APC

APPLICATION NOTE #146

Hot Aisle Containment Application Guidelines and Approved Configurations

By Kevin Lemke

Abstract

The Hot Aisle Containment System (HACS) is a modular ceiling panel and door system for use in isolating the supply and return air between an APC NetShelter rack and an APC InRow® cooling solution. The containment system is designed to create a separate environment for air distribution in order to prevent mixing of hot and cold air streams, resulting in a more predictable cooling pattern. The modular design and ability to retrofit to an existing Netshelter rack enables medium to high density racks to be cooled in an autonomous environment without overcooling the room.

How It Works

The most common configuration for rows of racks in the data center is hot / cold aisle design for separating the supply and return air paths. HACS takes this one step further by containing the return path of the hot air exhausted from the IT equipment. **Figures 1** and **2** show a containment configuration.

Figure 1 – HACS (airflow)

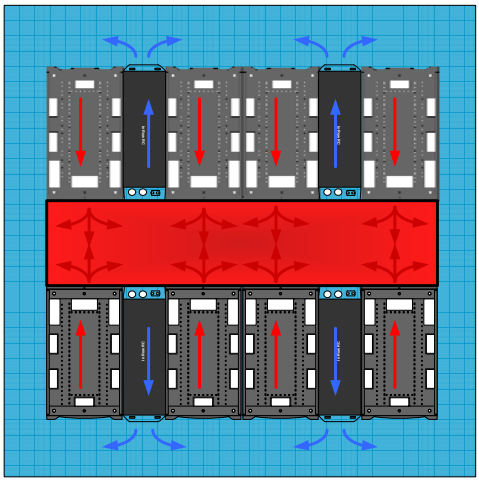

Figure 2 – HACS (assembled)

HACS configurations capture the hot exhaust air in a plenum that is also connected to one or more InRow® cooling unit(s). InRow® cooling units are designed to draw air in a back to front pattern. The warm air in the HACS plenum is drawn to the

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InRow® cooling unit(s) where it is cooled and then discharged from the front, into the room, at a room neutral temperature. The discharge temperature is at or slightly below room temperature.

Benefits of Hot Aisle Containment

Eliminating mixing of hot / cold air streams in the data center has several benefits over a flooded and mixed environment. The main benefits from this design are listed in **Table 1**.

Table 1 – Hot Aisle Containment benefits

Benefit	Description / Details
Warmer intake temperatures increase unit capacity	Higher temperature differentials, between the entering air and the cooling coil, increase the amount of heat transfer and therefore capacity of the cooling unit.
Predictable cooling	Removal of heat ensures that the supply temperature has little to no mixing and can be relatively constant and within the ASHRAE recommended guidelines for air delivery.
Isolate high density racks	Allows for mixed density racks to exist in the same environment without overcapacity or overcooling by the perimeter cooling system.
Reduction or elimination of moisture removal	Elevated entering and discharge temperatures almost guarantees that the leaving air temperature from the cooling coil will be above dew point. This saves energy on make-up humidification.
Improved redundancy	Hot aisle containment improves the capture index of InRow® cooling units, enabling redundancy to be achieved more easily and with less equipment.
Shared capacity	All of the InRow® cooling units that share a common hot aisle have the ability to share their cooling capacity with heat load in the system. This improves overall cooling capacity utilization of the equipment in the Hot Aisle Containment System eliminating stranded cooling capacity that can happen with rack-based containment solutions.

