

## Rack Air Containment application guidelines and approved configurations

By Kevin Dunlap

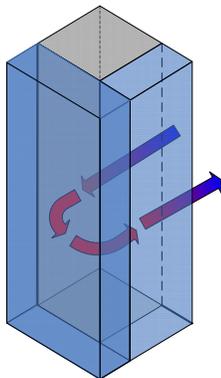
### Abstract

The Rack Air Containment System (RACS) is a modular front and rear plenum for use in isolating the supply and return air between an APC Netshelter<sup>®</sup> SX rack enclosure and an APC InRow<sup>®</sup> cooling unit. 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 SX rack enables medium to high density racks to be cooled in an autonomous environment without overcooling the room mixed with lower density loads.

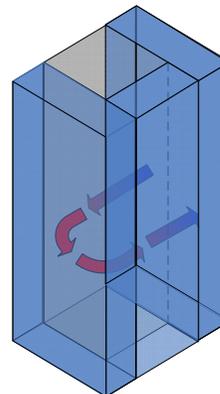
### How it works

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. RACS takes this one step further by containing the return path of hot air exhausted from the IT equipment. Optionally, the supply path can be contained as well to enhance the distribution path, isolate the rack or for noise attenuation. Figures 1 and 2 show a rear only and front/rear containment configuration.

*Figure 1 – RACS (Rear only)*



*Figure 2 – RACS (Front and Rear)*



Rear containment only configurations capture the hot exhaust air in a plenum that is also connected to one or more InRow cooling unit. InRow cooling units are designed to draw air in a back to front pattern. The warm air in the RACS plenum is drawn to the InRow cooling unit where it is cooled and discharged out the front and back into the room at a room neutral temperature. The discharge temperature is near, at, or slightly below, room temperature and the selected set point.

Front and rear containment configurations not only capture the hot exhaust air, but also the supply air from the InRow cooling unit, directing it to the IT equipment inlets in the adjacent rack(s).

Rear only containment is an option because it addresses the warm air discharge from IT racks preventing it from heating up the surrounding environment. Front only containment is not an option because of the net effect to the inlet side of surrounding rack enclosures with open fronts. It would also not produce the same energy and capacity gain realized from the warmest possible air return to the cooling unit.

## Benefits of Rack Air 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:

*Table 1 – Rack Air 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. This                      |
| 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. |
| *Sound Reduction                                  | Containing the front and/or rear of the rack muffles the noise created by server and cooling unit fans.   |

\*Using front rack air containment reduces the noise of the InRow unit by 10dba. Tests were conducted on four system configurations: 1 ACSC100 and 1 SX Rack with standard doors, 1 ACSC100 and 1 SX Rack with rear RACS only, 1 ACSC100 and 1 SX Rack with front and rear RACS, and 2 ACSC100 and 1 SX Rack with front and rear RACS. Measurements were taken on all four sides at a distance of 1m (3.28 ft) and 1.5m (4.92 ft) from the unit at a height of 1.2 m (3.94 ft).

### Applications and product usage

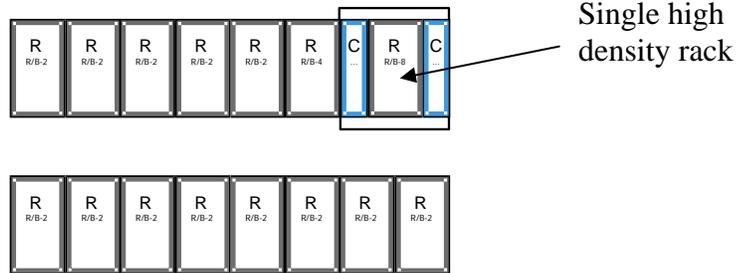
The use of RACS is not limited to one situation or application in the data center or wiring closet/computer room. In fact, it may be used as a general purpose cooling solution or as a targeted deployment for a single rack or group of racks. The following are some common applications for the product.

#### Isolating Hot Racks

There is a large number 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 unit, RACS 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 rack could be isolated using RACS.

