, 1070 mm (42 inches) deep, and 42U tall. However, most data centers today support a wide variety of IT equipment densities and form factors that require appropriate racks and accessories. For example, in racks housing 5 kW and above, the most popular rack size is no longer optimal as deeper equipment, higher density rack-mounted power distribution units (rack PDUs), and increased cable loads crowd the inside of the IT rack. This paper discusses the key size and feature options for IT racks and criteria for selection.

Introduction

An information technology (IT) rack is available in three forms; two-post rack, four-post rack, or a cabinet or enclosure. Two-post racks typically support telecommunications equipment, four-post racks typically support networking equipment, and cabinets or enclosures typically support compute and storage equipment (see **Figure 1**). IT racks not only save floor space by allowing the stacking of IT equipment, but they also play a role in mounting heavy IT equipment, providing an organized environment for power distribution, air flow distribution for better cooling performance, network cable management, rack environmental monitoring, security, etc. A populated rack can weigh several thousands of kilograms.

To avoid confusion and follow common language, we will use the term “IT rack” in this paper to refer to the IT rack frame and enclosure. This white paper introduces rack components, describes the decision criteria, and recommends a practical selection process.

Figure 1a

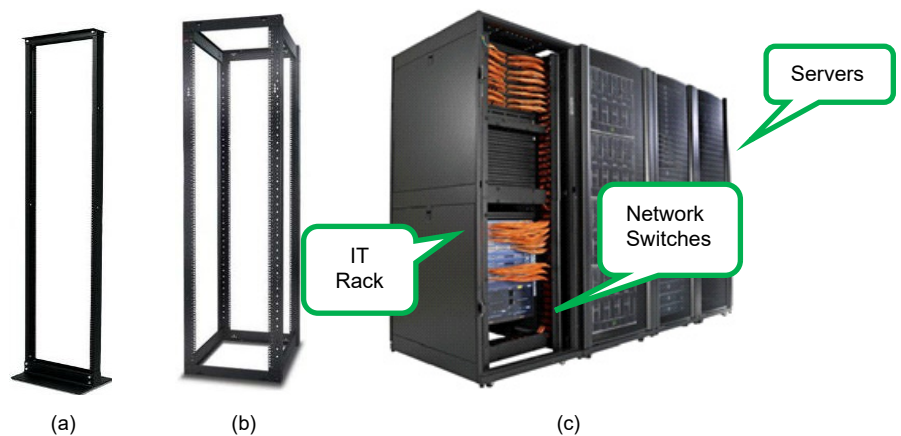
Two-post rack

Figure 1b

Four-post rack

Figure 1c

Four IT racks (cabinets/ enclosures)



Rack components

Figure 2 shows an exploded view of a typical IT rack. It consists of frame with vertical mounting rails and a zero-U accessory channel, front and rear door, side panels, roof with cable penetrations, castors, leveling feet, etc.

IT equipment and accessories are mounted upon the vertical mounting rails while the frame also provides space to mount some non-IT equipment and accessories to provide power, cooling, and cable management. The perforated front and rear doors provide access to mount the equipment in a lockable secure environment without limiting the airflow through the IT equipment. Side panels can optimize the rack air flow and eliminate mixing of air between racks. The rack roof provides two key functions; one is to protect the IT equipment from falling debris and the other is to provide an entry point for power and network cabling. Rack roofs should provide wide cable penetrations that allow full cable bundles to pass through. Also, roofs should have brush strip around cable penetrations to prevent air leakage. Some rack roofs also serve as a mounting point for overhead cable troughs. The weight rating of the castors and leveling feet is verified to ensure they can support the specified loading of the rack.

Accessories also play an important role in IT racks. **Table 1** lists some common accessories and their main functions. IT rack suppliers provide more accessories for specific applications.

Note that, depending on specific requirements, some IT rack components may not be required and are purposely excluded from an IT rack solution. For example, rear doors are commonly excluded for racks used in a hot aisle containment system. In some specific applications, IT racks must be anchored to the floor for stabilization, therefore ensure castors and leveling feet can be removed.

