White Paper

April 2015

Universal Aisle Containment

Increased Efficiency with Fewer Deployment Restrictions

PANDUIT®

building a smarter,
unified business foundation

Connect. Manage. Automate.

www.panduit.com

Introduction

Data center containment solutions increase cooling efficiency by preventing the mixing of cold supply air with warm IT equipment exhaust. The solutions are available in different varieties, including cabinet vertical exhaust ducts (also known as chimneys), cold aisle containment (CAC), and hot aisle containment (HAC).

Existing data centers often encounter impediments to deploying containment solutions. These limitations include inflexibility in the types of cabinets that can be included (often only supporting the containment provider's cabinets), inability to integrate with cabinets of different heights, restrictions on cabinet widths, etc.

New data centers can encounter various obstacles, such as the requirement to fully populate contained rows with cabinets, even if some of the cabinets will not be used on the first day of operation.

To help resolve these challenges, Panduit has introduced its Net-Contain™ Universal Aisle Containment system, or UAC. This containment solution has flexibility features that make deployment less costly and disruptive. These features include the following:

- Deployable as a CAC or a HAC solution.
- Compatible with numerous cold air delivery methods.
- Ability to contain rows of cabinets of different heights, widths, and manufacturers.
- Ability to contain unpopulated or partially populated rows.

The UAC flexibility advantages would be of little consequence without also providing superior thermal performance. The Panduit Corporate Research & Development team conducted thermal tests in Panduit's Data Center Thermal Lab to validate the advanced performance of the UAC system.

Containment Performance

Test Facility

Panduit's state-of-the-art data center thermal lab can test and evaluate multiple-row data center layouts, different containment solutions, various airflow delivery schemes, and supplemental cooling systems. The lab has a white space area of 1,600 square feet and a 36 inch deep raised floor. The test room height is 12 feet, with an above-ceiling hot air return plenum. The cooling infrastructure for the lab includes an air-cooled chiller and an air handling unit (AHU) equipped with air side economization capability. The AHU is equipped with temperature sensors and an airflow metering station. The lab is equipped with a configurable control system that allows customized cooling and airflow control sequences. AHU fan speed can be controlled independently from the chilled water valve. The control system is also capable of live monitoring and creating logs of the HVAC equipment performance, load bank heat load and airflow control, and lab space sensors. IT equipment heat and airflow can be simulated by using the lab's custom-designed, cabinet-mounted load banks. The load banks are network configurable, and they allow a wide range of heat loads and airflow rates.

Testing Approach

To demonstrate cooling performance, the Net-Contain™ Universal Aisle Containment system was tested against two well-established baselines – a pair of uncontained cabinet rows in a hot aisle/cold aisle (HA/CA) arrangement and a pair of cabinet rows contained using the Net-Contain™ cabinet-mounted CAC solution. Consistent supply air temperatures and simulated IT load characteristics were applied across all test configurations, at three different levels of IT load.

Data center configurations that use air containment solutions can operate at significantly different cooling system operating conditions. Since an uncontained HA/CA configuration was to be included in the study and compared to CAC configurations, a method for normalizing operating conditions was developed. The team used the "critical air ratio," or CAR method. In data centers, air ratio is defined as the ratio of air volume supplied by the cooling units to the volume of air being consumed by the IT equipment. An air ratio greater than one (>1) indicates that the air supply exceeds the amount required by the IT equipment, while an air ratio less than one (<1) indicates that insufficient air is deficient in cooling capacity for the equipment demands.

For test condition purposes, CAR is defined as the largest of the following air ratio values:

1. The minimum air ratio for all cabinet inlet temperatures to equal to, or to fall below the ASHRAE-recommended maximum inlet temperature of 80.6°F (27°C).
2. An air ratio of 1. This ensures that the containment configuration under test receives at least as much cold air as is required by the IT equipment.
3. For CAC configurations, the minimum air ratio required to maintain a positive differential pressure of 0.002" H_2O (0.50 Pa) in the cold aisle, relative to the room. This ensures that any containment system leakage will be cold air leaking out of the contained area (bypass air) rather than hot air leaking into the contained area (recirculated air). This helps to minimize elevated inlet temperatures caused by recirculation.

All configurations were tested using the CAR value to determine the volumetric airflow of the supply air.