Applications and product usage

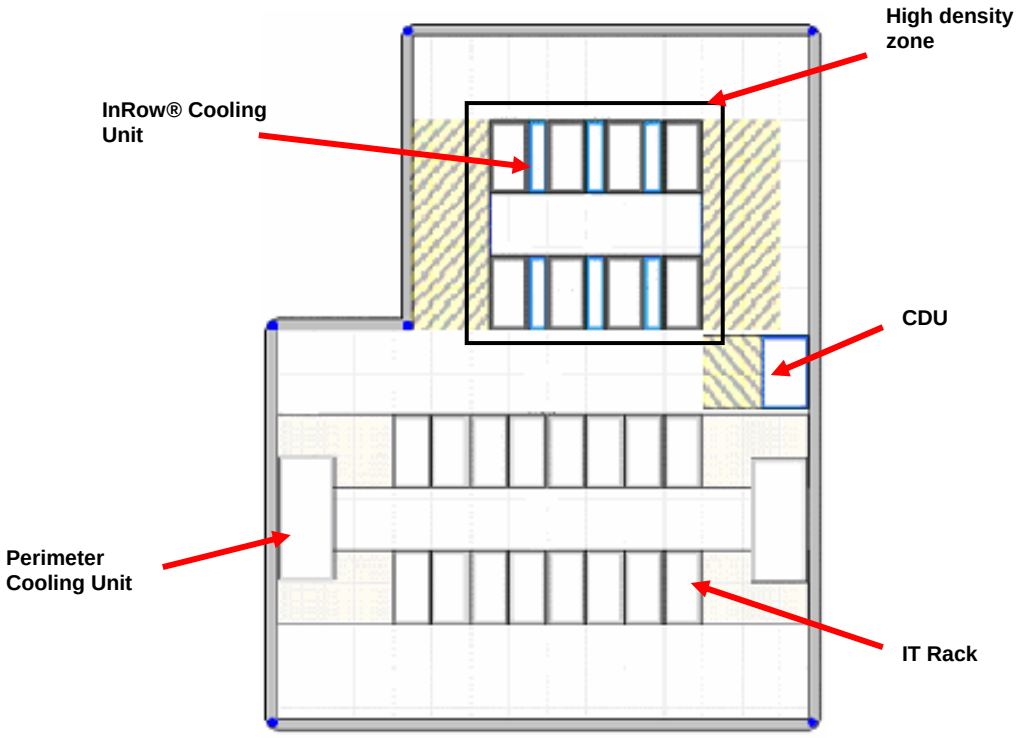
The use of HACS is not limited to one situation or application in the data center. In fact, it may be used as a general purpose cooling solution or as a targeted deployment for a group of racks. The following are some common applications for the product.

Isolating high density zones

There are large numbers of existing data centers, which were designed for densities below 3 kW per rack, in operation today. Newer IT equipment has pushed well beyond the design density of 3 kW per rack. This stressing of the perimeter or central air handling cooling system is sometimes compensated for by adding additional capacity (which doesn't solve the air distribution problem) or by overcooling the room by running the set point at a lower temperature. Overcooling is a "hope strategy" the does not address the hot spot directly but may temper the hot air by mixing in some portion of the overcooled surrounding air.

In this application, in conjunction with InRow® cooling, HACS provides a targeted cooling solution to higher density racks without changes to the existing system that was cooling lower density racks sufficiently. **Figure 3** shows how a single high-density zone could be isolated using HACS.

Figure 3 – Isolated high density zone with HACS



Virtualization / consolidation of servers

In today's data centers there is a push toward virtualization and consolidation of servers to reduce white space occupied by the IT equipment. The virtualization and consolidation of servers packs the racks with higher densities than their existing infrastructure was designed for. In the traditional perimeter approach, the datacenters are designed with a typical load of 3 kW per rack. **Figure 4a** shows a traditional design with a total IT load of 96 kW. **Figure 4b** shows the same data center with the same 96 kW total IT load, yet the number of IT racks is reduced from 32 to 8, pushing the load per rack from 3 to 12 kW. Utilizing InRow® with HACS would allow the same datacenter the ability to more than double in capacity without expanding into other building spaces.