Figure 2
Three dimensional exploded view of a typical IT rack

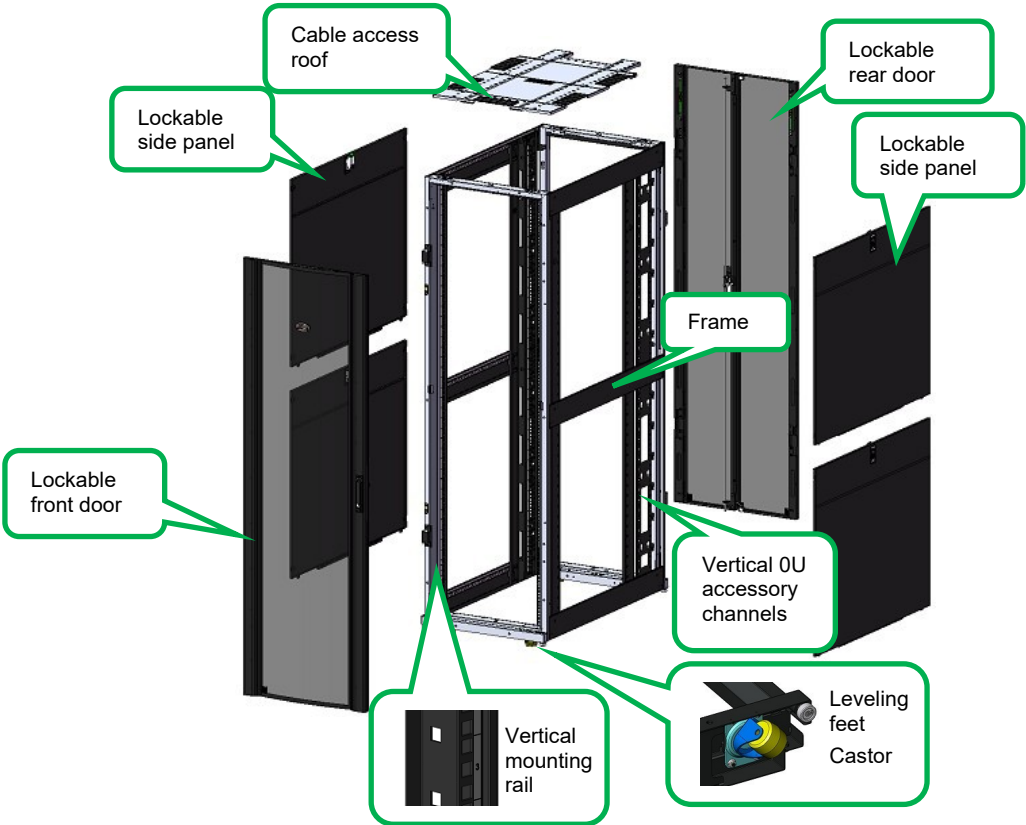


Table 1
Rack accessories and functions

Category	Name	Functions
Mounting hardware	Shelving	Enable the mounting of tower units, monitors, and other equipment into the rack environment Fixed or sliding version can be selected
	Stabilization hardware	Prevent tip-over and meet specific anchoring and seismic requirements
Power management	Rack power distribution unit (r-PDU)	Distribute the power at the rack level Real-time remote load monitoring and individual output power control if needed
Airflow management	Blank panel	Cover open rack space to prevent air recirculation and reduce bypass airflow, improving cooling efficiency
	Air containment	Cooling options that can increase the efficiency of the rack-level cooling system ¹

¹ For more information on containment see White Paper 153, [Implementing Hot and Cold Air Containment in Existing Data Centers](#)

Category	Name	Functions
Cable management	Vertical or horizontal cable organizer	Keep power cords and cables organized to facilitate power and data cable tracking which lowers the likelihood of human error by disconnecting the wrong cable. Protect the cables from kinking and bindings, etc.
	overhead cable troughs and partitions	Route power cords and data cables across the top of the rack and reduce the need for expensive suspended cable tray system
Security and monitoring	Environmental monitoring	Monitor the temperature, relative humidity, airflow, smoke etc. environmental parameters.
	Rack access HID system	Control and manage rack access privileges by HID proximity card
	Surveillance	Monitor valuable IT assets remotely

Decision criteria

Before a rack is selected, some decision criteria should be considered, such as dimensions, operational design, structural design, material, and color. Racks are closely tied to the operation of a data center and as such have a significant effect on how long it takes complete rack-based work orders. In general, the lowest-cost racks require more time for things like cable management and mounting which, in large quantities, can have a material impact on operational costs.

