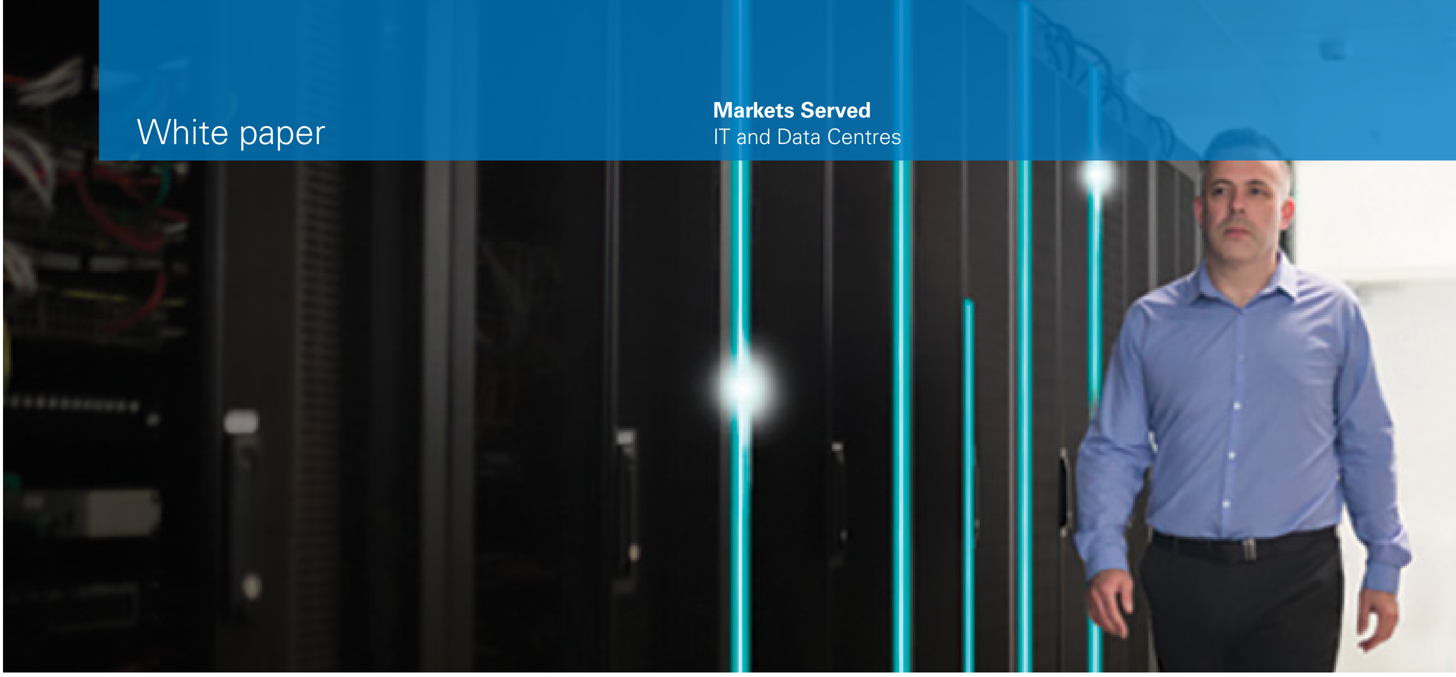

Rack Hygiene

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Executive summary

This paper describes the concept of Rack Hygiene and how failure to consider the rack as a critical element of a data room design can significantly affect operational efficiency. It offers a practical insight at rack level to defining a benchmarking methodology for setting performance goals for racks or enclosures.

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Today, virtualisation is being adopted at an increasing rate. A key driver for the deployment of this technology is the reduction of operating costs associated with the consolidation of server, storage and network devices. By-products of this new virtualised environment include a net reduction in IT equipment and associated space. However, the resultant power and cooling loads are condensed into a smaller footprint and have a dynamic association with the IT processing load.