Figure 4a – 96 kW deployment

(3 kW per rack perimeter design)

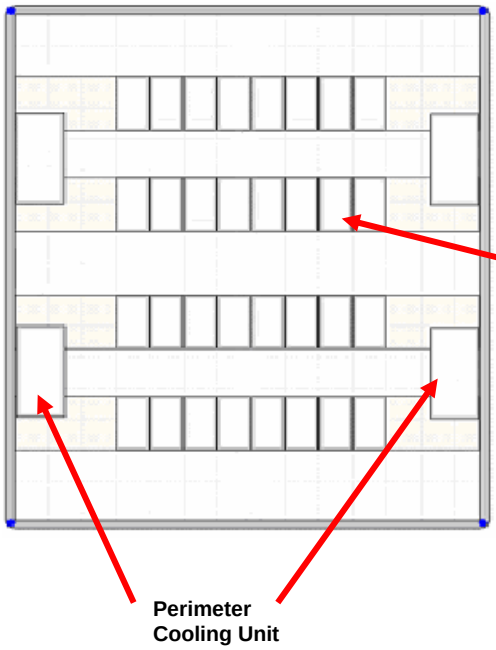
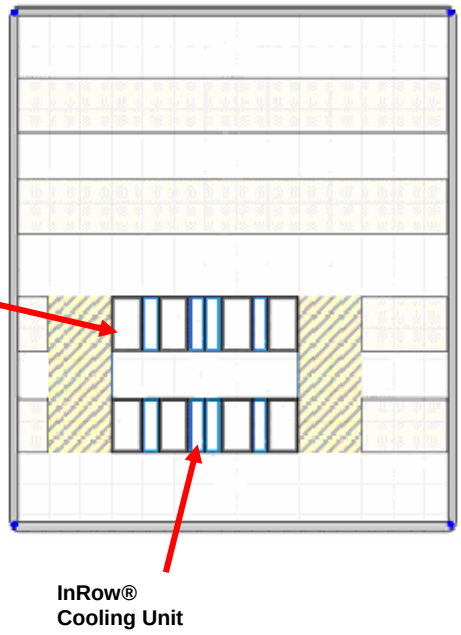


Figure 4b – 96 kW deployment

(12 kW per rack InRow® design with HACS)



Hot Aisle Containment Components

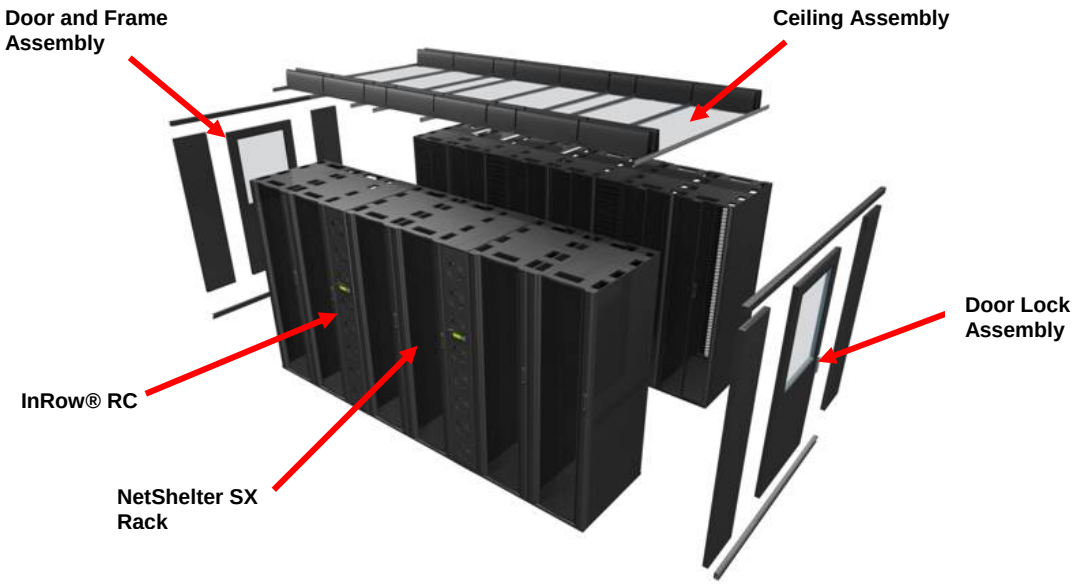
There are a number of components with the HACS system (**Table 2**) that allow it to be both retrofitted in the field and modular in nature. First, since every datacenter does not have the exact same equipment or layout each component of the HACS must be chosen separately. There are specific rules that must be followed to ensure that the HACS can be deployed on a project. These rules are discussed later in this application note.