Test Setup

The test configurations were set up based on a common cabinet arrangement in the lab space. Two rows, with five cabinets each, were constructed in the lab using a 56% open perforated tile installed in the front of each cabinet. The cabinets were all 600mm wide x 1,200mm deep x 45 rack units (RU) tall. Load banks were installed in the cabinets and each of the cabinets were fitted with temperature sensors. Three temperature sensors were positioned at different heights on the front perforated door and on the rear perforated door. CAC containment solutions were added to this cabinet arrangement for the cabinet-mounted and UAC cold aisle containment test configurations. The uncontained HA/CA configuration had CAC door frames attached without the doors and ceiling panels. Figure 1 shows the HA/CA test configuration. Figure 2 shows the CAC cabinet-mounted test configuration.

Figure 1. HA/CA.

Figure 2. Cabinet-mounted CAC.

Two different configurations of the UAC cold aisle containment were tested. The first setup was 3,000mm (9.8 ft.) long, matching the length of the cabinet rows, as shown in Figure 3. The second setup, shown in Figure 4, was 4,800mm (15.7 ft.) long, including 1,800mm (5.9 ft.) of unpopulated aisle which was filled using full cabinet height blanking panels. Inclusion of this second UAC-CAC configuration allowed a cooling performance validation of the UAC solution's expandability feature.

Figure 3. UAC CAC (3,000mm shown).

Figure 4. UAC CAC (4,800mm shown).

The configurations were set up following industry best practices. The team filled the empty rack units with blanking panels, installed sealing grommets on cable cutouts, mounted cabinet air dams, and attached front cabinet skirts to the cabinet bases to maintain separation of the hot and cold air streams.

The lab was set up for under floor cold air supply, with the AHU configured to control cooling based on a supply air temperature set point of 75°F (23.9°C). Lab space air supply volume was set to be controlled manually by adjusting the variable speed drive output frequency of the supply fans.

Test Procedures

Each configuration was tested at three IT load levels:

- 4.5 kW and 600 CFM (17.0 m^3/min) per cabinet
- 15 kW and 1,800 CFM (51.0 m^3/min) per cabinet
- 25 kW and 3,000 CFM (85.0 m^3/min) per cabinet

The following procedure was followed for each test configuration:

1. Start the lab cooling system with a 75°F (23.9°C) supply air set point and supply volumetric airflow equal to the test case IT load airflow (i.e. air ratio of 1).
2. Start the load banks at the heat and airflow levels specified for the test case.
3. Monitor cabinet inlet temperatures as the lab environment and cooling system approach steady state conditions.
4. Adjust the volumetric airflow, as needed, to achieve the CAR (i.e. inlet temperatures at or below 80.6°F (27°C) and CAC relative pressure at or above 0.002” H_2O (0.50 Pa).
5. Monitor and record temperature data for one hour at steady state CAR.

Test Results

Inlet Temperatures

The team examined the inlet air temperatures to determine the cooling performance of the configuration. Perfect performance for a containment solution occurs when all inlet side cabinet temperatures equal the supply air temperature. However, in a practical case heat from the IT exhaust will migrate to the inlet side, whether through air leaks or conduction. Inlet temperatures therefore tend to be higher than the supply air temperature. Measuring the distribution of the inlet temperatures can provide a somewhat better indication of the configuration’s cooling effectiveness.

The inlet temperature distributions for the four tested configurations at the 4.5 kW per cabinet load level are shown in Figure 5. The range boxes on this chart depict the spread of temperatures measured for all inlet temperature sensors installed in the tested cabinet configurations. The horizontal lines within the range boxes depict the median measured value.

The 4.5 kW per cabinet test was the only load level at which the uncontained HA/CA configuration operated with a CAR achieved. In fact, a few inlet temperatures still exceeded the maximum 80.6°F (27°C) level.