While a legacy cooling architecture can be adapted to the new environment, it is most often inefficient and/or ineffective due to the following inherent design flaws:

- Hot and cold air mixing
- Misalignment of cooling units and IT racks
- Localised inability to reject heat due to unbalanced heat loads on cooling units
- Excessive distance between cooling units and heat loads
- Air distribution is compromised by excessive cable loading
- Inability of legacy cooling infrastructure to react to dynamic heat loads
- Lack of airflow management to accommodate side to side heat rejection devices
- Oversupply of cold air

Containment strategies are gaining increased acceptance with IT and facility managers who want to optimise their existing room layouts. As containment of hot and cold air streams increases in popularity, it becomes necessary to segregate supply (cold) and return air (warm) airstreams to gain maximum effectiveness. This method is deployed today in well-managed raised-floor data centres, in which sealing all potential air leakage gaps is critical to maintaining uniform, sub-floor, static pressure and airflow distribution.

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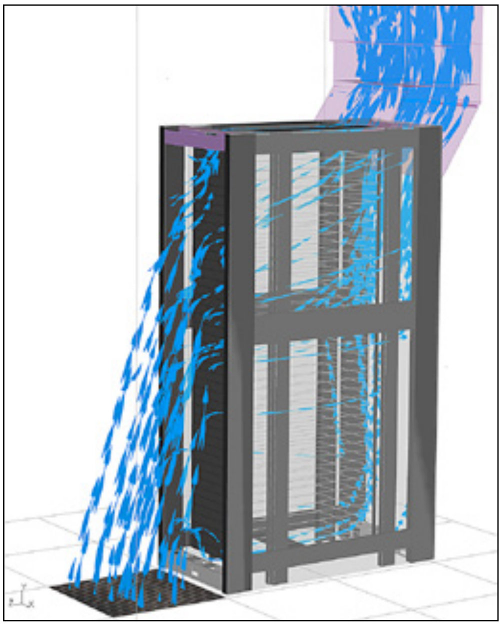


CFD Model of rack using cold air stream to indicate typical Airflow Fault Areas

The "rack" is the forgotten, yet critical, component in the airflow stream. In the rack, air leakage is rampant (Figure 1). It causes recirculation and bypass airflow inefficiencies. Though the EIA-310 industry standard exists for mounting IT equipment in racks, there are no standards for managing hot and cold airflow streams within the rack environment.

Rack Evolution

Over the last decade, racks have evolved into a "front-to-back" dominated airflow environment. Glass doors have been replaced with perforated doors which have advanced from 45% open area to today's 65% (and more) open area for maximum airflow. In some instances, where individual rack security is not an issue, doors are being eliminated altogether.

Roof-mounted fan trays are being replaced in favour of rear-door fans. Cooling coils have been integrated on rear doors to promote "front-to-back" airflow. Heat containment duct systems continue to evolve as a method for rejecting hot air from the rack. Meanwhile, the sheer volume of power and network cables has increased significantly, resulting in additional rack clutter and greater potential for airflow blockages within the rack.

As a result, rack depths have increased with 1000mm deep racks often being considered to be the minimum industry norm. The increasing depth of servers and the need to maintain provision in the rear (behind the servers) for power distribution and cable management often means it is advantageous to deploy deeper racks. This not only helps to optimise air flow but it also provides increased scope for accommodating future technology trends.

Assuming that all variables relating to air blockage within the rack are constant, increased rack depth has a neutral effect on airflow. Although with heat containment, deeper racks (1200mm) provide more space to exhaust air upward, as opposed to simply pushing it through the rear of the rack.

Although a rack width of 800mm is common for networking applications with "side-to-side" cooled switches, the industry trend for server rack width is still 600mm. However, it is not uncommon today for 800mm wide racks to be deployed for server applications. The wider server rack enables the end user to minimise airflow obstructions by locating power distribution and data cables further away from the hot air exhaust stream.

In most cases, room geometry will dictate rack height. The most common server rack height is approximately 2000mm, which provides 42U of internal mounting available for rack-mounted equipment (1U = 44.45mm). The drive towards increased foot print utilisation and the convergence of networking devices sees an increase in customer demand for taller racks with racks of height of up to 52U not being uncommon.

