APC APPLICATION NOTE #133

Cable Trough, Ladder, and Partition Configuration Guide

By Bob Oliver

Abstract

Management of power and data cabling is critical for data center installation and long-term maintenance. APC has developed a line of products designed to contain and manage this array of cabling and piping. These products include cable troughs, ladders, and partitions. The following application note contains guidelines on positioning these products within a data center, determining cable capacity / fill of each product, planning for location of different services (power, data, cooling) within the data center, and installing these products.

Introduction

Generally speaking, data centers are made up of IT equipment housed in racks / enclosures or other physical structure (such as open frame racks). Data and power cabling are required to interconnect IT equipment in a single rack as well as across multiple racks in the data center. In addition, electrical conduits and piping are often required for cooling equipment. All cabling and piping must be supported, organized, and managed. The overhead trough / cabling system offered by APC is designed to serve this function. The system has three basic components: cable troughs, cable ladders, and partitions. The system is designed for quick, tool-less installation and can be configured in many different ways using the same basic set of components to offer maximum flexibility to meet the requirements and needs of each particular data center.

Planning

In most cases, the design and layout of the data center is driven by the physical dimensions of the space and additional considerations such as entry and exit locations for users, power source, and the amount and type of IT equipment to be installed. Since trough / cabling systems are flexible and can be adapted to many different data center configurations, the trough / cabling system layout is generally left until the above issues have been resolved. In most cases, when layout of the trough / cabling system begins, the physical locations of IT equipment, racks, and cooling equipment have already been determined.

First determine cabling requirements for the data center

The first consideration when designing a trough system for a data center is to determine the volume and type of cabling and piping that will need to enter and exit each rack or piece of cooling equipment. For example, for a rack populated with 40

servers, the number of cables exiting the rack can be as many as 120 data cables and 2 power cables. For a rack populated with switches and patch panels, the number of cables exiting the rack can be as many as 1,000 data cables and 1 power cable. The number and type of cabling can vary widely and should be determined as accurately as possible to ensure the most optimized trough system solution. Once the number of cables and piping that are passing in and out of each rack has been identified, the next objective is to determine the total volume and type of cables and piping that must pass over each rack (also over aisle ways and from row to row). Consider the following example. **Figure 1** shows an example datacenter layout with four rows of three racks with two rows separated by an aisle way. For each rack, the number of data cables entering and / or exiting the rack is shown.

Figure 1 *– Example data center layout with racks and data / power cable entering / leaving each rack*