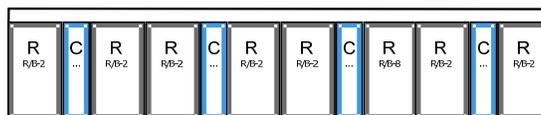
*Figure 3 – Isolated high density rack with RACS*



#### Single rows

In some cases where hot aisle containment system (HACS) is the preferred method, there may still be a single odd row. This happens when there are an odd number of rack rows stranding a single row from the ability to use HACS. If such a scenario occurs, RACS can be used on the odd row to continue the containment architecture using a containment system without blocking panels to create a shared plenum for air distribution.

*Figure 3 – Odd or single row RACS deployment*



### Small Deployments

Small computer rooms and wiring closets are typically not designed for cooling around the clock and through each seasonal change. Most of the time, these spaces are designed for comfort cooling and may have evening and weekend set backs on the thermostat to save money. In addition, these environments change from cooling to heat during the winter months.

For this reason, a dedicated cooling system that is separate from the surrounding environment may be required. This application is ideal for any of the InRow cooling products with RACS and a small number of racks.

## Rack Air Containment Components

There are a number of components with the RACS system that allow it to be both retrofitted in the field and modular in nature. First, since the front containment components are optional, these must be chosen separately. Both rear and front containment components have the option for separator panels (end caps) to isolate airflow from racks to specific InRow cooling units. While these are optional, there are specific rules that must be followed to ensure proper air distribution that are discussed later in the application note.

