White Paper

December 2015 WP-24

Panduit Net-Access™ Cabinet Doors Keep Data Center Equipment Cool and Secure

Key Points:

- How does the magnitude of airflow restriction impact the operation of typical IT equipment?
- Are the effects significant?
- Can we determine the effect that the door perforation pattern has on preventing access to the IT equipment?

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Overview

Data center equipment cabinets are provided with front and rear doors for aesthetics and security. A potential tradeoff of installing cabinet doors is any negative impact that the doors may have on the flow of air that must be drawn through the cabinets to cool the equipment housed inside. Published studies have concluded that increasing the percent open area of front door perforations will provide no meaningful benefit from an airflow perspective. However, some cabinet manufacturers continue to market higher open area perforated doors as better. In this study, the Panduit research team takes another look at this issue.

Cool air enters through the front door of IT equipment cabinets when fans draw air through the chassis to cool the internal components and exhaust the warmed air out the rear of the cabinets. Any airflow restriction either reduces the volumetric airflow rate drawn through the equipment chassis, causing the equipment to operate at a higher temperature, or demands that the equipment fans run faster to compensate, increasing the electrical energy required to keep the equipment cool. Adding perforated doors in front of and behind IT equipment creates an airflow restriction. But how does the magnitude of this restriction impact the operation of typical IT equipment? Are the effects significant?

The most secure data center cabinet would have solid doors. Obviously, solid front doors would be unacceptable from a cooling standpoint. Perforated doors are a compromise, providing a deterrent to unauthorized access to the mounted equipment while allowing air to be drawn through the cabinet. Higher percent open area perforation patterns require less metal, suggesting a reduction in security. With these points in mind, Panduit set out to determine the effect that the door perforation pattern has on preventing access to the IT equipment.

Airflow Performance

Industry Guidelines (ANSI/BICSI 002-2014)

ANSI/BICSI published a best practice that defines the minimum open area for data center cabinet doors. This best practice defines a door's "airflow capacity" (AFC_D), not as the percent open area of the perforation pattern, but as the ratio of the door's total open area to the area between the cabinet's equipment mounting rails. Therefore, both the percent open area of the perforation pattern and the total area of perforation on the door impact this value.

For a fixed area of perforation in a door, the perforation percent open area has a linear impact on the AFC_D value. Figure 1 shows this impact for the perforation areas of Panduit Net-Access™ cabinet doors of various widths compared with the minimum AFC_D as specified by ANSI/BICSI.