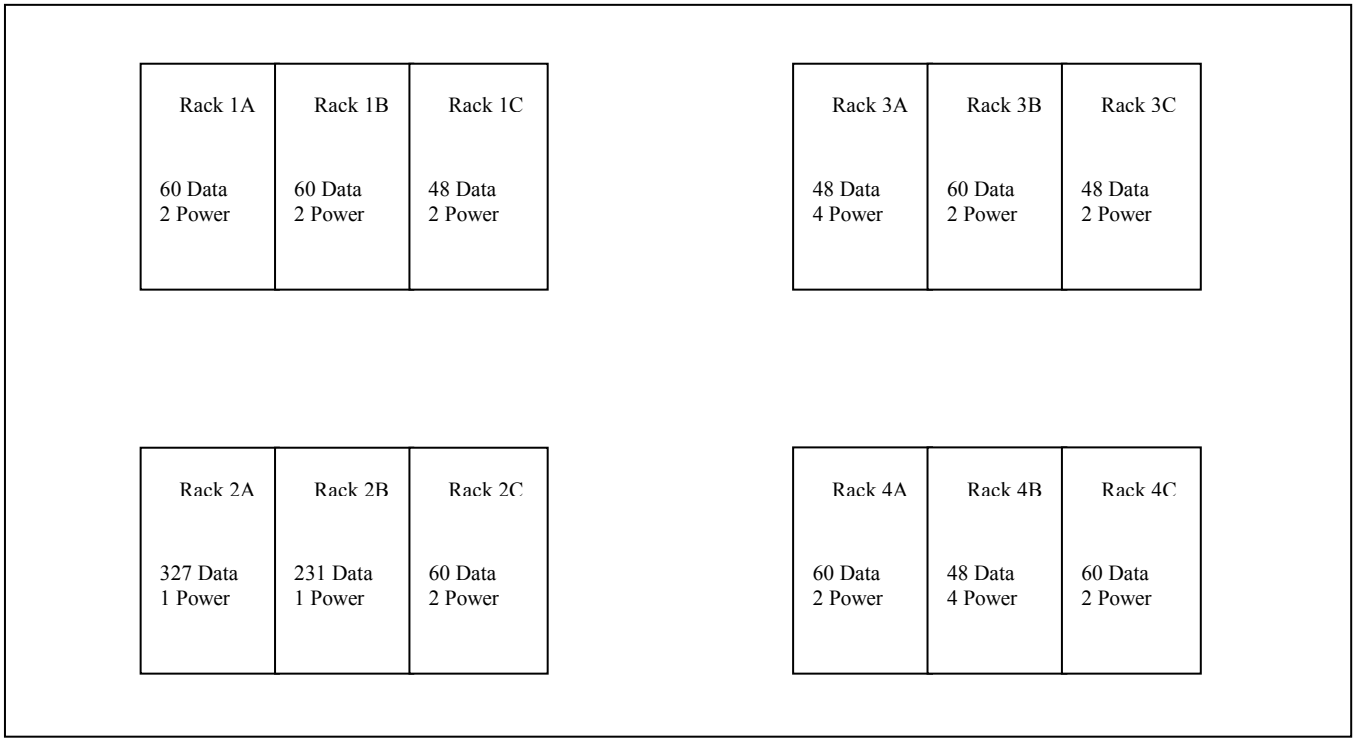
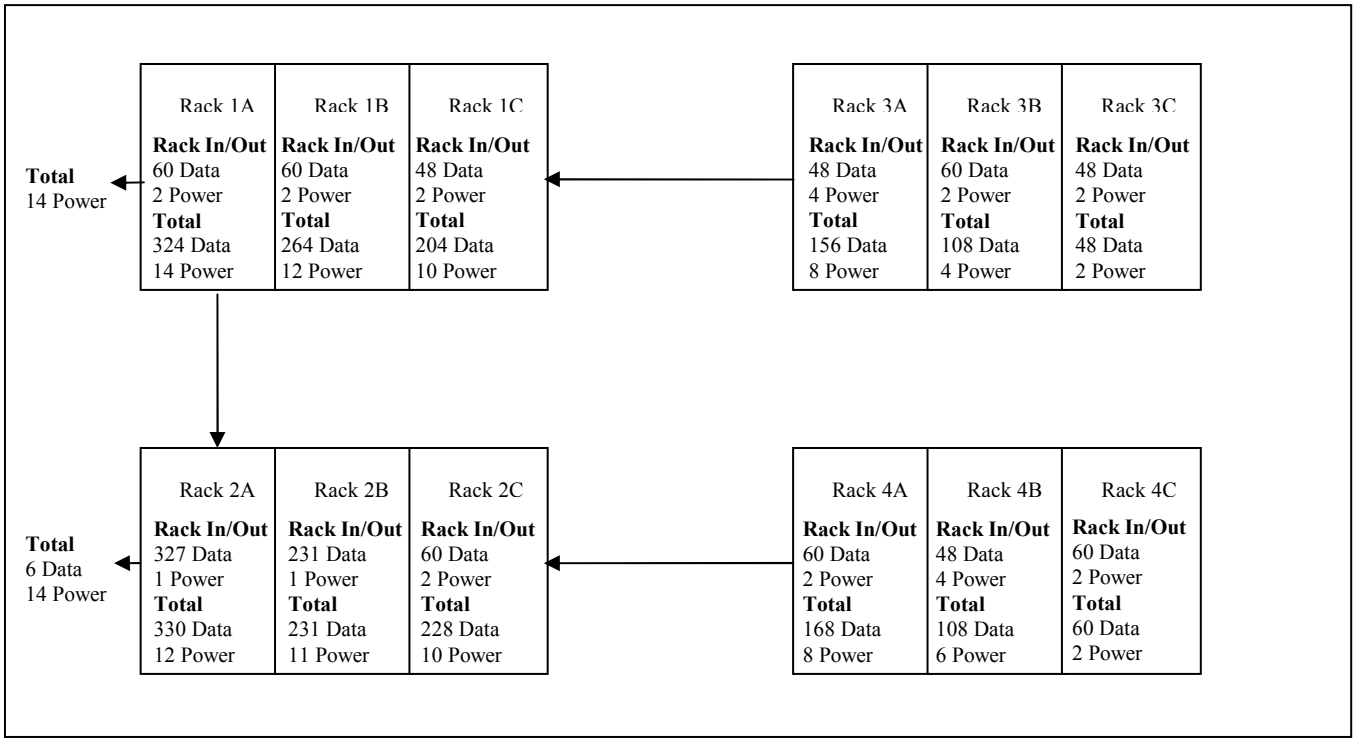