Table 2 – SKUs and descriptions

SKU	Description		SKU	Description
ACDC1005	Baying Kit – 900mm to 900mm (PDU/UPS to PDU/UPS)		ACDC1016	Door and Frame Assembly SX to SX
ACDC1006	Baying Kit – 1070mm to 900mm (Rack to PDU/UPS)		ACDC1017	Door and Frame Assembly SX to VX (VX Right Side)
ACDC1007	Baying Kit – 1070mm to 1070mm (Rack to Rack)		ACDC1018	Ceiling Assembly 300mm (InRow® RC and InRow® RD)
ACDC1008	Privacy Panel for Symmetra PX and RX Frame		ACDC1019	Retrofittable Ceiling Assembly 600mm (SX, InRow® RP, InRow® RC, InRow® RD)
ACDC1009	Door Lock Assembly		ACDC1020	Door and Frame Assembly VX to SX (VX Left Side)
ACDC1015	Retrofittable Ceiling Assembly 750mm		ACDC1021	Door and Frame Assembly VX to VX

Each SKU is designed to either be installed at the same time as the rack and cooling units, or retrofitted to an existing InRow® cooling environment. **Figure 5** illustrates the different components and how they are assembled to make the final solution.

Figure 5 – HACS exploded view with InRow® RCs and NetShelter SX racks



Product and Component Configuration Options

The ability of the HACS to work with multiple InRow® cooling products and the modularity of the parts enables many different configuration possibilities which are shown in **Tables 3-5**. However, since all of the racks and cooling units are not the same physical size there are rules that must be followed to ensure a successful deployment of the HACS.

APC products supported and guidelines

Table 3 – HACS door kits

HACS Door Kits							
	Right side of hot aisle						
Left side of hot aisle		SX	VX	RC / RD / RP 600mm*	PX40 / PX80 / XR	PD40 / PD60 / PD80	Door Handle
	SX	ACDC1016	ACDC1017	ACDC1016	ACDC1017	ACDC1017	ACDC1009
	VX	ACDC1020	ACDC1021	ACDC1020	ACDC1021	ACDC1021	ACDC1009
	RC / RD / RP 600mm*	ACDC1016	ACDC1017	ACDC1016	ACDC1017	ACDC1017	ACDC1009
	PX40 / PX80 / XR	ACDC1020	ACDC1021	ACDC1020	ACDC1021	ACDC1021	ACDC1009
	PD40 / PD60 / PD80	ACDC1020	ACDC1021	ACDC1020	ACDC1021	ACDC1021	ACDC1009
	Door Handle	ACDC1009	ACDC1009	ACDC1009	ACDC1009	ACDC1009	

*InRow® cooling units placed at the end of the row is not recommended

Table 4 – HACS ceiling assemblies

HACS Ceiling Assemblies								
	SX / VX 600mm	SX / VX 750mm	RC / RD 300mm	(2) RC / RD 300mm*	RC / RD / RP 600mm	PX40 / PX80 / XR	PD40 / PD60	PD80
SX / VX 600mm	ACDC1019			ACDC1019	ACDC1019	ACDC1019	ACDC1019	
SX / VX 750 mm		ACDC1015						ACDC1015
RC / RD 300mm			ACDC1018					
(2) RC / RD 300mm*	ACDC1019			ACDC1019	ACDC1019	ACDC1019	ACDC1019	
RC / RD / RP 600mm	ACDC1019			ACDC1019	ACDC1019	ACDC1019	ACDC1019	
PX40 / PX80 / XR	ACDC1019			ACDC1019	ACDC1019	ACDC1019	ACDC1019	
PD40 / PD60	ACDC1019			ACDC1019	ACDC1019	ACDC1019	ACDC1019	
PD80		ACDC1015						ACDC1015