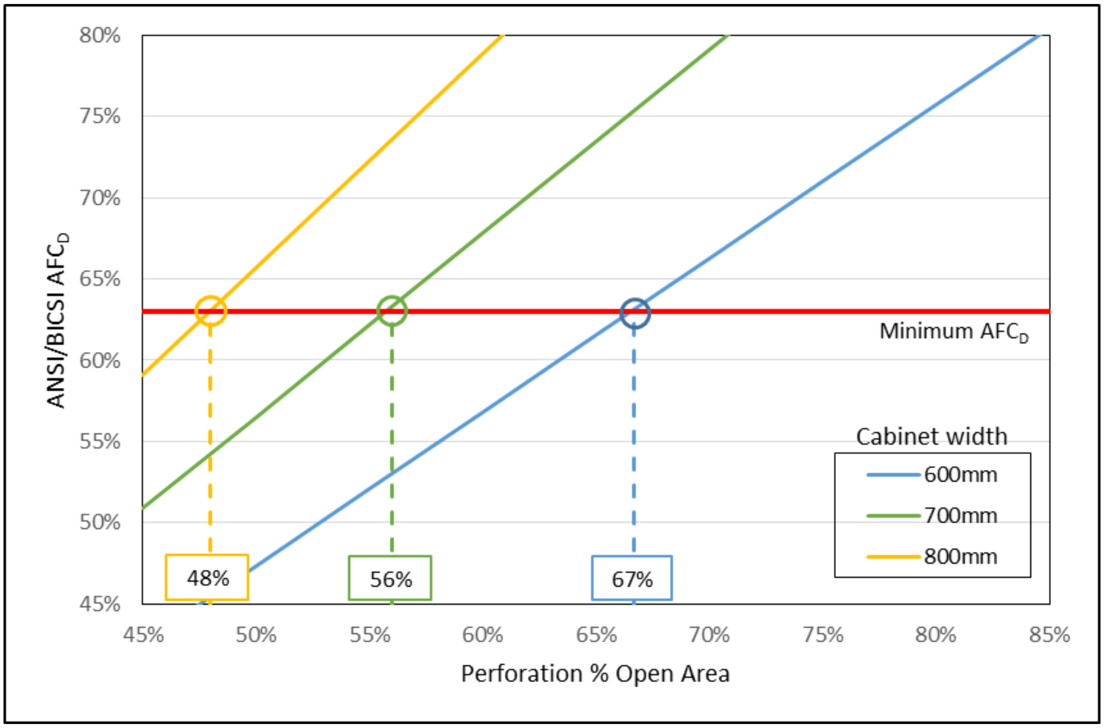

Figure 1. ANSI/BICSI 002-2014 Airflow Capacity. Effect of perforation % open area on AFC$_D$ for Panduit Net-Access™ 42 RU cabinets.

Figure 1 shows that wider cabinets, which have more perforated area on the doors, require a lower percent open area of perforation pattern to meet the minimum AFC$_D$ requirement. For wider cabinets, because the door is broader but the equipment mounting area is not, the required perforation percent open area drops considerably. A Panduit 800mm wide Net-Access™ cabinet only needs a 48% open area perforation pattern to meet the ANSI/BICSI AFC$_D$ minimum. By contrast, a Panduit 600mm wide Net-Access™ cabinet with a perforation pattern that provides a 67% open area meets the minimum value. All Panduit doors have a 69% open area perforation pattern, exceeding the requirement.

Perforated Sample Testing

To fully understand how the perforated door affects cabinet cooling, Panduit Laboratories performed airflow testing at the Jack E. Caveney Innovation Center. We tested perforated steel sheet samples with 57% and 80% open areas and a front door from a Panduit cabinet, which has a 69% open area perforation pattern. These perforation patterns are shown in Figure 2.

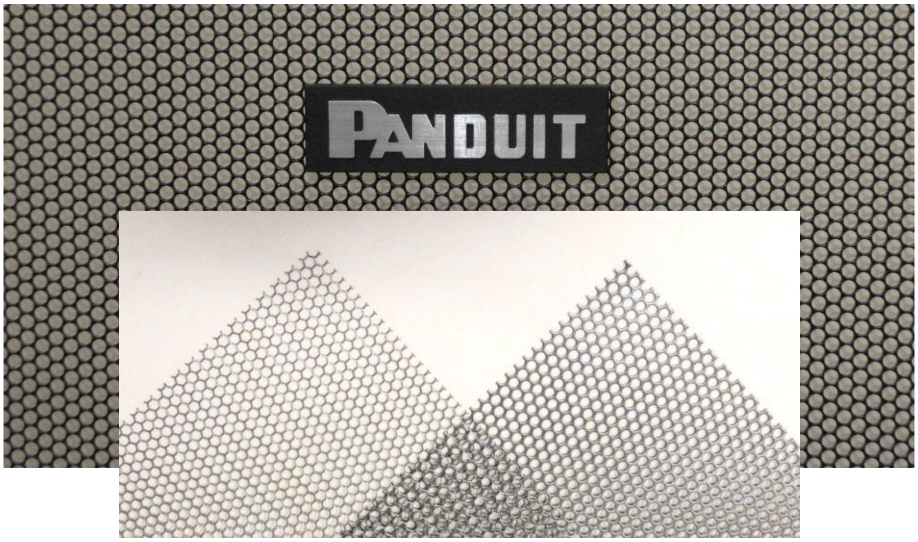

Figure 2. Panduit Net-Access™ door and perforated sheet samples tested.

Test Method

The Airflow Laboratory used an ANSI/AMCA 210-99 compliant test chamber and fabricated a 20-inch (50.8 cm) square cross section duct with pressure measurement tubes installed on both sides of the test samples (Figure 3). Pressure drop was measured across the samples at a variety of airflow rates. This pressure drop indicated the airflow resistance of the perforation pattern.