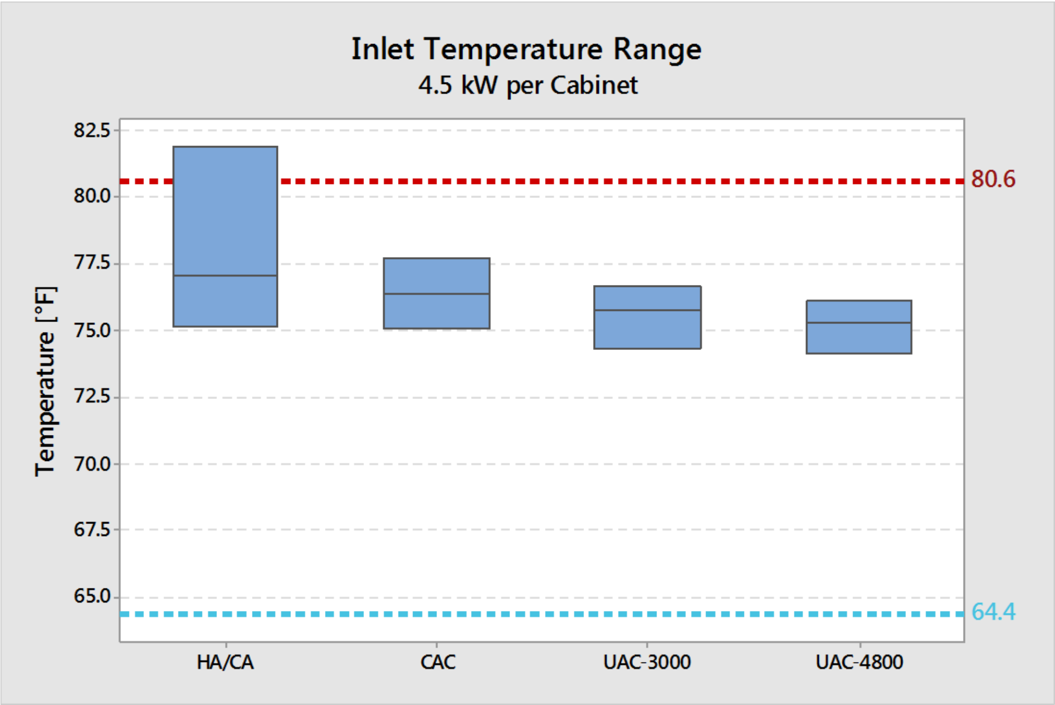

Figure 5. Inlet temperatures at 4.5 kW per cabinet IT heat load.

The inlet temperatures for all of the contained configurations are 2.9°F (1.6°C) or more below the maximum, with a tight spread of values with approximately 2.6°F (1.4°C) between the lowest and highest values for each configuration. The actual measured supply air temperatures were close to the 75°F (23.9°C) set point.

Temperature distributions for the three CAC configurations for IT load levels of 15 kW and 25 kW per cabinet are shown in Figures 6 and 7. All three of the configurations performed similarly, with no inlet temperatures exceeding the maximum value, and with a tight spread of temperatures.

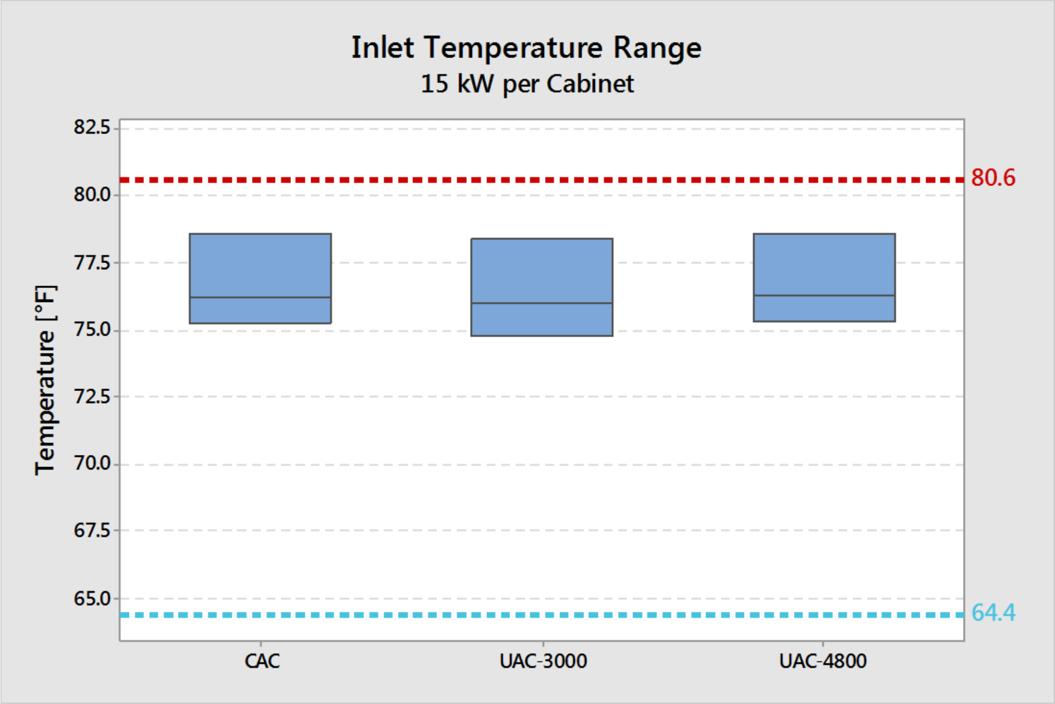

Figure 6. Inlet temperatures at 15 kW per cabinet IT heat load.