Dimensions

The vast majority of IT equipment has a standard width of 482.6mm (19 inches), including the edges or ears which allow for mounting in 19-inch racks. The current 19-inch rack standard was established by the Electronic Industry Alliance (EIA). The specific standards are the EIA-310-D, *Cabinet, racks, panels and associated equipment standard*, and the equivalent IEC 60297-3-100, *Mechanical structures for electronic equipment – dimensions of mechanical structures of the 482.6mm (19 in) series - Part 3-100: Basic dimensions of front panels, sub-racks, chassis, racks and cabinets*.

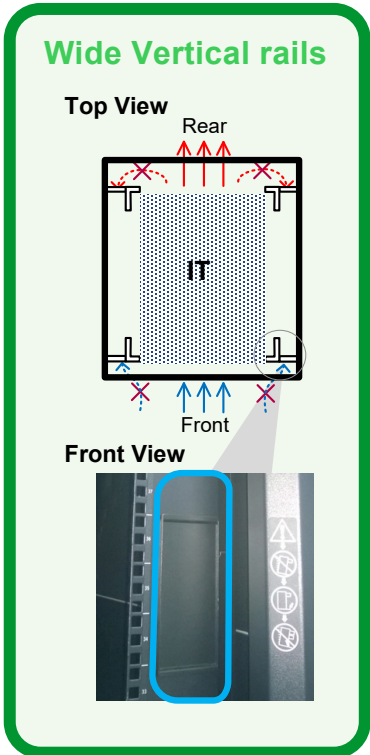
The usable vertical mounting grid is often specified in "U". 1U is equal to 44.45mm (1.75 inches). If a rack is described to be 42U, it means that there is a physical interior vertical space of 1.87m (73.5 inches) available for equipment mounting. Some racks are specified with customized U heights for specialized applications.

The most prevalent IT rack dimensions have been 600 mm (24 inches) wide, 1070 mm (42 inches) deep, and 42U tall. However, deeper IT equipment, higher cable densities, higher power densities, and greater equipment weight loadings are driving the need for deeper, wider, taller, and more robust IT racks along with a wider array of rack accessories. **Table 2** describes the benefits of alternative IT rack dimensions compared to typical rack dimensions, to help with the decision-making process.

Table 2

Benefits of alternative IT rack dimensions (height, width, and depth) compared to benefits of typical rack dimensions

Typical dimensions	Benefits of typical dimensions	Alternative dimensions	Benefits of alternative dimensions
Height 42U	<ol style="list-style-type: none"> 1. Lower cost than taller racks (\$/rack) 2. Easier to reach all U positions without the need for a step ladder 3. Fits through all standard door openings, i.e. trucks, entrance doors, openings, and elevators 4. Less likely to interfere with overhead fire suppression sprinklers 	Height 45U, 48U, 52U up to 60U;	<ol style="list-style-type: none"> 1. More U space to mount equipment increases available space in the same rack footprint
Width 600mm (24 in)	<ol style="list-style-type: none"> 1. Lower cost (\$/rack) than wider racks 2. Decreased rack footprint than wider racks 	Width 750mm (29.5 in) 800mm (31.5 in)	<ol style="list-style-type: none"> 1. More space for high-capacity cable management and power distribution 2. More space for wider IT equipment, like blade servers or network equipment which uses side-to-side cooling instead of front-to-back cooling²
Depth 1070mm (42 in)	<ol style="list-style-type: none"> 1. Lower cost (\$/rack) than deeper racks 2. Decreased rack footprint than deeper racks 	Depth 1100mm (43 in) 1200mm (47.2 in) 1500mm (59 in)	<ol style="list-style-type: none"> 1. Accommodates deeper servers 2. More space for data and power cable management 3. More positions for zero-U accessories, such as rPDUs for redundancy or ultra-high density



In general, networking racks should be 750 mm (29.5 in) **wide** by 1070 mm (42 in) deep to accommodate the network cabling trunks. Server racks should be 600mm (24 in) wide by 1200 mm (47.2 in) **deep** to accommodate deeper servers and provide room for cable management at the back of the rack. When choosing a wide rack, ensure that the rack vendor provides wide vertical rails that prevent cold air leakage and hot air recirculation (see side bar). Racks should be no taller than the lowest door dimension to simplify transportation and installation. Finally, if racks pre-configured with IT equipment are being moved, ensure that the vendor offers shock packaging to avoid damage to the IT equipment and rack during transportation. Understanding the equipment weight loading will also determine the type of rack and will be discussed in Structural design.