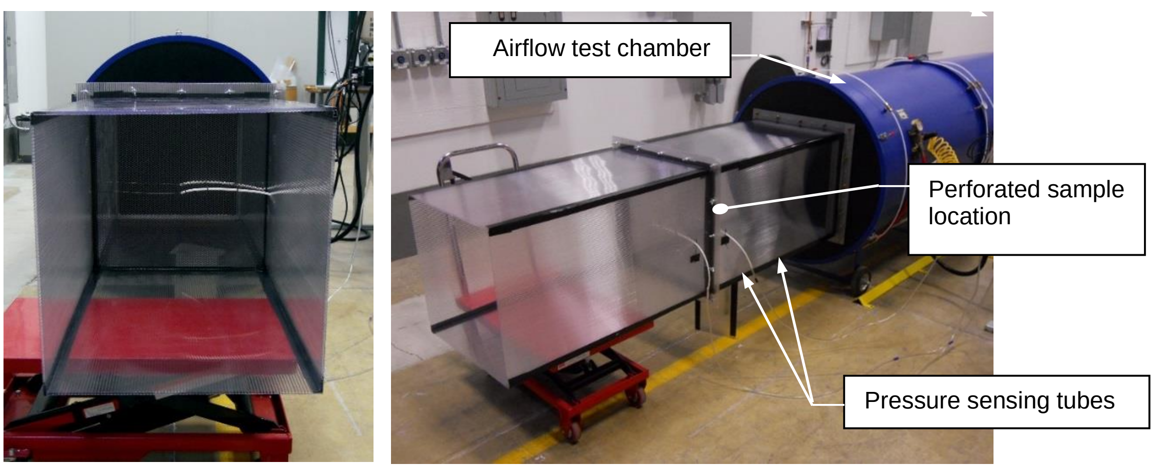

Figure 3. Flow testing apparatus.

Airflow Test Results and Analysis

Figure 4 shows airflow resistance curves from the test results for the perforated sheet samples and for a Panduit perforated door. As expected, higher percent open area samples had lower resistance to airflow.

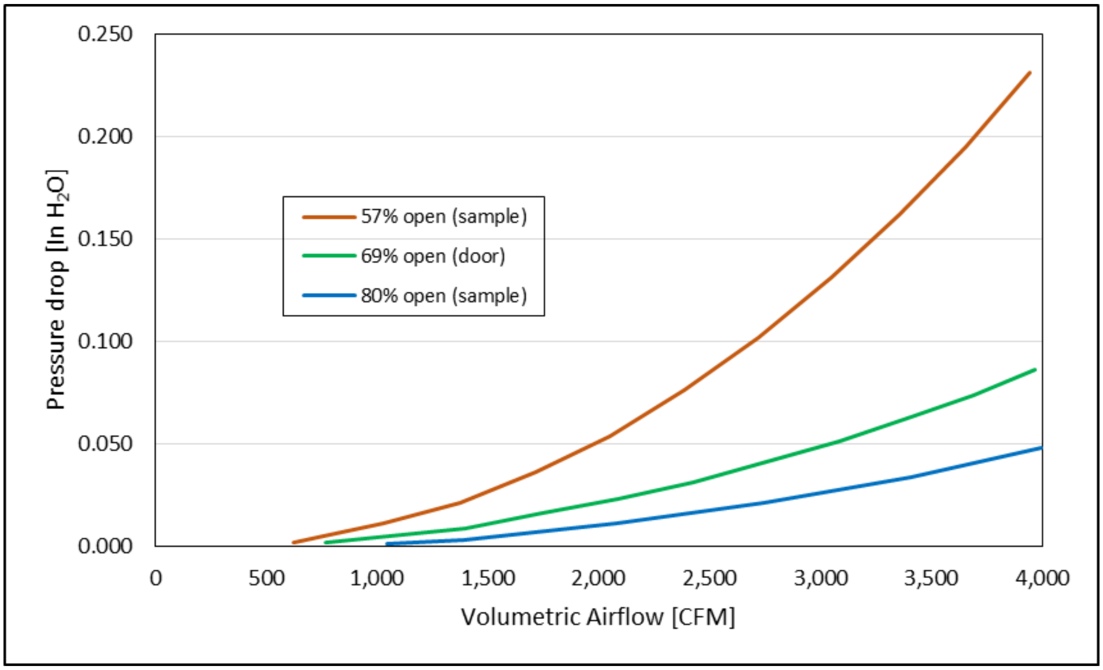

Figure 4. Perforated sample flow testing results through a 20-inch square duct.