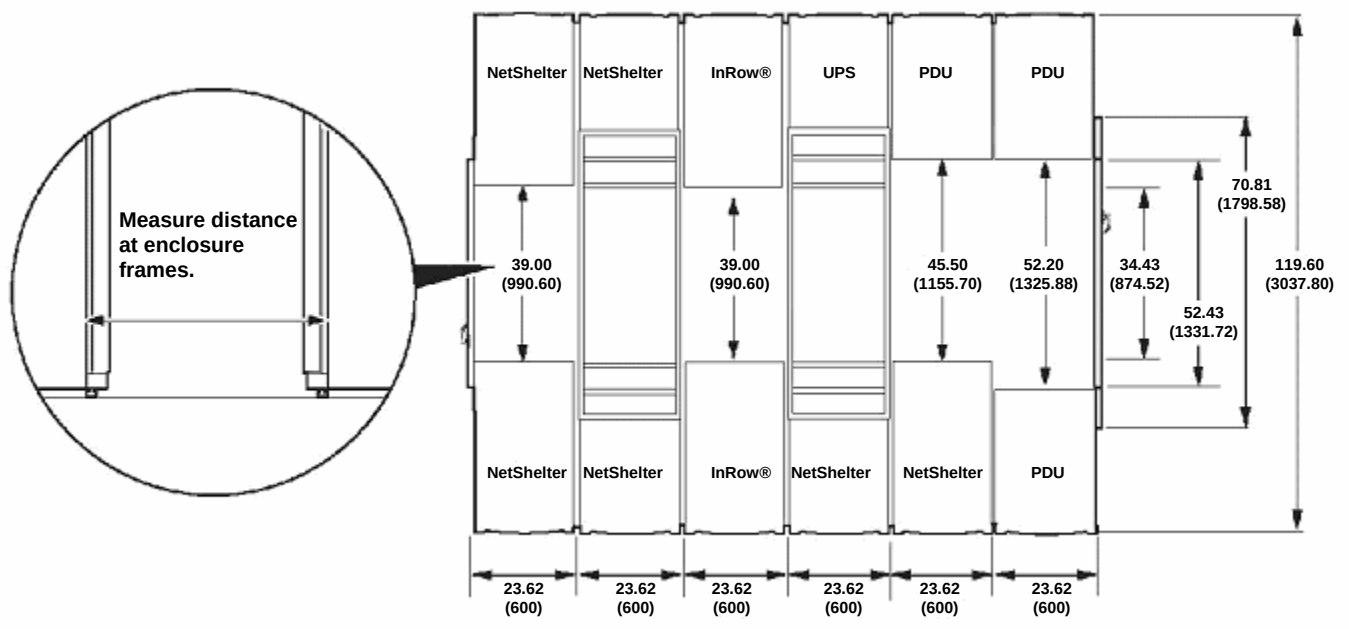
*Two 300mm InRow® cooling units placed side by side

Table 5 – HACS roof height adapters to VX 42U racks

HACS Roof Height Adapters	
	Roof adapter SX to VX 42U
SX 600mm	AR7203
SX 750 mm	AR7202
RC / RD 300mm	ACAC10003
RC / RD / RP 600mm	ACAC10004

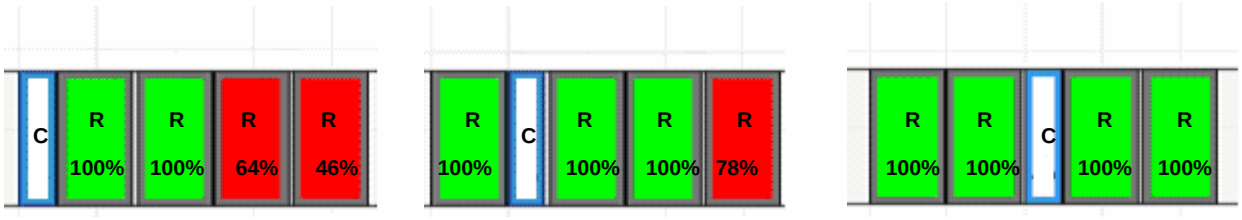
1. The standard HACS is compatible with either 600 mm or 750 mm wide NetShelter racks.
2. HACS may only be deployed on equal length rows.
3. PDU/UPS in VS racks in a layout, the fronts of the racks are required to be aligned. The difference in the depth between the VS (35.4 inch (900 mm)) and the SX racks are accommodated by the door (ACDC1017, ACDC1020 or ACDC1021) and ceiling assembly panels (ACDC1019). **See Figure 6**
4. The hot aisle width between rows (frame to frame) of NetShelter SX racks must be 39 inches (990 mm). The ceiling panels and door assemblies are designed to work with the 39 inch (990mm) aisle width. **See Figure 6**