Operational design

In addition to the attributes discussed above, some attributes increase data center operations efficiency such as speed of the deployment, easy maintenance, etc. These attributes include, but are not limited to, the following:

- Tool-less mounting decreases time required to assemble doors, side panels, roof, and accessories during installation and maintenance
- Adjustable vertical, tool-less mounting rails save time

² White paper 50, [Cooling Solutions for Rack Equipment with Side-to-Side Airflow](#)

- Numbered U positions assist in mounting IT equipment and assist in identifying server locations when creating work orders or creating an asset database
- Half-height removable side panels make handling easier and safer
- Pre-installed leveling feet allow fast adjustment with a cordless screw gun on unlevel surfaces such as a concrete slab
- Pre-installed castors help to move IT racks without the need for a pallet jack
- Pre-loaded cabinets that ship on shock packaging should include ramps and easily removeable pallet mounting brackets to aid in removal

Structural design

Static and dynamic³ load capacities are critical parameters for the rack frame. Different manufacturing techniques, such as the formed or folded sheet, tubular sheet with continuous seam welding, or stitch welding yield different capacities. Each technique has its own strengths and weaknesses. For example, the folded sheet technique is used in the majority of industrial racks with a relatively low cost and high static load capacity. However, this technique is not recommended for IT applications because of its weak dynamic load capacity which limits the movement of IT racks around the data center. Another example is in the type of welding technique used on seams. Robot welding is preferred over human welding due to reduced human error and more consistent quality. There are many more examples of manufacturing techniques, but ultimately what is important for specifying a rack's structural design is the static and dynamic load capacity, the higher the capacity the stronger the rack. Note that for seismic zones there are seismic-rated racks available that conform to the NEBS GR-63-CORE standard.

All rack components (i.e. door, frame, mounting rails) should be bonded to ground for human safety. The simplest way is to connect the components to electrical wires, usually by screws. Some racks can attain continuous grounding without screws through their structural design; which increases speed of deployment and lowers human-error during installation and maintenance.

Doors provide both physical security and airflow for mounted IT equipment. Therefore, the basic requirements for doors are structural strength and door perforations which can sometimes conflict with each other. For example, some structural design may be required to achieve 85% perforation or more. Fortunately, studies have shown that perforations of 64 percent do not impact airflow and cooling performance even with loads of 30 kW/rack or higher.⁴

Material

Considering the increase in average rack power density over the years, more IT equipment is mounted in a given rack. Therefore, a rack's load bearing capacity should be evaluated and confirmed in advance. The required load bearing capacity of a rack can be from several tens to thousands of kilograms. IT racks are commonly made of metallic material, like steel and aluminum depending on cost, strength, and corrosion resistance requirements. Steel construction represents the majority of racks due to its high strength and low cost. Electrogalvanized steel (Zinc coating) has good corrosion resistance but is **NOT** recommended for racks because it is prone to Zinc-whiskers⁵. Zinc-whiskers are prone to dislodging and becoming

³ A static load is fixed (i.e. 10 servers mounted in a stationary rack), a dynamic load occurs when the rack is moved / rolled across a floor due to vibrations, torsion, moments, etc.

⁴ Travis North, Understanding How Cabinet Door Perforation Impacts Airflow, BICSI News Magazine, Sep, 2011,

⁵ http://nepp.nasa.gov/whisker/other_whisker/index.htm

entrained in a data center's strong air flow. This increases the risk of Zinc whiskers creating a short circuit on printed circuit boards of IT equipment and other electronics. Occasionally composite wood IT racks can be found in an office environment to meet requirements such as security, noise reduction, and mobility. For more information on IT racks for office environments see White Paper 174, [Practical Options for Deploying IT Equipment in Small Server Rooms and Branch Offices](#).

Color

The surface of cabinets or accessories can be finished to suit an end user's color requirements such as black, white, grey, or even matching the company's colors. Typical colors are black and white. In general, dirt and touch-up repairs are less noticeable on black racks than white racks, lowering the cleaning lifecycle cost. White racks tend to fade in color after about two years with high-temperature air flow. Differences in white shading are also easier to notice compared to black racks. However, white racks reflect more light than black racks and provide more contrast to IT equipment and cabling, making it easier to see when working in the rack. Because of the increased reflection, lighting may be operated at a slightly lower power level. For lighting that is always on, this may result in a measurable lighting power savings, but is less so when lighting management is used.