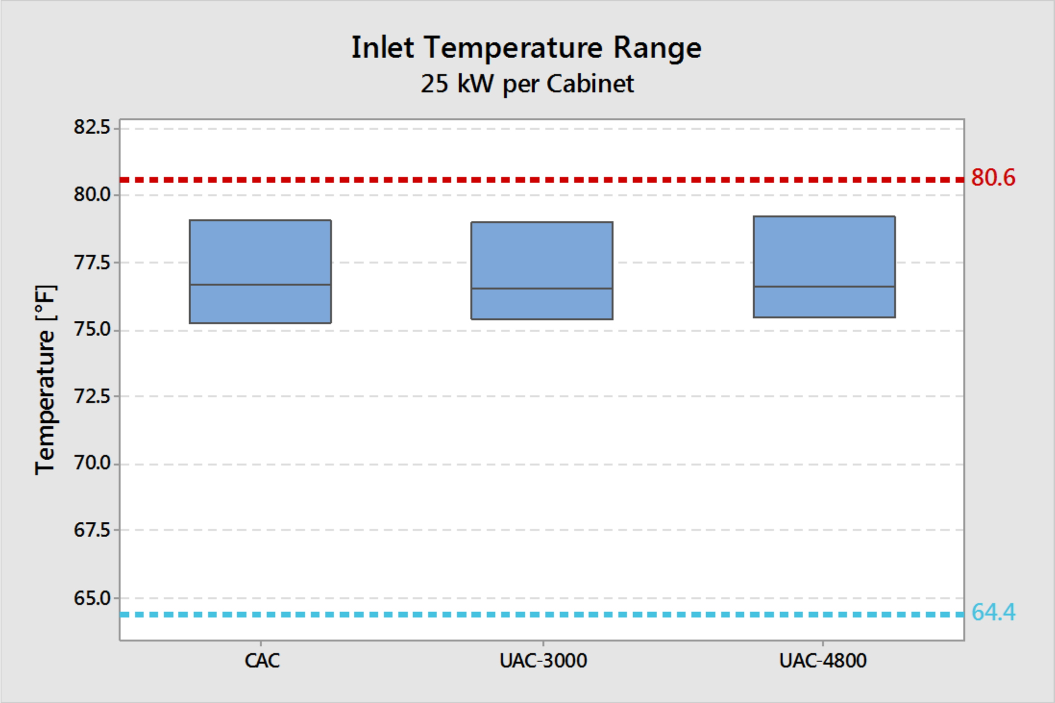

Figure 7. Inlet temperatures at 25 kW per cabinet IT heat load.

The temperature results showed that the UAC configurations had a thermal performance nearly identical to the cabinet-mounted containment solution. None of these configurations had a single inlet temperature that measured above the maximum recommended value. The inlet temperatures for all of the contained configurations were 1.4°F (0.8°C) or more below the maximum, with a range of approximately 3.8°F (2.1°C) between lowest and highest values for each configuration. Again, the actual measured supply air temperatures were close to the 75°F (23.9°C) set point.

Critical Air Ratio

Critical air ratio, as defined for this study, was used as a benchmark to normalize the operating conditions under which the various configurations were evaluated. CAR can also be useful as an overall indicator of the efficiency of a configuration to utilize the cold air supply. When the cold air volume required by the containment system exceeds the total IT equipment airflow, the following inefficiency characteristics are occurring:

- Cold air bypass - This is the process in which supplied cold air does not reach the IT equipment before returning to the cooling unit.

- Hot air recirculation - This is the process in which IT equipment exhaust air finds its way to the inlets of the IT equipment.

A surplus air supply is needed to compensate for these two issues. Air containment solutions are intended to minimize these inefficiencies. Figure 8 shows the CARs that were established for the completed test cases.