Figure 2 shows that same example datacenter with cable volume passing over each rack and over each row or aisle way.

Figure 2 *– Quantities of cables passing over each rack from row to row and over the aisle way*



Next determine cable volume at each location within the data center

Once the cable volumes passing over each rack are known, the amount of trough space required at each rack can be determined. To prevent the risk of noise within data cables, power and data cables should be separated. Therefore, cable volume (or cable fill area) required for power and data cable should be considered separately.

Calculations are made based on Article 392 of the National Electric Code which is the section which governs cable tray. According to the NEC, cable tray is defined as a rigid structural support system used to securely fasten or support cables and raceways. APC's cable trough, cable ladder, and partitions fall under this definition since they are a rigid system when installed and are designed to support cabling. Calculations should be made as indicated in **Table 1**. Each APC cable trough is considered to be Solid Bottom Cable Tray with the width of the bottom equal to 6.25 inches. In some instances, a cable trough is not large enough to accommodate all of the cables required. In these instances, data partitions can be attached direction to the top of each rack. Data partitions can be attached at different locations on the rack so that the cable fill area can be increased.

Table 1 *– Calculation of cable fill for power and data cable in either a cable trough or between cable partitions*

Type of Cable	Formula for Cable Fill Area Required	Allowable Cable Fill Area per Trough	Calculations for Example Data Center
Power Cable	CFA = (Max. # Cables) * pi * ((Cable diameter) / 2)²	Lookup from Table 392.9 of the NEC based on: - Cable size - The fact that cable troughs are considered solid bottom tray - The width of the cable trough bottom is 6.25 in	Assume we are using 12 AWG (20A) cables so cable diameter = 0.471 in. CFA = (14 Cables) * 3.14 * (0.471 / 2) ² = 2.43 in² Width of cable trough bottom = 6.5 in Cable is < 4/0 so maximum fill area from Table 392.9 is 5.5 in². 2.43 in² < 5.5 in² so maximum number of power cables will fit in one trough.
Data Cable	CFA = (Max. # Cables) * pi * ((Cable diameter) / 2)²	Allowable Cable Fill Area = 50% * (Cable Trough Usable Cross Sectional Area) Or Allowable Cable Fill Area – 50% * (Total Usable Area Between Cable Partitions)	Assume we are using Cat 6 cables so cable diameter = 0.23 in. CFA = (330 Cables) * 3.14 * (0.23 / 2) ² = 26.5 in.² Cable Trough Usable Cross Sectional Area = 30 in.² Allowable Cable Fill Area = 50% * (30 in.²) = 15 in.² **Cable will not fit into one trough. Use data partitions instead.** Plan to set data partitions so they are a minimum of 11.5 inches apart at the base to achieve 26.5 in.² of Allowable Cable Fill Area.