Additional rack-mounting space above 42U is typically populated with networking switches, routers and patch panels. Higher racks accommodate more rack-mounted IT devices. This results in even higher heat densities at higher elevations, where air stratification makes it difficult to ensure optimum inlet temperatures.

Rack as a Plenum

Today's hot and cold air containment solutions are highly dependent on a tight interface with the rack. Therefore, there is a need to change our thinking about the rack and its function in today's data centre environment.

The rack should be thought of as a "plenum" in the airflow stream. Unlike a typical empty air duct plenum, the rack plenum is the critical space in which high-performance servers, storage and switches reside. To ensure sufficient IT device cooling, predictable rack level airflow management is necessary. In order to achieve this, all potential airflow openings should be controlled and managed. In addition to sealing unused U-space in the rack, there are at least five other rack-related areas that can directly affect airflow management and cooling performance, as well as improve energy efficiency.

Rack Hygiene Overview

The concept of Rack Hygiene is a term that encompasses the identification, analysis and avoidance of supply (cold) and return (hot) air crossover, including cold air bypass within and around individual racks.

Rack Hygiene is a term coined to describe the care in which the rack envelope is designed, controlled and maintained. The rack envelope consists of the entire volume of space from the floor to top of the rack itself; and perhaps, a measurement of rise above the floor to include empty space above the rack that would rise to the "heat deck".

Regardless of the rack's dimensions, it is incumbent upon the data centre professional to employ solutions that provide an impenetrable barrier around the front plane of the rack in a front-to-back dominated airflow environment. The tighter the seal provided around the front of the rack – exclusive of a thorough blanking panel strategy – the closer one can come to achieving rack hygiene nirvana.

For optimal cooling efficiency the aim is to deliver the supply air at the highest safe temperature for the least tolerant network device. Delivering air at the highest practical temperature has the effect of increasing the return air temperature, improving the operational efficiency of the cooling plant and so reducing operational costs. Couple this with the aim of delivering air at a uniform condition to each equipment intake will help to eliminate data centre hot spots and airflow abnormalities and avoid the need for the air conditioning units to over-supply.

Two primary drivers of rack hygiene best practices are:

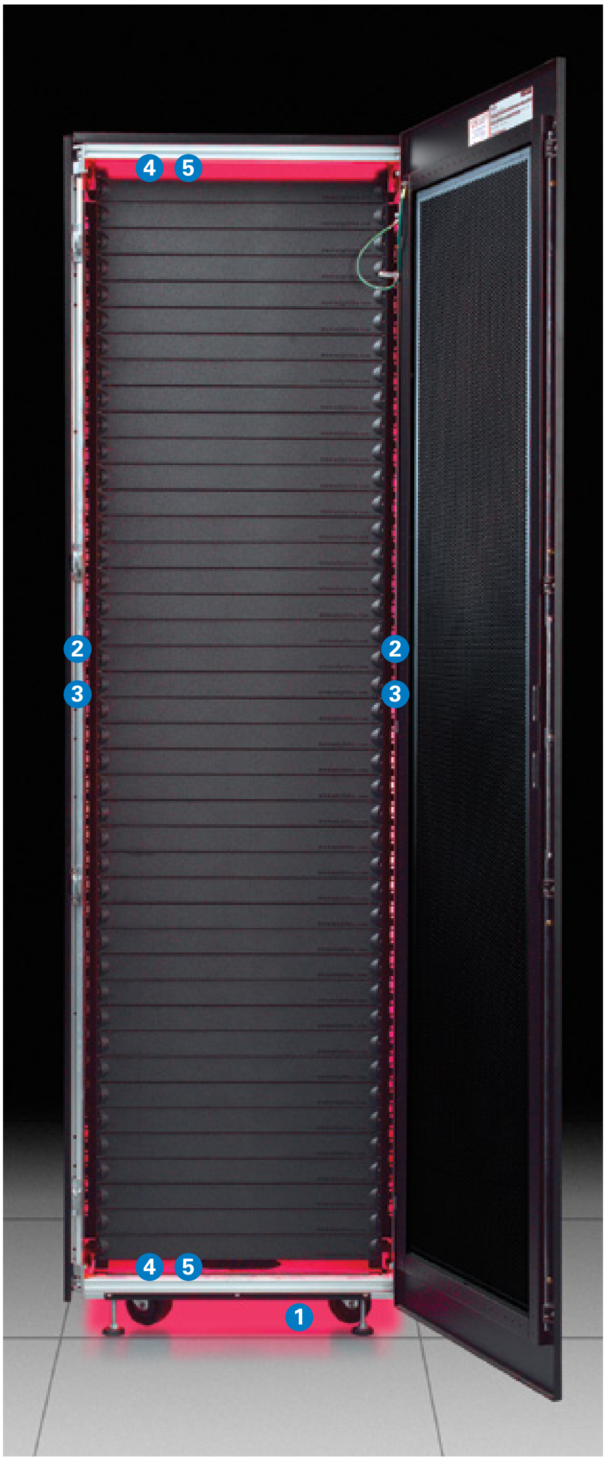
1. Hot spot prevention
   This helps to maintain a constant inlet temperature and allows IT equipment to operate at optimal levels.
2. Matching the cooling supply and demand.
   This can save energy and eliminate wasteful recirculation and by-pass air streams which are part of the "chaotic-cooling method" (over-supply of cool air into the data centre).

