APC

APPLICATION NOTE #138

Benefits of the Airflow Calculator

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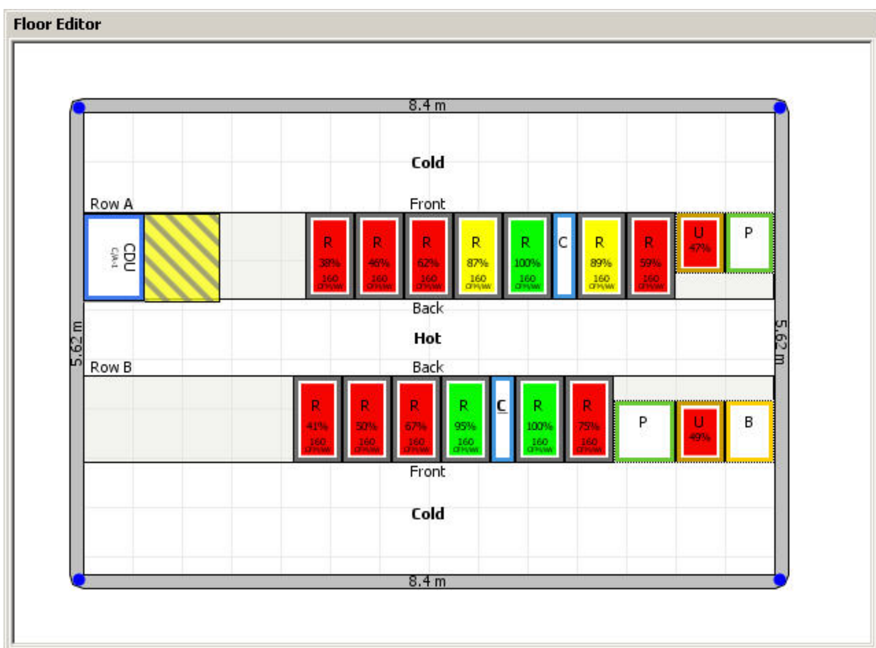
Abstract

Creating optimal data center designs is one of the main priorities for APC, and the following application note outlines the benefits of the real-time calculation of the airflow within a data center design, along with guidelines for optimal layout of data center equipment.

Introduction

To help customers design and optimize their data center facilities APC has created an Airflow Calculator, used both in the InfraStruXure Designer software and the Capacity Manager software. The Airflow Calculator is based on a cooling performance metric, called the Capture Index (CI). The CI is computed in real time, while the user is laying out the physical arrangement of equipment in the data center, and can compute the impact on CI of the loss of one or more cooling units. As a result, APC can achieve most of the benefits of a full CFD analysis with very little cost, time, and user skill.

Figure 1 – An equipment cluster that has an insufficient amount of in-row cooling assigned