In many cases, cable ladders are required to bridge the gap between racks over aisle ways or between rows of racks. The cable capacity must be calculated for cable ladders as well to make sure the width and quantity of cable ladders is determined accurately. To prevent the risk of noise, it is considered good practice to make separate cable ladder runs for power and data cable. Perform calculations as indicated in **Table 2**.

Table 2 *– Calculation of cable fill for power and data cable on a cable ladder*

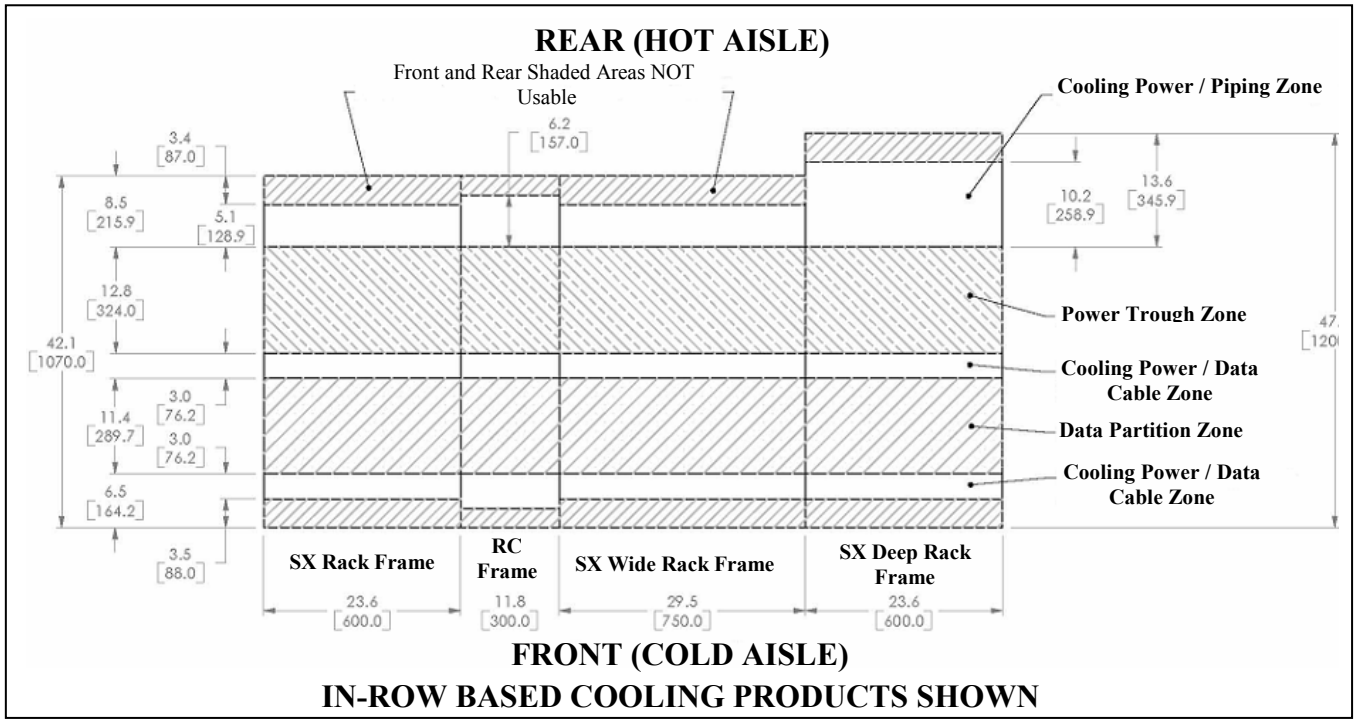
Type of Cable	Formula for Cable Fill Area	Allowable Cable Capacity per Ladder	Calculations for Example Data Center
Power Cable	CFA = (Max. # Cables) * pi * ((Cable diameter) / 2)²	Lookup from Table 392.9 of the NEC based on: - Cable size - The fact that cable ladders are considered ventilated / ladder bottom tray - The width of the cable trough bottom is 6.00 in. or 12.00 in.	Assume we are using 12 AWG (20A) cables so cable diameter = 0.471 in. CFA = (14 Cables) * 3.14 * (0.471 / 2) ² = 2.43 in² Width of cable trough bottom = 6.0 in Cable is < 4/0 so maximum fill area from Table 392.9 is 5.5 in². 2.43 in² < 5.5 in² so maximum number of power cables will fit on one cable ladder.
Data Cable	CFA = (Max. # Cables) * pi * ((Cable diameter) / 2)²	Allowable Cable Fill Area = 50% * (Ladder Width * 6" Max Fill Depth)	Assume we are using Cat 6 cables so cable diameter = 0.23 in. CFA = (168 Cables) * 3.14 * (0.23 / 2) ² = 6.97 in.² 6" Cable Ladder Allowable Fill Area = 50% * 6.00 * 6.00 = 18 in.² 6.97 in.² < 18 in.² so maximum number of data cables will fit on one cable ladder.