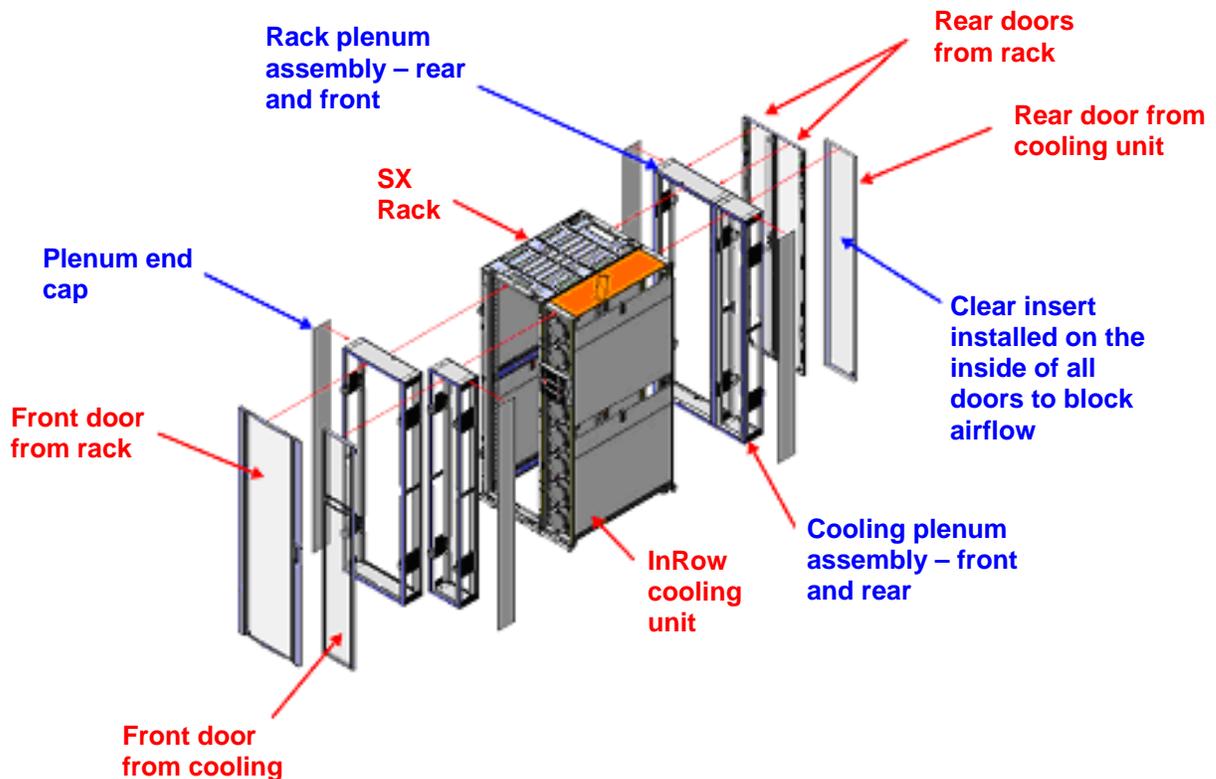
*Table 2 – SKUs and descriptions*

| SKU      | Description                                     |
|----------|---|
| ACCS1000 | Rear Assembly for InRow RC100, SC, RD100/200    |
| ACCS1001 | Rear Assembly for Netshelter SX 42U 600mm Wide  |
| ACCS1002 | End Caps  |
| ACCS1003 | Front Assembly for InRow RC100, SC, RD100/200   |
| ACCS1004 | Front Assembly for InRow RP, RC500 and RD500    |
| ACCS1005 | Front Assembly for Netshelter SX 42U 600mm Wide |
| ACCS1006 | Rear Assembly for NetShelter SX 42U 750mm wide  |
| ACCS1007 | Front Assembly for NetShelter SX 42U 750mm wide |



Each SKU is designed to be either installed at the same time as the rack and cooling units, or be retrofitted to an existing row-based cooling environment. Rear and front (optional) rack doors are reconfigured with plexiglass and re-mounted on the new frame extensions. Figure 4 illustrates the different components and how they are assembled to make the final solution.

*Figure 4 – RACS exploded view with InRow RC and Netshelter SX rack*



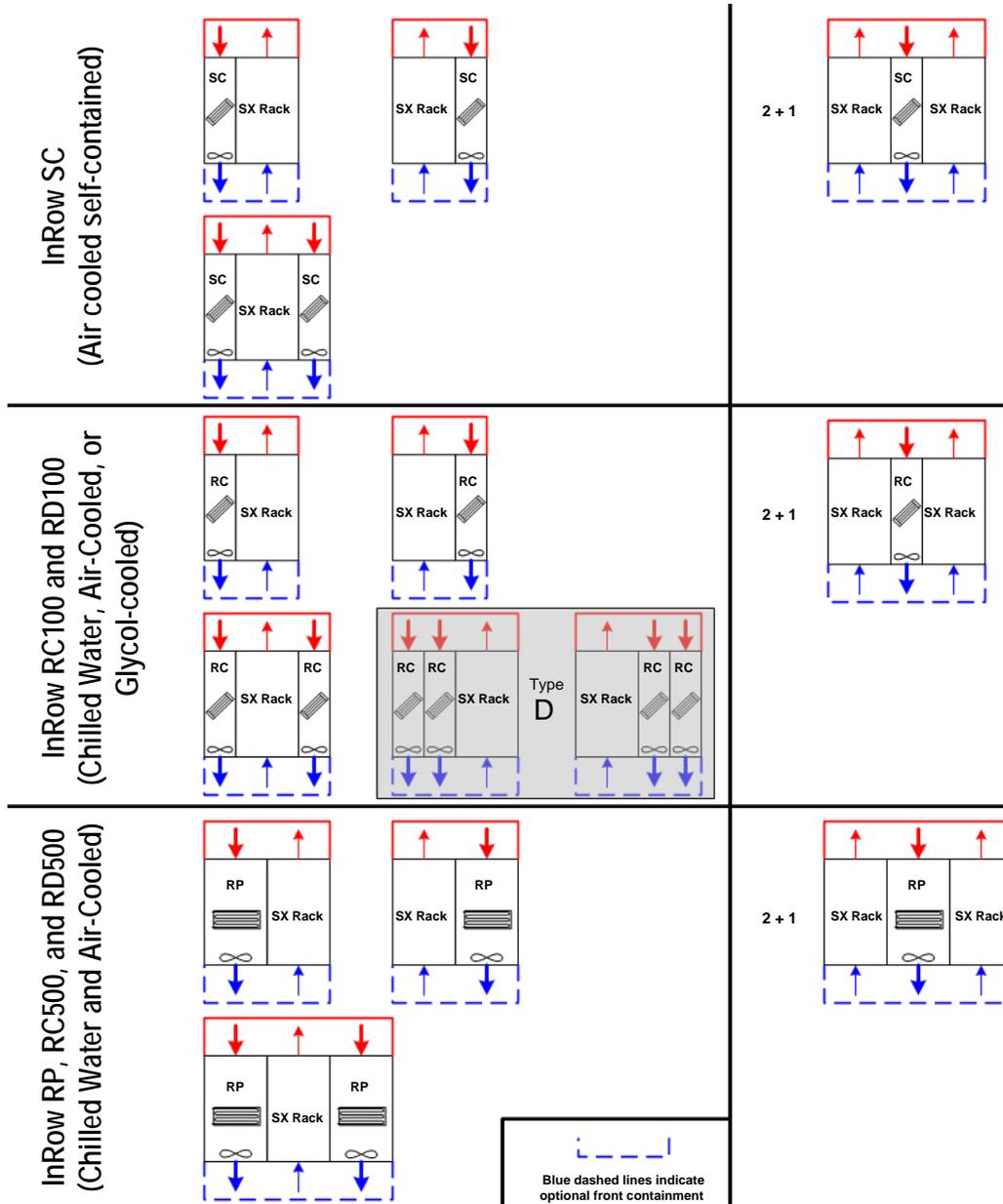
## Product and Component Configuration Options