Recommended rack selection process

Based on the IT rack components and decision criteria discussed above, the following rack selection process is recommended:

- Identify the attributes of equipment to be mounted
- Select IT rack dimensions and load capacity
- Select IT rack preferences
- Select IT rack accessories
- Qualify enclosure weight capacities

Identify the attributes of equipment to be mounted

Depending on the IT equipment mounted inside the IT rack, it would be categorized as either a server rack or a network rack. Network racks are usually wider than server racks due to extra space required for cabling. Therefore identifying the attributes of the IT equipment will help establish some basic rack parameters, such as dimensions and load capacity. The attributes of non-IT equipment should be considered as well, such as rack PDU, automatic transfer switch (ATS), rack-mounted UPS, etc.

The following key attributes effect the choice of rack:

- Number of power cords (affects cable management in the rack)
- Cooling requirement including side-to-side or front-to-rear airflow, CFM, etc.
- Rack unit (RU) spaces to be occupied
- Width and depth dimensions of IT and non-IT equipment
- Total IT and non-IT equipment weight
- Network ports required – how many cables are entering the rack

Select IT rack dimensions and load capacity

Based on the attributes of IT and non-IT equipment, the minimum requirement for the IT rack width and depth dimensions and load capacity can be determined. However, three factors should be considered before selecting IT rack dimensions and load capacity.

One is the growth plan of the IT equipment. An IT rack generally has more than an eight-year life cycle which will support multiple generations of IT equipment. As we mentioned on the dimension attribute above, most IT equipment is standardized to be mounted into a 19-inch rack. If the data center will use standard homogeneous IT equipment, oversizing the rack may not be required. However, if future equipment needs are unknown, oversizing the width and depth may be the right approach. **Table 3** provides recommended rack dimensions for different IT equipment. In some cases, administrators or data center designers want to maximize the number of racks in their data center but also want racks with extra room for cabling. In these cases, multiple rack layouts (horizontal and vertical directions) are created to compare the rack quantities between wide racks and deep racks. For example, certain data center dimensions may allow you to add 10 more wide racks compared to deep racks.

Table 3

IT rack size recommendations per IT equipment type

IT equipment	Recommended IT rack dimension
1U servers	600 mm (24 in) by 1200 mm (48 in)
2U/4U servers, mixed environment	600 mm (24 in) by 1070 mm (42 in)
Blade servers	750 mm (30 in) by 1070 mm (42 in)
High density networking	750 mm (30 in) by 1070 mm (42 in)
Deep, high density networking	750 mm (30 in) by 1200 mm (48 in)
Network storage	600 mm (24 in) by 1070 mm (42 in)
Converged IT infrastructure	750 mm (30 in) by 1070 mm (42 in)

The second factor is the rack density (kW/rack). Higher rack densities generally translate into higher rack weight. Ensure that the rack is capable of supporting the weight load at the maximum rack density. This is discussed further in the “Qualify enclosure weight capacities” subsection.

Finally, IT rack vendors typically offer standard IT rack models based on market analysis. Selecting from standard rack models is generally lower cost compared to non-standard racks. Standard, vendor-neutral racks almost always guarantee universal compatibility and allow for greater flexibility when purchasing and mounting equipment.

Select IT rack preferences

Some preferences include color, door style (curved, angled), type of door lock, seismic bracing, etc. Regardless of preferences chosen, design criteria should be achieved. For example, any change to the front or rear door should not restrict the required IT airflow.

Select IT rack accessories

Selecting an IT rack is obviously critical to data center availability; however selecting rack accessories (e.g. for power, airflow, cable management, and monitoring) improves operational efficiency. **Table 1** provides a list of accessories to select from. The following white papers provide additional information on rack accessories:

- White paper 44, [Improving Rack Cooling Performance Using Airflow Management Blanking Panels](#)
- White Paper 102, [Monitoring Physical Threats in the Data Center](#)

- White Paper 103, [How Monitoring Systems Reduce Human Error in Distributed Server Rooms and Remote Wiring Closets](#)
- White Paper 202, [How to Choose IT Rack Power Distribution](#)
- White Paper 203, [Planning Effective Power and Data Cable Management in IT Racks](#)

Qualify enclosure weight capacities

As mentioned above, enclosure weight capacities are specified as static and dynamic. These capacities should be validated by Underwriters Laboratory (UL)⁶ and International Safe Transit Association (ISTA)⁷. This confirms that the stated claims have been verified by an independent third party and are accurate. UL certification and ISTA performance ratings are discussed below. The **appendix** contains the test methods to achieve these two certifications.