Once the cable fill area and the type of cable management solution required have been determined, the next step is to determine where the cables, troughs, ladders and partitions will be located within the data center.

Area on top of the rack

APC cable troughs and partitions are attached to the roof of each APC rack. As a 'rule of thumb', the top of each rack has different areas reserved for different types of services (data, power, and piping). The layout of each rack top is shown in **Figure 3**. When a particular service type is not required or requires less space than indicated, this space can be used by another service.

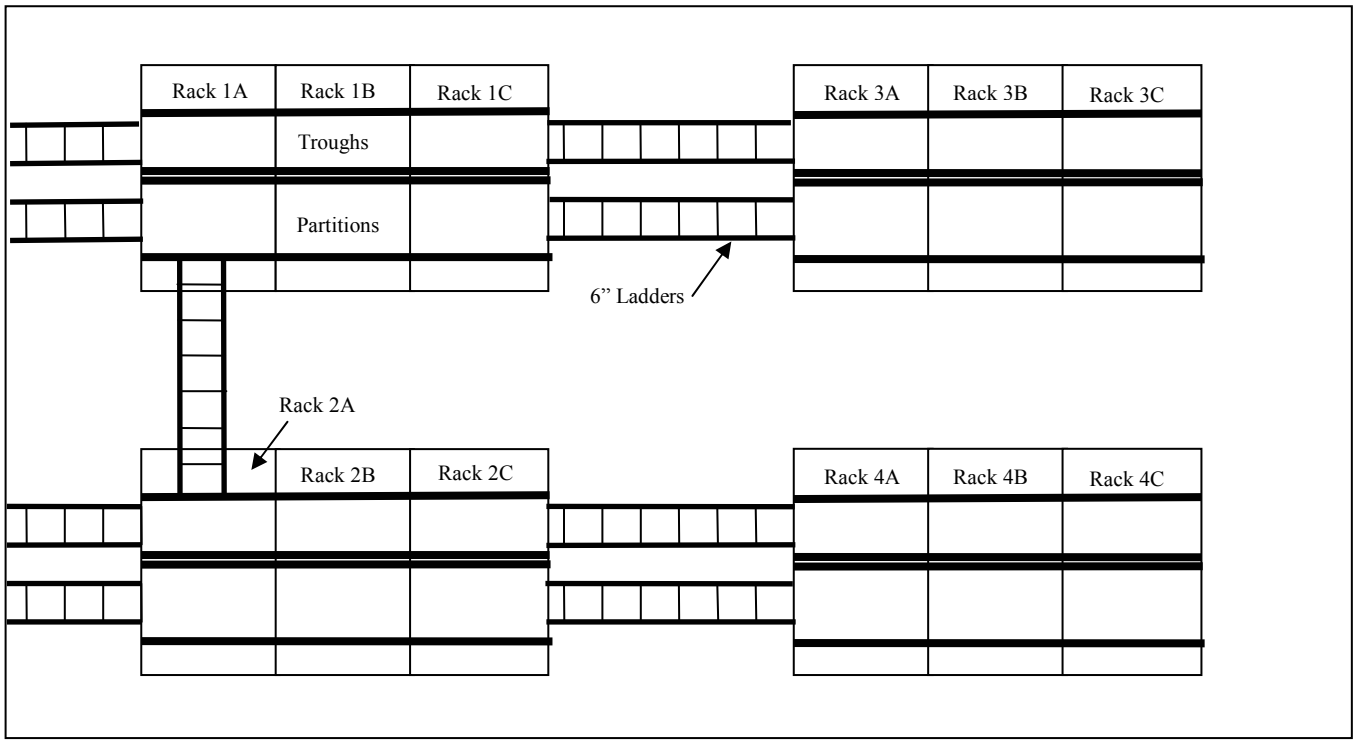
Figure 3 *– Designated cable areas atop APC racks*