The ability of the RACS to work with multiple InRow cooling products and the modularity of the parts enables many different configuration possibilities. However, since each cooling unit has different performance capabilities, there are pre-tested configurations that have been tested for performance to ensure the proper air distribution within the RACS system. In addition, while the number of racks is not limited in RACS, the ratio of racks to cooling units and spacing must adhere to approved configuration layouts and application rules.

Figure 5 represents the tested and approved modules for RACS. Modules are defined as a set of racks and cooling units paired together in a configuration. Each module has end caps to close off the rear plenum from the surrounding space. End caps can be removed to join multiple modules together as long as the rules for common plenum are adhered to. These rules are:

1. The InRow SC may not be used in combination to create a common plenum between modules without consulting the factory.
2. Any combination of InRow 300mm wide or InRow 600mm wide units may be used in combination without end caps.
3. InRow SC units may not be mixed within the same aisle on a common return plenum with any other types of units.
4. InRow RD100 and RD200 units may be mixed on the same common return plenum.
5. InRow RC500 and RP500 Units may be mixed within the same aisle on a common return plenum.
6. InRow RD500 and RP100 Units may be mixed within the same aisle on a common return plenum.
7. Any unit type combinations not specifically allowed in Rules 5, 6, and 7 may not be mixed within the same aisle on a common return plenum.
8. InRow RC100 and RD100 configurations highlighted as "Type D" may not be combined with another module when three InRow RC100 or RD100 units would then be adjacent.
9. Containment systems using InRow RP should never mix heat of rejection methods (chilled water and air-cooled).

Figure 5 – RACS Modules and Module Combination Rules



## System Controls

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

In addition, the RACS 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. The reason is, 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 RACS 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 unit must respond much quicker in RACS mode to ensure that spikes in rack exhaust temperature that occurs over a time scale of a few seconds is 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).

*Figure 5 – 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        |

Selection of the fan speed preference should be done by the user using the chart above if the deltaT or CFM/kW (L/s per kW) is a 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 too low or high, it can be easily adjusted.

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 the greater than that of the cooling unit. 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, RD, or RC, refer to APC application note #119.

## Conclusions

The rack air 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 Dunlap** is Director of Business Strategy for Cooling Solutions at APC. Involved with the power management industry since 1994, Kevin previously worked for Systems Enhancement Corp., a provider of power management hardware and software, which APC acquired in 1997. Following the acquisition, Kevin joined APC as a Product Manager for management cards and then precision cooling solutions following the acquisition of Airflow Company in 2000. Kevin has participated on numerous power management and cooling panels, as well as on industry consortiums and ASHRAE committees.