Because test results through a 20-inch square duct do not directly represent data center cabinet cooling conditions, the results need to be related to the airflow of IT equipment. Panduit has server airflow data from previous tests. Figure 5 shows the airflow performance curves of sample servers while they operate at typical CPU utilization levels. The results shown in Figure 5 are for 1 RU and 2 RU servers as well as a 9 RU blade server.

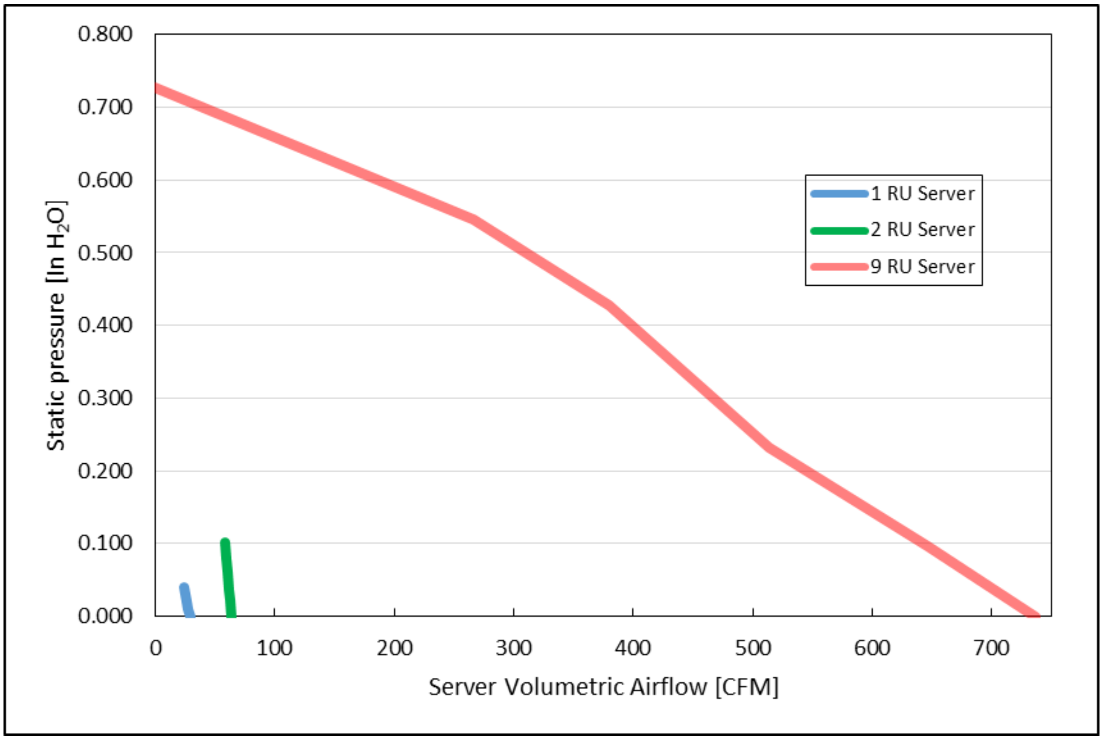

Figure 5. Server airflow performance curves.

These curves show how the airflow through a server, shown on the horizontal axis, is reduced by the presence of a resistance, represented as a static pressure on the vertical axis.

Notice that both server airflow curves (Figure 5) and perforation flow test curves (Figure 4) use the same units on both axes. To observe the effects of perforated door resistance on server airflow, Figure 6 plots these two data sets on the same graph and scales them to a cabinet fully populated with blade servers. The airflow values from the 20-inch square duct sample tests were scaled to the area of the perforation pattern for a 600mm wide, 42 RU tall cabinet door (1,200 in^2). The 9 RU server airflow values were multiplied by four – the number of servers that can be installed at once in that same type of cabinet.