For our example data center and based on **Figure 3**, cable troughs will be installed in the 'Power Trough Zone' while data partitions will be installed in the 'Data Partition Zone'. Six inch cable ladders will extend across the aisle way and from the rack row to the wall for cabling exiting the data center. One six inch cable ladder will connect the two rows of racks. The layout has been updated to show the cable troughs, partitions, and ladders included in the datacenter layout (See **Figure 4**).

Some cooling products (such as several offered by APC) are designed to be installed 'in-row' with racks. In those cases, space must be allocated above the racks for electrical conduits to the cooling equipment as well as piping for the coolant.

Figure 4 *– Data center configured with troughs, partitions, and cable ladders*



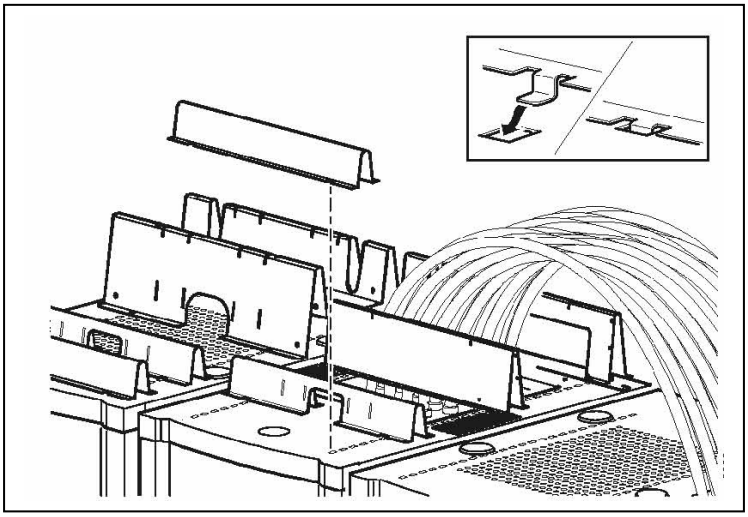
Installation

The following are some installation details showing how troughs, partitions, and ladders connect to APC racks as well as how they interconnect with one another.

Attachment of cable troughs and partitions

APC cable troughs and partitions are attached to APC racks without tools. Tabs on the bottom of each trough or partition snap into square holes in the rack roof. Ground wires are included with each trough and partition to 'chain' all individual units together and then attach to a common ground (which is generally on the racks in the row). See **Figure 5**.