Figure 6 – Required row spacing for HACS deployment



5. The HACS was designed to incorporate racks without rear doors. The doors on the end of the hot aisle were designed to secure the hot aisle and the racks. The clearance required to lift rear doors up and off of their hinges does not exist in a HACS configuration with the NetShelter SX rack. Additionally, NetShelter SX racks with rear doors installed in the HACS may result in the doors contacting the ceiling panels. If door removal or contact with the ceiling panels is an issue, roof height adapters may be installed on top of every rack and cooling unit to create clearance for the door swing.
6. InRow® cooling units placed at the end of a row is not recommended in an open row configuration.
    a. Cooling is not optimized when the units are placed at the end of a row. The "Capture Index" is limited when there is not a rack on either side of the cooling unit. If the cooling unit is placed in between racks the cooling equipment will be able to capture the heat from adjacent racks on both sides of the cooling unit. If the unit is placed at the end of the row, then the heat is only being captured from the racks on one side of the unit, and will pull more air from the room as illustrated in **Figure 7**.

Figure 7 – Capture Index of InRow® cooling units



While one of the big advantages of the HACS is to improve the capture index of the cooling units in the row, general best practice is to configure the design to optimize the capture index of the cooling units in an open aisle configuration, and then add containment to the solution. As a result you end up not placing units at the end of the row.

    b. The InRow® RP, RD 600mm and RC 600mm are built in NetShelter SX frames, so physically they can be placed at the end of a row.
    c. The InRow® RC 300mm and RD 300mm are not built in a NetShelter SX frame therefore they do not have the mounting holes required to mount the door assembly. A custom engineered solution must be implemented to accommodate this preference.

APC products not supported

1. The only InRow® cooling unit that cannot be installed in a HACS is the InRow® SC. All of the other InRow® units can be installed in a HACS configuration. The InRow® SC is not supported because there is interference between the ceiling panels of the HACS and the supply and return air ducts for the condensers on the top of the unit.