   Ineffective rack airflow management at the rack and row level is a key contributor to aisle and room overheating. Rack Hygiene can solve this problem by approaching the rack as part of the airflow management system and setting benchmarked standards for leakage.

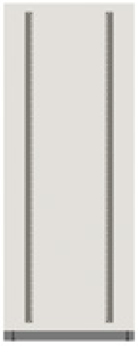
Five Airflow Fault Areas

Though the industry has learned the benefits of blanking panel best practices for the data centre, this is only one airflow containment measure within the Rack Hygiene approach. There are as many as five additional rack-related areas requiring containment that are overlooked when one discusses rack-based airflow management faults. These fault areas can drive true performance gains in a front-to-back cooled world. The areas, known as the **Five Airflow Fault Areas**, include:

1. Under the rack (external to rack)
2. Left side of front-left 19” vertical mounting rail (internal to rack)
3. Right side of the front-right 19” vertical mounting rail (internal to rack)
4. Below the bottom rack-mount space (internal to rack)
5. Above the top rack-mount space (internal to rack)



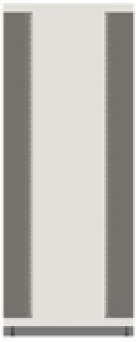
Fault Area #1: Under the Rack



The area under the rack to the floor deck can be difficult to manage because the height is a variable based on the size of rack levelers or casters and will vary from one rack manufacturer to another. This space can contain a substantial amount of uncontrolled air in an enterprise data centre with multiple rows of server racks. Therefore, this is an area that can yield a large benefit, if sealed appropriately.

Typically, there is no solid panel under the rack due to the requirement for power and network connectivity. This is a potential leakage area because hot air can come across from below the rack, and cold air from perforated floor tiles can bypass the rack in this space.

Fault Area #2 & #3: Left and Right Side of Front 19” Vertical Rails



Because of customer demand for adjustable front rails and cable pass-thru capability, the areas to the left and right of the front rails on most 19” racks are potential leakage points. The space between the side of the vertical rail and the side of the rack frame or side panel is typically wide open. It is a potential leakage area into which hot air can penetrate or by which cold air can pass. This rack environment can severely compromise a robust blanking panel strategy.

Today’s wider racks (i.e. 800mm) have an additional 100mm on each side of the 19” rails to provide space for cooling side-to-side switches or space for managing a high volume of network cables. To get out to the side or up to the top, cables are passed through openings that are typically unsealed. These openings should be covered with a material that provides a seal around the cables to minimise air leakage.

Fault Areas #4 & #5: Above and Below the Vertical Rack-mount Space

Areas above the top U space and below the bottom U space are also regions of suspicious leakage. Typically, some amount of space exists in these areas and varies per rack manufacturer. However, it is not unusual for this space to equal that of a missing blanking panel.