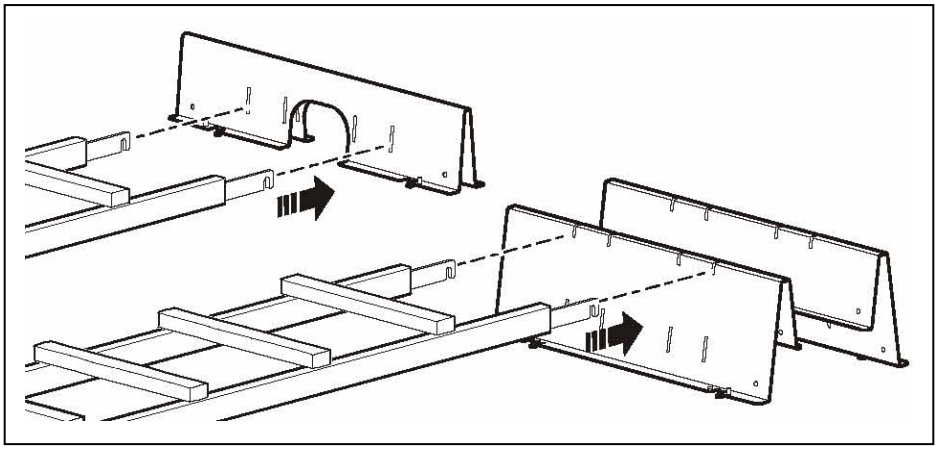
Figure 5 *– Cable trough and partition attachment*



Attachment of cable ladders to cable troughs and partitions (over aisle ways and between rows)

APC cable ladders are generally used to span aisle ways and rows. They are designed to attach to cable troughs and partitions without tools. Each trough and partition has slots in each side that can accommodate either a 6” or 12” wide cable ladder fitted with a Ladder Bracket Kit (Part Number AR8166ABLK). **Figure 6** shows the addition of a 12” wide cable ladder between rows and attached to either a partition or a trough.

Figure 6 *– Cable ladder attachment*



Cable ladders can also be attached over aisle ways to partitions or troughs. **Figure 7** shows a cable ladder attached to partitions using the AR8166ABLK Ladder Bracket Kit. Attachment to a cable trough is completed in the same way. Grounding kits are provided to allow a grounded connection between the trough / partition and the cable ladder.

Figure 7 *– Cable ladder attachment to partitions using ladder brackets*

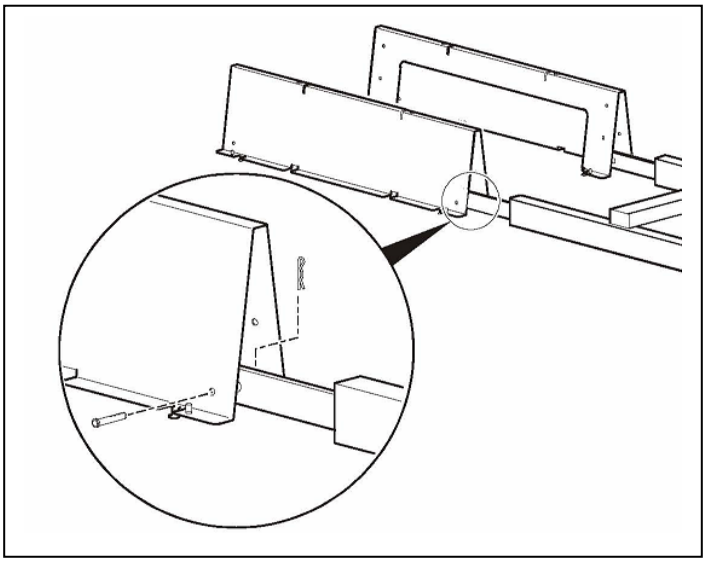
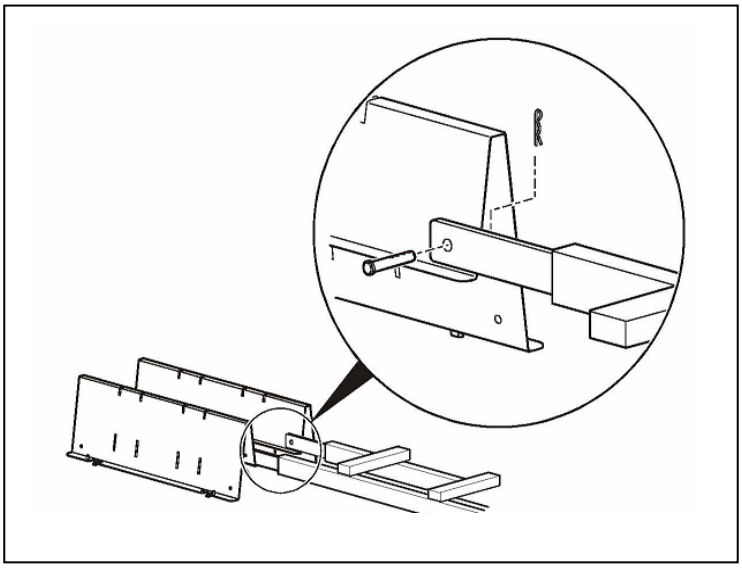