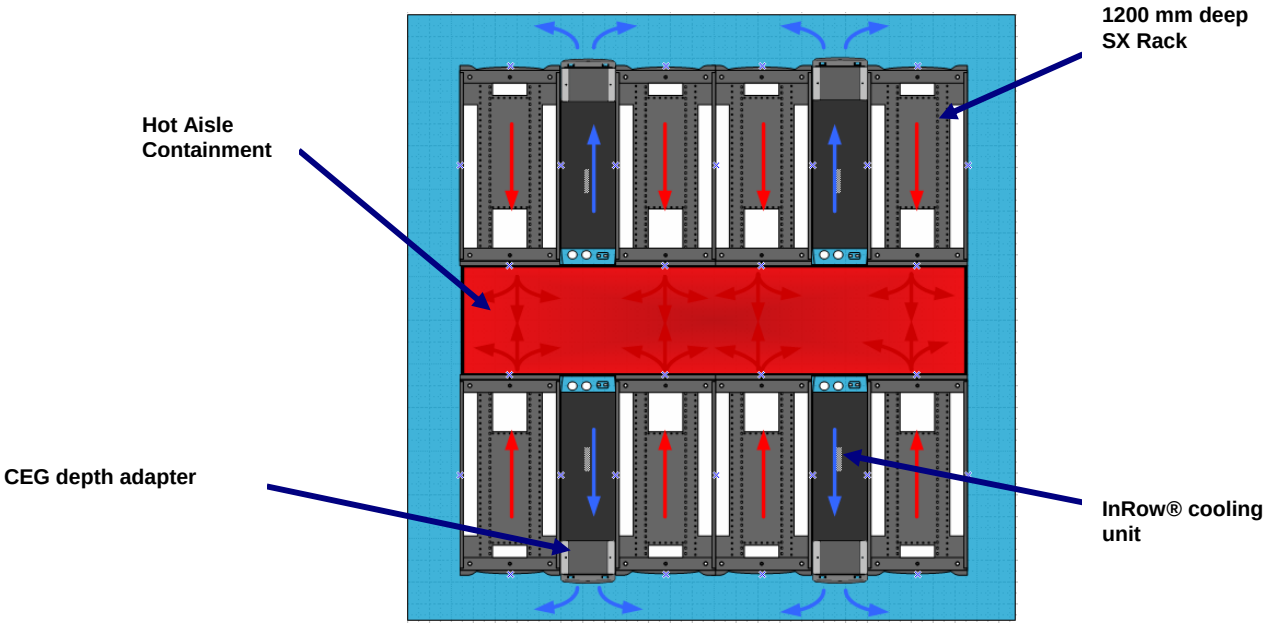
2. The standard HACS is not compatible with the AR7709 NetShelter SX channel mounting bracket. This bracket requires the removal of the casters from the racks resulting in the misalignment of the mounting flange / holes of the door assembly and the rack mounting position.

Custom installations of HACS

While the standard HACS will support a wide variety of applications the system is limited in what it supports as a standard offering. However, with some assistance from the APC Custom Engineering Group (CEG), and appropriate on site services, the HACS can be installed to support a wider range of installations.

1. 48 inch (1200 mm) deep SX racks (AR3300 and AR3350) may be installed in a HACS with the following clarifications. This is also illustrated in **Figure 8**.
    a. The InRow® cooling units are not the same depth as these racks. The backs of the racks are required to be aligned with the backs of the cooling units. Custom engineered components have been developed to compensate for the difference in depth of the components.
    b. The ceiling panel mounting holes do not line up with the mounting holes on the deep racks. A drill or a self tapping screw must be used to secure the ceiling panels to the racks. Care must be taken to avoid getting metal shavings into the IT equipment.
    c. All of the racks in the HACS solution must be SX racks. VX racks cannot be installed in a HACS zone with 48 inch (1200 mm) deep racks.

Figure 8 – HACS with 1200mm deep racks

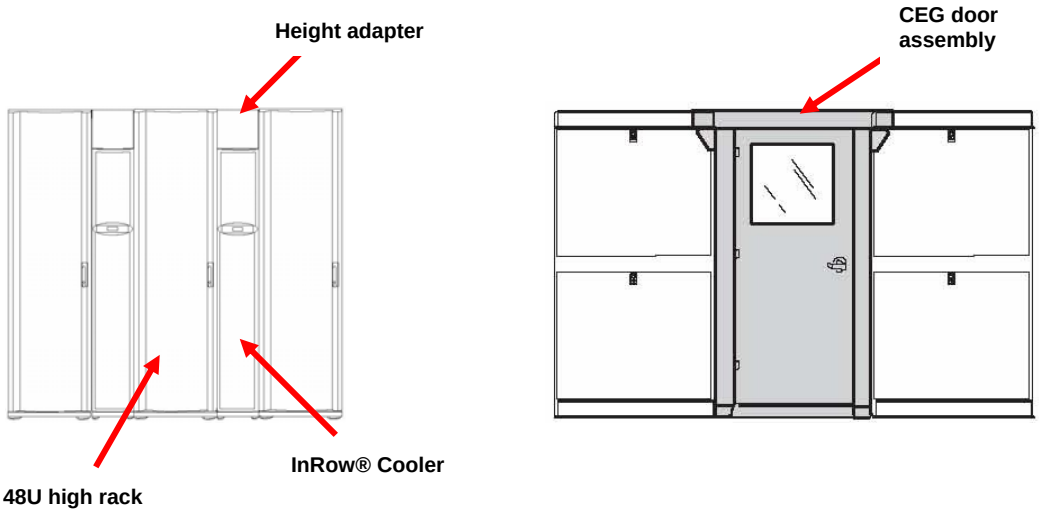


2. 48U NetShelter SX (AR3107 and AR3157) racks. Custom engineered components have been developed to support the 48U rack installation, however special considerations need to be made when using 48U racks as shown in **Figure 9**.
   a. 48U height adapters need to be used on the InRow® cooling units as shown in **Table 6**.