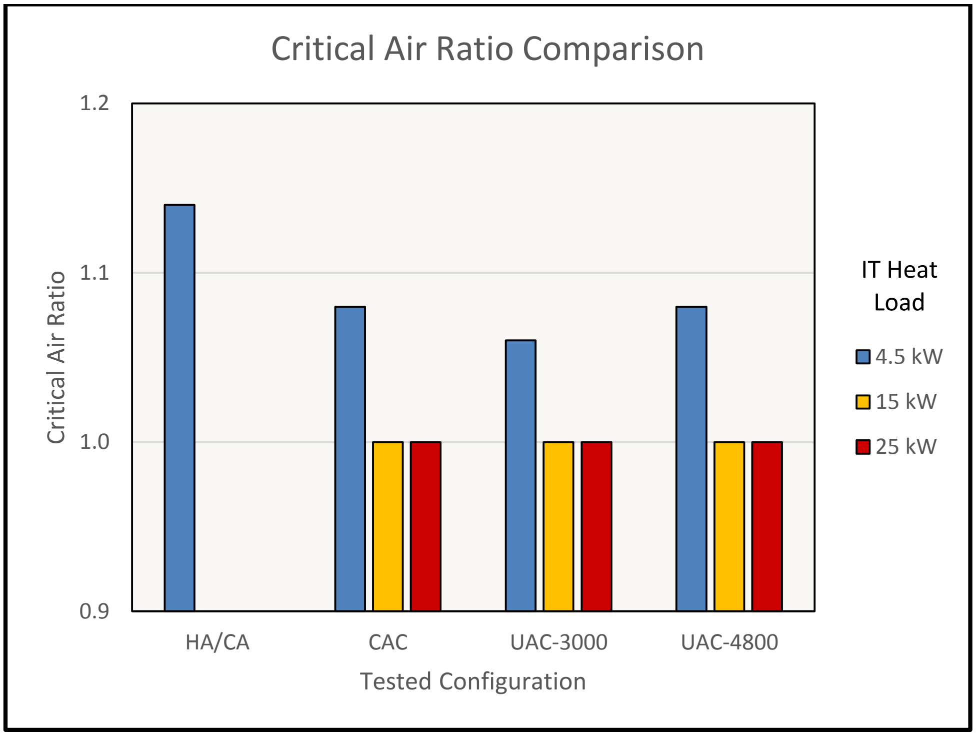

Figure 8. CAR of tested configurations and IT heat loads.

The CAR for the uncontained HA/CA configuration was 6% to 8% higher than any of the CAC configurations tested. This clearly demonstrates that the cold air utilization efficiency is improved when using the containment solutions. CAR comparisons among the three contained solutions were nearly identical, further reinforcing the performance equivalence of the UAC configurations to the cabinet-mounted configurations.

UAC-HAC and UAC-CAC Equivalent Performance

The Net-Contain™ Universal Aisle Containment solution can be configured for either CAC or HAC. For this testing program, only the cold aisle configuration was compared to other baselines: uncontained HA/CA and cabinet-mounted cold aisle containment. Subsequent to the completion of this study, further testing was performed that verified equivalent thermal performance when the UAC solution was configured for HAC.

Conclusion

This study verified that the UAC-CAC solution is effective at separating cold and hot air streams, with performance on par with cabinet-mounted cold aisle containment. This holds true whether the rows are fully populated with cabinets or partially populated with full height blanking panels. Effectiveness was demonstrated by uniform cabinet inlet temperatures that nearly match the supply air temperature at supply airflow volumes very close to the IT equipment airflow demand.

Cooling effectiveness for the tested CAC configurations was dramatically improved over the uncontained HA/CA cabinet arrangement. The uncontained aisle configuration was only able to approach the acceptable cabinet inlet temperatures at the lowest IT load tested for this study. The UAC and cabinet-mounted CAC solutions performed nearly identically and easily cooled the highest tested load level of 25 kW per cabinet.

The potential cooling energy cost savings that can be realized from deploying a containment solution results from reduction in required cooled air volume and from more efficient cooling due to less mixing of hot and cold air streams. Savings from UAC-CAC deployment can be expected to be equivalent to those from cabinet-mounted cold aisle containment deployments – as much as 30% when the entire cooling chain is taken into account (for details see the Impact of Air Containment Systems white paper).

The enhanced deployment flexibility features of the Net-Contain™ Universal Aisle Containment solution can allow full realization of air containment benefits while avoiding impediments commonly encountered in both new and existing data centers.

Reference

Impact of Air Containment Systems White Paper

About Panduit

Panduit is a world-class developer and provider of leading-edge solutions that help customers optimize the physical infrastructure through simplification, increased agility and operational efficiency. Panduit's Unified Physical Infrastructure℠ (UPI) based solutions give enterprises the capabilities to connect, manage and automate communications, computing, power, control and security systems for a smarter, unified business foundation. Panduit provides flexible, end-to-end solutions tailored by application and industry to drive performance, operational and financial advantages. Panduit's global manufacturing, logistics, and e-commerce capabilities along with a global network of distribution partners help customers reduce supply chain risk. Strong technology relationships with industry leading systems vendors and an engaged partner ecosystem of consultants, integrators and contractors together with its global staff and unmatched service and support make Panduit a valuable and trusted partner.

www.panduit.com · cs@panduit.com