Figure 8 shows attachment of a 6" cable ladder to a cable trough.

Figure 8 *– Cable ladder attachment to trough using ladder brackets*



Additional kits and accessories are available from APC. Please visit www.apc.com for additional details. See **Table 3** for a partial list of available products:

Table 3 *– APC product listing for cable troughs, ladders, partitions, and accessories*

Part Number		Description	Use
For 600mm Wide Racks	For 750mm Wide Racks		
AR8160ABLK	**AR8178BLK**	Power Shielding Trough – Black	Facilitates overhead power cabling distribution. Has protective grounding provisions. Tool-less mounting. Includes Installation Guide and (1) 20 cm grounding strap.
AR8161ABLK	**AR8171BLK**	Power / Data Shielding Trough for Racks – Black	Facilitates overhead power or data cabling distribution. Has protective grounding provisions. Tool-less mounting. Includes Installation Guide and (1) 20 cm grounding strap.
AR8162ABLK	**AR8172BLK**	Solid Shielding Partition for Racks – Black	Facilitates overhead cable management. Has protective grounding provisions. Tool-less mounting. Includes Installation Guide and (1) 20 cm grounding strap.
AR8163ABLK	**AR8173BLK**	Pass-Through Shielding Partition for 600mm Wide Racks – Black	Provides the ability to pass cables in and out of the cabling area contained by two partitions. Facilitates overhead cable management. Has protective grounding provisions. Tool-less mounting. Includes Installation Guide and (1) 20 cm grounding strap.
AR8164ABLK		6” Wide Cable Ladder with Bracket Kit – Black	Support data or power cabling across aisle ways or between rack rows.
AR8165ABLK		12” Wide Cable Ladder with Bracket Kit – Black	Support data or power cabling across aisle ways or between rack rows.
AR8166ABLK		Ladder Bracket Kit - Black	Allows tool-less attachment of cable ladders to troughs and partitions. Includes Installation Guide.
AR8168BLK		Ladder to Rack Attachment Brackets – Black	Allows a cable ladder to attach direction to a rack. Tool-less mounting. Includes Installation Guide and (1) 20 cm grounding strap.

Conclusion

With careful planning, cabling and piping can be accommodated within the data center. APC offers many products that install quickly and easily and can be adapted to many different layouts to help make this process more efficient and effective.

About the Author:

Bob Oliver is the Engineering Manager for Racks and Enclosures for APC. He is responsible for design and development of racks and enclosures as well as rack accessories. Bob received a Bachelor's degree in Mechanical Engineering from the University of Missouri – Columbia in 1992 and a Master's degree in Engineering Management from the University of Missouri – Rolla in 1999.