Table 6 – HACS roof height adapters to 48U racks

HACS Roof Height Adapters	
	Roof adapter 42U to 48U
RC / RD 300mm	ACAC10007
RC / RD / RP 600mm	ACAC10009

Figure 9 – HACS with 48U high racks



   b. Please keep in mind this is a custom engineered solution and appropriate services and engineering support should be allowed for APC to support this type of installation.
3. Ceiling suspended and non-APC rack installations
   a. The standard HACS is not compatible with other manufacturer's racks. A custom engineered solution would have to be implemented.
   b. The standard HACS is not able to be suspended from a ceiling. A custom engineered solution would have to be implemented.

System Controls

InRow® cooling products have multiple modes of operation for system control. When placed in a hot aisle containment system, the InRow® cooling unit must be set to RACS / HACS to ensure that the system is operating properly.

In addition, the HACS mode has two set points that must be configured. These set points are "supply air temperature" and "fan speed preference." In this mode, the cooling set point will have no effect on the operation of the unit. This is because the cooling set point looks at a remote temperature probe in an open-row configuration in order to maintain the inlet temperature to the adjacent racks. In a HACS configuration, the temperature of the supply air (discharge from the unit) will be the same as the inlet to the IT equipment because it will not have a chance to mix with the surrounding environment. In addition, the InRow® cooling unit must respond much quicker in HACS mode to ensure that spikes in rack exhaust temperature that occur over a time scale of a few seconds are properly neutralized.

While most IT equipment is designed for approximately a 20°F (11.1°C) temperature rise from the inlet to the exhaust (deltaT), some equipment will require more or less airflow. In cases where the deltaT is known, the fan speed preference setting can be configured for the desired cfm / kW (l / s per kW). Selection of the fan speed preference should be done by the user using the chart in **Table 7** if the deltaT or CFM / kW (l / s per kW) is known. If neither of these two values is known, then a setting of medium is recommended. If it is later determined that the fan speed is to low or high, it can be easily adjusted.

Table 7 – Fan speed preference selection

Fan Speed Preference	DeltaT °F	CFM per kW	DeltaT °C	L / s per kW
High	10	325	5.5	2.56
Medium-High	15	215	8.3	1.69
Medium	20	160	11.1	1.26
Medium-Low	25	130	13.9	1.02
Low	30	105	16.6	.83

Choosing a fan speed preference that is too low (higher delta T and lower CFM / kW) could result in the airflow from the servers to be greater than that of the RC. In this case hot air would be exhausted out the top and bottom of the racks resulting in an increase in heat load to the rest of the room. Operating with the fan speed preference set higher than necessary does not have a negative effect on cooling capability, but in general the fans will run faster and the unit will use more energy. For

more information on the controls of the InRow® RP refer to APC application note #119. For more information on the controls of the InRow® RC refer to APC application note #142.

Conclusions

The hot aisle containment system is a modular plenum system for improving the predictable architecture of InRow® cooling. Following the guidelines for mating the containment system, system control settings, rack placement, and cooling units will ensure proper air distribution throughout the system.

About the Author:

Kevin Lemke is the Product Manager for InRow® Cooling Solutions for APC-MGE. Kevin is responsible for managing the products focused on applications greater than 16 kW for in-row cooling architecture. He has 8 years experience in design, sales, and support of complex cooling solutions. Kevin received a Bachelors degree in Mechanical Engineering from Southern Illinois University, Carbondale, IL in 2000.