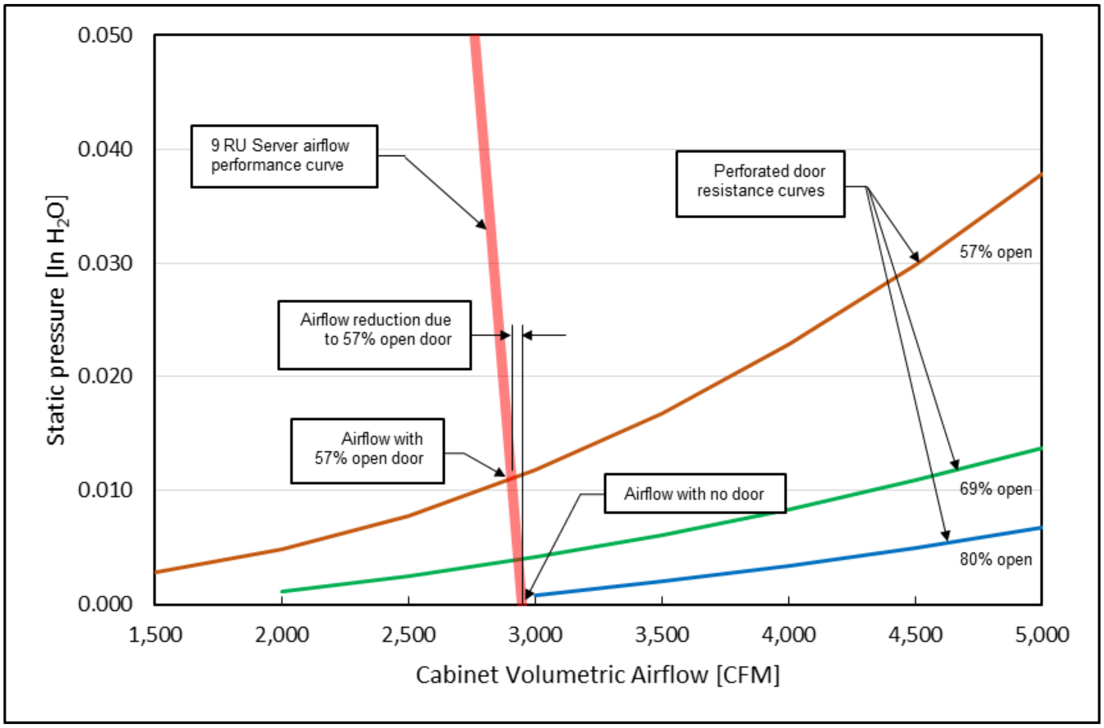

Figure 6. 9 RU server airflow curve and perforated door resistance curves.

The intersections of the curves are the key to interpreting the graph depicted in Figure 6. The point where the server airflow curve intersects the horizontal axis shows the server airflow through a cabinet with no doors, and therefore no airflow restrictions. Similarly, the point where the server airflow curve intersects the 57% open area resistance curve shows the server airflow through a cabinet with a 57% open area perforated door in place. The airflow difference between these intersections is the airflow reduction due to the 57% open area perforated door.

This example demonstrates the variables that determine the impact that the perforated door has on the cooling airflow:

1. The airflow resistance curve of the perforated door.
2. The flow required by the servers in a populated cabinet. (Greater flow means more impact).
3. The slope of the server's airflow performance curve. (Steeper curve means less impact).

The test data for all three sample server types and the three tested perforation patterns were evaluated to determine the curve intersection points. Next, the airflow reductions for various door and server combinations were quantified and the airflow reduction values were doubled to account for the effects of both front and rear perforated doors on the cabinets. Table 1 shows these airflow reduction values and the calculated estimates of the resulting increase in server exhaust temperatures.

Table 1. Perforated door airflow reduction and resulting increase in exhaust temperature.