UL certification - It's critical that you specify a cabinet that delivers the performance stated by the manufacturer for your application. The increase in IT equipment densities has required cabinet manufacturers to deliver solutions that can support higher weight capacities for both static and dynamic applications.

The published static weight load capacity indicated by a cabinet manufacturer is valid if the cabinet is UL listed. The weight claim is verified by an independent third party (e.g. UL), not based on the manufacturer's own testing. UL2416 is a specific standard used to verify weight capacity. To comply with UL2416 requirements, the manufacturer has the option of testing the weight load using two methods:

1. Placing the cabinet on a tilt table subjected to a tilted test and push test.
2. Placing the cabinet on a solid surface and load it with 4 times the published weight load.

The first method places the cabinet on a test fixture called a tilt table. The cabinet is loaded to the manufacturer's specifications and the table is then tilted. The UL inspector inspects the cabinet for deflection of the levelers, rails, frame, and welds. The inspector also performs an overall inspection, including a check for permanent deformation, to ensure the rack will not tip over and cause injury to persons that are moving the equipment into place. The rack is also subjected to a push test, to ensure the rack will not tip over.

The second method places the cabinet on a solid surface and loads it with 4 times the published weight load. The UL inspector inspects the cabinet for deflection of the levelers, rails, frame, and welds, and also performs an overall inspection. UL requires that the cabinet support 4 times the rated weight load using this test, the tested weight load is then reduced by 75% to establish the published weight load, providing a factor of safety of 3.

UL2416 certification also requires that the cabinet must be fully bonded to protect against an electrical short scenario, where the fault will clear an OCPD (over current protection device). A continuity test is performed between the main grounding point and the grounding location of each component, to ensure employee safety and equipment safety. In addition, a well-designed cabinet will have electrically-isolated levelers, since concrete is porous and can be conductive.

⁶ <https://www.ul.com/services/certification>

⁷ https://ista.org/test_procedures.php

ISTA testing - ISTA test results are critical when selecting a cabinet in a rack and stack application. The test pass/fail criterion is determined before the test procedure has started. The IT enclosure must show minimal cosmetic damage while retaining all functionality and be fully useable in the field (see **Appendix** for more details). Inspections are done both visually and mechanically on the structural welds and all components of the enclosure. Tool-less features, such as rails, can cause catastrophic damage when they become loose due to the vibrations introduced through shipping.

Cabinets designed to be shipped fully populated, generally rely on an ISTA 3E test. This test verifies the product and packaging integrity through simulation of typical transport hazards, including vibration, shock, and stresses encountered during shipping. All these tests evaluate load stability during transportation, as well as the ability for the product and packaging to survive the trip.

Dynamic weight load capacity is a term used interchangeably in the IT industry. In a test environment it refers to a cabinet undergoing a test on a shaker table, however the term is also often used to describe when a cabinet is being transported or moved into place. If your application requires shipping a cabinet loaded with IT gear, be sure to request the UL certification and ISTA report from your cabinet supplier. Mitigate the risk of equipment damage during transport by requiring that racks are UL listed and tested to ISTA 3E standards.

Conclusion

As the building blocks of a data center, IT rack plays an important role to service multiplier generations of IT equipment to maximum the business value. Less than 5% of the capital cost of data center physical infrastructure, IT racks affect the availability, serviceability, flexibility, and manageability of the data center for years. Only IT racks and their attributes are well known, the right rack solutions can be recommended, evaluated and managed considering the growth plan, rack performance and user preference before the installation.