Not only is this area susceptible to hot-air recirculation, but it is also more likely to allow bypass of the cool supply air supply from CRACs.

Measurement

Just as the efficiency of data centres is measured with PUE and DCiE, the efficiency of the rack should be measured to promote proper airflow management. The correct approach to rack hygiene and to reducing data centre energy consumption is measurement. That is, establishing a baseline, and tracking performance for a given data centre facility.

Benchmarking methodologies set performance goals for air leakage in the data centre. By combining virtual models with measured test results, one can locate precisely where, in the data centre, airflow management issues arise and take corrective action to improve airflow containment.

The benchmarking process will assign a graduated scale of performance to:

- Identify problems with energy profiles in the data centres
- Analyse data centre energy performance for potential improvements
- Add high density servers and increase rack density in an energy efficient way
- Determine and select efficient data centre cooling methods
- Predict design limitations of new and future facility expansion

In order to measure airflow leaks, data centre design specification calls for server racks designed and supplied with a maximum rated amount of airflow (CFM) to service a full load rating.

The pressure within the racks should not exceed 0.25 pascal at the front of the rack. Ideally, the IT equipment in a rack is exhausting air without experiencing any significant back pressure.

Testing

To test the racks and ensure they meet the required specification, the following tests are performed:

Measurement of the overall gaps in leakage area (they will be measured as a ratio to the overall surface area of the rack enclosure inlets.)

Mapping and identification of leakage areas within the rack (a fog generator will be used to trace and detect areas of concern.)

Data centre testing includes the Five Airflow Fault Areas:

1. Under the rack (external to rack)
2. Left side of front-left 19" vertical mounting rail (internal to rack)
3. Right side of the front-right 19" vertical mounting rail(internal to rack)
4. Below the bottom rack-mount space (internal to rack)
5. Above the top rack-mount space (internal to rack)

Tests include those that determine:

- Withstand Pressure Range: To determine the envelope's useful operating range
- Leakage Level: To measure the amount of air that escapes in the Five Fault Areas when the U space is 100% blanked off

The Goal is Zero Leakage

An experienced team, trained in containment strategies should analyse test results and provide a list of immediate energy efficient cost saving solutions.

Reporting includes:

- A summary overview of test results measurements
- A detailed analysis of each test including:
  - The facility, infrastructure, and baseline metrics for which the test were conducted
  - The apparatus used to conduct each test
  - The procedure used to conduct each test
  - How the results were collected and measured
- A spreadsheet indicating which racks have passed and failed each of the tests
- A summary illustrating any issues in which the specification was not met and where improvements would be required, equal that of a missing blanking panel

Conclusion

The evolution of the rack as a critical component of the engineered airflow system enables the data centre to become more energy efficient, saves on costs and restores flexibility to the data centre manager.

Unfortunately, the industry has relied on workplace intuition and creative problem solving for far too long. It has utilised everything from cardboard and duct tape to foam seal kits and other "weather-proofing" types of devices. However, the market is moving toward standardised solutions that are designed and integrated within the rack during the manufacturing process.

As data centre containment at the rack and row level strengthens its foothold on retrofits and new construction, more data centre managers will look for elements of Rack Hygiene to be included as standard feature sets, not premium options, of their future rack purchases.

The separation of hot and cold air dramatically increases the predictability of the data centre's performance and enables:

- Efficient utilisation of existing physical infrastructure and cooling capacity
- Active control and normalisation of supply temperature, eliminating recirculation and stratification
- Doing more with less in a smaller data centre footprint with increasing heat loads
- Elimination of "stranded" physical, electrical and mechanical capacity

A smart containment strategy begins with the rack, regardless of whether or not one currently is employing cold aisle or hot aisle containment. Improved Rack Hygiene, even in legacy chaos-cooled environments, is the first step toward mitigating the re-circulation and re-mixing of hot and cold air streams in the data centre. Justifiably, it could account for up to 60% of the overall data centre containment strategy.

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Rupert Jarman has over 25 years of experience within the automotive and commercial electronics sector and has performed diverse roles within business development, specification sales and product management.

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