	600 mm Cabinet Perforated Door % Open Area					
	57%		69%		80%	
Servers [qty] type	Airflow reduction	Exhaust ΔT	Airflow reduction	Exhaust ΔT	Airflow reduction	Exhaust ΔT
[42] 1 RU servers	1.8%*	0.33°C	<0.1%	0.21°C	<0.1%	<0.1°C
[21] 2 RU servers	0.4%*	0.06°C	<0.1%	0.04°C	<0.1%	<0.1°C
[4] 9 RU servers	2.8%	0.26 C	1.0%	0.09°C	0.2%*	0.02°C

* Value obtained by extrapolation beyond test data

This table indicates the magnitude of airflow impact that perforated doors have in typical data center applications and the impact that this reduction in airflow has on equipment cooling. The amount of airflow reduction is very low. Even the worst-case example – high airflow 9 RU servers with a high resistance 57% open area perforated door in the narrowest width cabinet – results in only a 2.8% reduction in airflow through the servers and a fraction of a degree increase in exhaust temperature.

Security

Preventing unauthorized access to IT equipment is a key function of data center cabinet doors. The strength of the perforated material is a primary factor in how effectively the door performs this function. As percent open area of the perforation pattern increases, the area of the door that is metal decreases. Naturally, the strength of the door also decreases.

The Industrial Perforators Association provides yield strength and elastic properties of perforated sheet metal. Because their data only includes perforated patterns up to 58% open area, we explored the impact of the percent open area on a sheet's strength through finite element modeling of perforated sheet sections. We considered examples of malicious attempts to shut off or damage IT equipment and chose the force required to penetrate a door with a #2 Phillips screwdriver to represent the strength of the perforation from a security perspective. To ensure that all force differences were due to perforation percent open area only, the hole size and sheet thickness were held constant across the finite element models. Figure 7 shows the force required to penetrate each percent open area model.

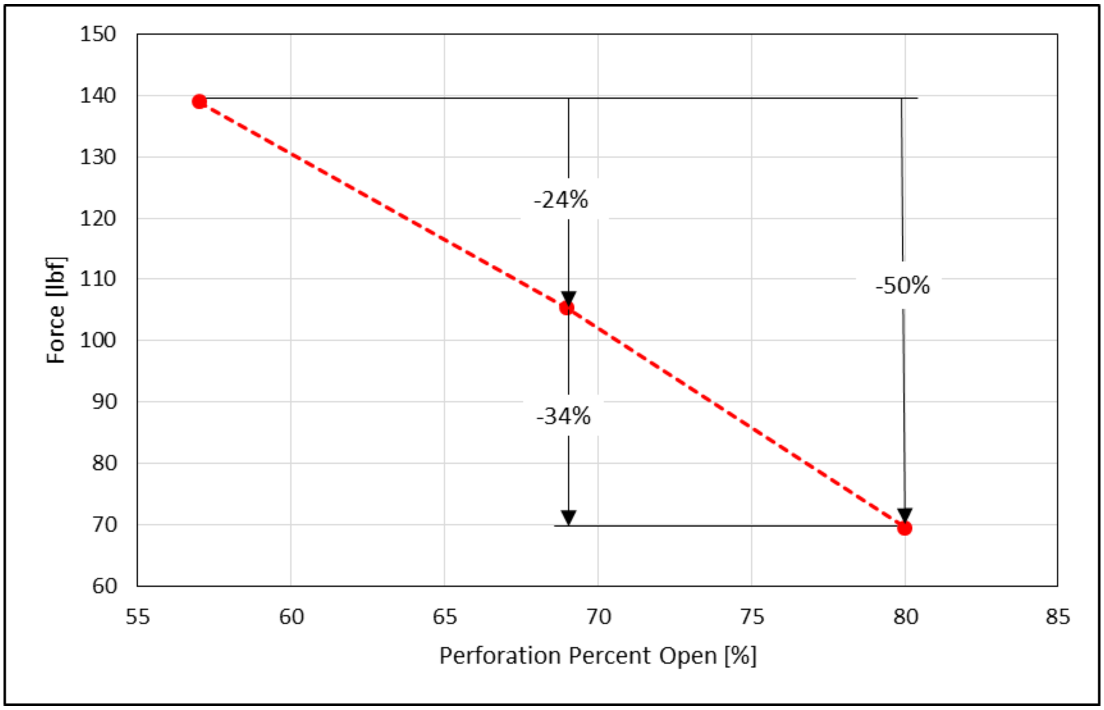

Figure 7. Force required to penetrate perforated patterns with a #2 Phillips screwdriver.