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Appendix:

Methods of testing weight load capacity for UL certification

Testing weight load capacity is done by placing the cabinet on a test fixture called a tilt table. The levelers of the cabinet are fully extended to replicate the worst-case scenario in the field. The cabinet is loaded to the manufacturer's specifications and the table is then tilted to a 10° angle, which is measured using an inclinometer. The UL inspector inspects the cabinet for deflection of the levelers, rails, frame and welds while performing an overall inspection. The tilt table is then returned to the horizontal position where the cabinet is rotated 90° and the test is repeated, until all four sides have been tested. The cabinet is then inspected a final time including a check for permanent deformation. This test is repeated on casters (if dynamic rating is specified) at the specified loads (the casters are placed against a hard stop to prevent movement). If a dynamic rating is specified, the rack is also subjected to a dynamic tip stability test where the rack is moved in a continuous motion at the specified weight rating for a period of time. The intent is to ensure the rack will not tip over and cause injury to persons that are moving the equipment into place. The rack is also subjected to a push test where a force determined by the weight is put on the rack no higher than 2 meters from the floor for 1 minute. This test is repeated on all four sides. The intent is to ensure the rack will not tip over.

UL certification also requires the cabinet must be fully bonded to protect against an electrical short scenario where the fault will clear an OCPD (over current protection device). A continuity test is performed between the main grounding point and the grounding location of each component. Testing also includes placing an electrical load of 12 VDC maximum and the OCPD rating, between the farthest point of the rack to the main grounding lugs. The dissipation of the load is monitored and measured using a multimeter between the two points. The test requires that the meter register no more than 2 ohms of resistance during the 2-minute-long test. Voltage drop across the circuit is measured to ensure no more than 2 V is dropped. The bonding test ensures employee safety and equipment safety. In addition, a well-designed cabinet will have levelers with an electrically isolative feature as concrete is porous and can be conductive.

Methods of testing dynamic weight load capacity for ISTA certification

The test environment for dynamic weight load capacity refers to a cabinet undergoing a test on a shaker table. Note, however the term is also often used in the IT industry to describe when a cabinet is being transported or moved into place.

ISTA test results are critical when selecting a cabinet in a rack-and-stack application. The pass/fail criterion is determined before the test procedure has started. The IT enclosure must show minimal cosmetic damage while retaining all functionality and be fully useable in the field. Inspections are done both visually and mechanically on the structural welds and all components of the enclosure. Tool-less features, such as rails, can cause catastrophic damage when they become loose due to the vibrations introduced through resonance during shipment.

Cabinets designed to be shipped fully populated generally rely on an ISTA 3E test. The test verifies the product and packaging integrity through simulation of typical transport hazards including vibrations, shocks and stresses encountered during shipping. The testing is performed in a laboratory and a test report is delivered, including pictures. The report documents how the product and packaging performed at a given weight load. The ISTA 3 standard is comprised of a family of tests developed from simulated test references based on recordings made during thousands of shipments worldwide by the ISTA testing organization. They measure a wide variety

of shipping scenarios. All the tests evaluate load stability during transportation and the ability for the product and packaging to survive the trip.

Testing includes an incline impact test at a speed of greater than 1.22 meters per second (48 inches/s) on all 4 sides of the unit. A rotational edge-drop test at a pre-defined height based on packaged weight is also required. One long and one short side is tested after the inclined impact testing. The compression testing is completed if it is determined the enclosure is short enough that it can be stacked in a warehouse or on a shipping container. Vibration testing is then also performed at a vibration profile designated by ISTA based on the type of transportation that the unit will receive. The duration of the vibration is based on the suggested distance the packaged item will generally be shipped with a max time of 4 hours. After the vibration testing is completed, the package is then subjected to another round of rotational edge drops on 2 sides of the pallet. This battery of testing guarantees your equipment will arrive free of damage, functional and ready to deploy when it reaches your facility. Packaged enclosures tested to this standard, usually add a level of increased safety factor to be ensure that ratings are as true as possible.




 [Improving Rack Cooling Performance Using Airflow Management Blanking Panels](#)
White Paper 44

 [Cooling Solutions for Rack Equipment with Side-to-Side Airflow](#)
White Paper 50


 [Monitoring Physical Threats in the Data Center](#)
White Paper 102

 [How Monitoring Systems Reduce Human Error in Distributed Server Rooms and Remote Wiring Closets](#)
White Paper 103


 [Implementing Hot and Cold Air Containment in Existing Data Centers](#)
White Paper 153

 [Practical Options for Deploying IT Equipment in Small Server Rooms and Branch Offices](#)
White Paper 174

 [How to Choose IT Rack Power Distribution](#)
White Paper 202

 [Planning Effective Power and Data Cable Management in IT Racks](#)
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