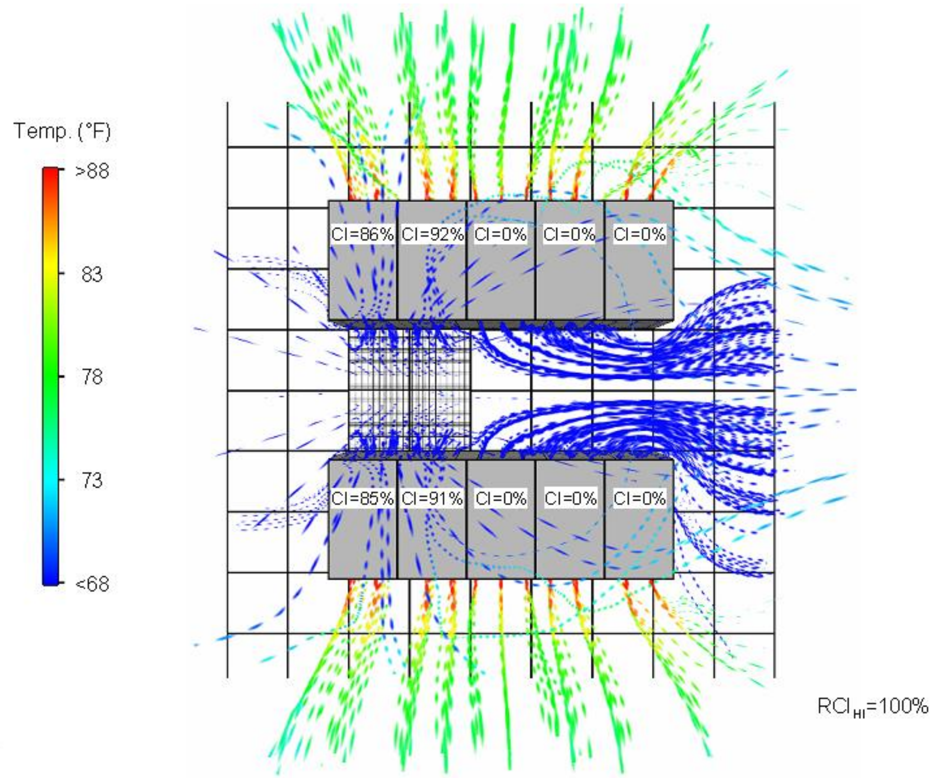


The Capture Index

There are two types of Capture Index; a hot-aisle CI and a cold-aisle CI. The current Airflow Calculator, which works with APC InRow cooling units, only calculates the hot-aisle CI. The Capture Index is expressed as a percentage from 0 to 100 which is computed for each rack in a data center. A value of 100% implies that all of the air either entering or leaving a rack is following the most desirable path. A value of 0% implies than none of the air either entering or leaving a rack is following a desirable path. There are lots of other metrics than the CI and each serves a valuable function. The CI is the only metric which is defined based solely on airflow patterns; the other metrics are based on temperature. However, temperature alone does not express the cooling system's ability to deliver or capture air as intended. The fact that the inlet temperatures are acceptable may be more luck than science. Furthermore, as data centers grow in size, complexity, and density, it becomes even more critical that the cooling architecture is designed to be predictable and scalable. Physically measuring the CI in an operating data center is probably unrealistic; however, you definitely can estimate the CI from a laboratory smoke study.

For example, **Figure 2** shows a grouping of racks around a cold aisle in a raised-floor environment with a very undesirable airflow pattern, in which the rack inlet air comes almost exclusively from the ends of the aisle and over the top of the racks instead of directly from the perforated tiles.

Figure 2 – An equipment cluster showing temperature performance, but an undesirable airflow pattern



If the surrounding room temperature is low enough, the rack inlet temperatures might be acceptable. However, as the surrounding room environment changes, the rack inlet temperatures will also change. Additionally, if you tried to repeat this same grouping of equipment across the data center, the groupings would share their cooling resources with one another and the surrounding room environment instead of operating in an independent and standardized manner. Hence, even though the as-designed inlet temperatures are satisfactory, this design is not very predictable or scalable. If the CI had been computed, the low numbers would have immediately indicated a problem with airflow delivery to the racks which could compromise the cooling performance in the future.

Achieving Optimal Airflow Design

In order to achieve the optimal airflow conditions in a data center and realize more reliable performance predictions, APC recommends setting up regular room shapes and symmetrical clusters of equipment with the same or similar density, as well as clearly laid out hot aisles and cold aisles (for further information see White Paper #120, “Guidelines for Specification of Data Center Power Density”. While such clusters are indeed optimal in terms of achieving good, predictable, and scalable performance, it is due to the limitations of the Airflow Calculator that CI predictions can only be provided for such room arrangements.

A cluster contains two rows of racks and APC InRow cooling units, placed on either side of a hot aisle, with the following attributes:

- Each row must be parallel to the other, ensuring that the overall length of the equipment rows should not vary more than the width of a single floor tile at each end.
- Cooling performance predictions, which assume the racks will be populated evenly, will be reasonably accurate if racks are populated in the preferred bottom-to-top order.
- The equipment sets cannot include gaps or spaces although a blockage can be modeled as a zero-airflow rack.
- In Hot Aisle Containment Systems (HACS), cooling units must be placed in pairs directly across from each other.

The Airflow calculator is currently unable to produce valid outputs with traditional perimeter cooling units or under-floor cooling as the APC InRow Cooling solutions are optimized by establishing airflow in closed loops, with air circling between the hot racks and the cooling units on a distributed level.

In-Row Airflow View

Each rack in an equipment cluster displays a CI percentage that identifies what fraction of the rack's exhaust heat is captured by the in-row cooling units included in that rack's equipment cluster. Each rack in an equipment cluster is color-coded to indicate the rack's CI performance:

Green:	All or nearly all of the rack's exhaust is being captured. When all racks in an equipment cluster are green, the cluster is 'room neutral' i.e. it is not adding heat to the room.
Yellow:	A warning condition that indicates that most, but not all, of the rack's exhaust is being captured.
Red:	A critical condition that indicates too little of the rack's exhaust is being captured.

Some isolated poor (low) CI values may be acceptable, with careful design consideration. For example, a low-power rack with a low CI value that is located among several higher-power racks may add little net heating to the room.

Design Analysis

The Airflow Calculator offers different options for design analysis. CRAC airflow allows users to test the effect of a failed in-row cooling unit on the airflow of an entire equipment cluster, showing individual CI ratings for each rack within the equipment cluster. Different combinations of cooling units can be activated and deactivated to see what affect the failures will have, thus indicating if the cluster can withstand a single failure. Within InfraStruXure Designer, the Airflow Calculator also offers a worst-case simulation to simulate the failure of the in-row cooling unit that would have the most affect on the CI percentage for the racks in a row, instantly highlighting the weakest part of a data center design.

Conclusions

The Airflow Calculator has taken the guesswork out of data center design and has enabled users to instantly calculate the impact of a cooling solution, saving valuable time and ensuring the optimal data center solution. For data center operators, the ability to carry out design analysis provides peace of mind knowing that the worst-case scenario has already been explored.

About the Author:

Rikke Jensen is a Product Information Manager for APC-MGE. She is responsible for developing product sales and training support for APC Service Management Applications and Configurators. Rikke received a Masters degree in Business Administration from Oxford Brookes University in 2002 as well as a Bachelors degree in 1999 and has over 5 years experience in marketing and business mentoring.