The data shows that as the percent open area of the perforated pattern increases from 57% to 69%, the force required to penetrate the pattern decreases by 24%. An increase to 80% open area reduces the force required to half of the 57% open area pattern's required force. The 80% open area pattern requires 34% less force to penetrate than the 69% open area pattern.

It is clear that increasing the percent open area of a cabinet door's perforated pattern has a negative effect on the door's effectiveness as a security feature.

Conclusions

This study shows that increasing the percent open area of a data center cabinet door's perforation pattern has beneficial and detrimental effects on two of the door's primary functions: security and cooling efficiency. While increased percent open area reduces resistance to cooling airflow, it also reduces the strength of the door and its ability to prevent malicious access to the IT equipment housed in the cabinet.

The ANSI/BICSI 002-2014 best practice specifies a minimum total open area standard for cabinet doors, but the percent open area of the perforation pattern is only one factor used to calculate this value. Panduit Net-Access™ cabinets, with their 69% open area perforation pattern, all exceed the ANSI/BICSI 002-2014 AFC_D minimum value.

Evaluation of airflow test results compared to actual server operating conditions showed that the real effect of perforation pattern percent open area on the equipment is minimal over the relatively wide range of percent open areas tested. The highest airflow density servers the team evaluated, in a cabinet with the lowest percent open area perforation pattern, resulted in only a fraction of a degree rise in the servers' exhaust temperatures. That perforation pattern's AFC_D would be 54%, well below the ANSI/BICSI 002-2014 minimum value of 63%. These results suggest that the ANSI/BICSI AFC_D minimum value is a conservative target.

We used resistance to penetration to evaluate the security effectiveness of perforation patterns. Finite element analysis results showed that an increase in perforation percent open area reduces the force required to penetrate the pattern. An 80% open area perforation pattern requires 34% lower force to penetrate than Panduit's 69% open area pattern.

Based on the study findings, there is no apparent reason that perforated cabinet doors must be any more open than what is needed to meet the ANSI/BICSI 002-2014 AFC_D minimum value. A further increase in percent open area has a nearly unmeasurable effect on the IT equipment in the cabinet while having a clear negative effect on resistance to door penetration.

Here are key takeaways from this study:

- The ANSI/BICSI 002-2014 AFC_D minimum requirement of 63% appears to be a conservatively safe target for perforated cabinet doors.
- Panduit Net-Access™ cabinets, which use 69% open area perforation patterns, all exceed the ANSI/BICSI 002-2014 AFC_D minimum requirement.
- Cabinet door perforation patterns with open areas that exceed the ANSI/BICSI AFC_D minimum provide virtually no cooling benefit, with a resulting server exhaust temperature increase of less than 0.5°C.
- Increasing the perforation pattern percent open area from Panduit's current 69% open area to 80% open area results in a 34% reduction in the force required to penetrate the perforation pattern.

Based on the test results, the Panduit Laboratories team concluded that there is no compelling reason to choose cabinets with door perforations with higher percent open area than required to meet the AFC_D minimum value.

About Panduit

Panduit enables data centers to realize their full potential through an integrated stack of physical and intelligent infrastructure solutions that drive actionable performance gains and efficiencies to reduce operating costs and maximize capacity of power, cooling, space, and connectivity for the greatest ROI. Bridging physical equipment (cabinets, copper and fiber connectivity, and pathways), intelligent solutions (monitored rack PDUs, intelligent patching, and DCIM software), and professional services, Panduit offers the most comprehensive integrated data center portfolios available from one single source vendor. Complemented further by strong technology partnerships, Panduit integrated data center solutions are designed to answer increasing demand for IT services and technologies, while simplifying growing complexity in the data center design.

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RKAT05--WW-ENG, Rev 0, 12/2015