Whitepaper

Increase your data center energy efficiency by choosing the right firestop products

Executive Summary

The cost of energy is the highest operation cost in data centers. To improve overall data center energy efficiency, address air management issues. While there is no single thermal management architecture that is the most energy efficient for all installations, critical factors like partition tightness must always be considered. Deliver and keep air where it is needed by choosing firestop products with lower air leakage ratings.

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1. Airflow management: a fundamental requirement for energy efficient data centers

Current estimates indicate that data centers consume approximately 3% of the world's power supply, a figure that is expected to triple over the coming decade. [1] Despite continuous innovation in cooling methods and design, airflow management remains a crucial factor in overall energy efficiency.

The importance of airflow is evidenced by the increasing number of internationally recognized design guidelines such as the ASHRAE "Best Practices for Datacom Facility Energy Efficiency" and the "EU Code of Conduct on Data Centre Energy Efficiency." Both dedicate entire chapters to air management.

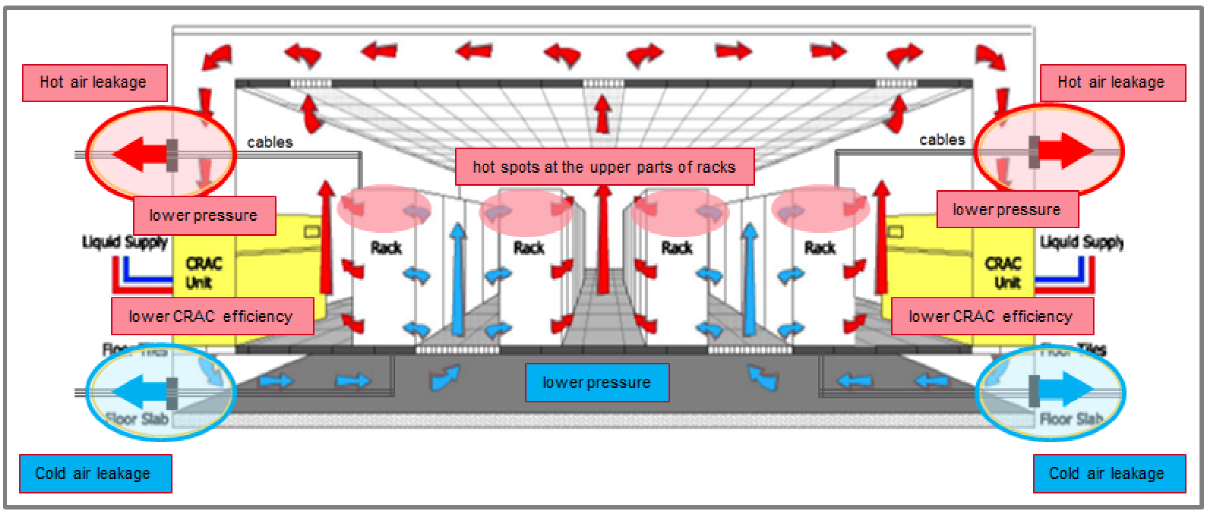
An increasing number of new and existing data centers employ computational fluid dynamics (CFD) software to optimize airflow for improved energy efficiency.

All of these standards, guidelines and tools have one thing in common<u>: they assume the envelope and partitions within a data center are 100% airtight and consider the data hall as a closed system.</u> Unfortunately, this does not always correspond to reality.

2. Leakages in the white space envelope affect airflow distribution, negatively impacting energy efficiency

Where the perimeter of the server hall is breached by services such as cables or pipes, the integrity of the partition is compromised. As data centers continue to scale up and/or adapt to the quick evolution of IT and telecommunication technology, cables continuously repenetrate these perimeter walls, floors and ceilings. Most often, these breaches in the white space envelope are sealed with passive firestopping products.

Poor air integrity of firestopping systems may seriously deteriorate cooling system performance and decrease overall energy efficiency. The following picture shows common leakages due to penetrations in the partition and their consequences on data center design:



*CRAC: computer room air conditioning

Fig. 1: Impact of penetration leakage on airflow in data centers with cold/hot aisle containment - Adapted from ASHRAE [6] [7]

- Leakages below raised-floors reduce underfloor pressure and allow costly cold air to bypass the IT equipment, generating hot-spots at the top of the racks due to insufficient airflow.

- At overhead cabling penetrations, leakages allow hot air to escape from the server hall, reducing the return air temperature and decreasing computer room air conditioning unit efficiency.

Although there is no single thermal management architecture that is best suited for all data centers, all designs should strive for an airtight data hall envelope.

> *„Poor airflow management often results in attempts to compensate by reducing cooling air unit air supply temperature or supplying excessive air volumes, which has an energy penalty"* [17]

3. L-ratings: the standard method of measuring air leakage performance of firestop products in North America

In the United States, the most wide-spread method of measuring leakage in through-penetration firestop systems is the L-rating according to ANSI/UL 1479, the UL Standard for Safety for Fire Tests of Through-Penetration Firestops. This UL standard defines rigorous testing parameters to ensure comparability of various tested systems. For air leakage measurements, the ambient chamber temperature must be 75 ±20°F (24 ±11°C) and the air flow into the test chamber is adjusted to provide a positive test pressure differential of 0.30 ±0.01 inch water (75 ±2 Pa). After the test conditions are stabilized, the airflow rate through the air flow metering system and the test pressure differential is measured and recorded. This airflow rate is designated the total metered air flow at ambient temperature and represents the air leakage of the firestop system. [8]

It is important to understand that airflow measurement is complex and many factors influence the air tightness of penetrations, e.g.:

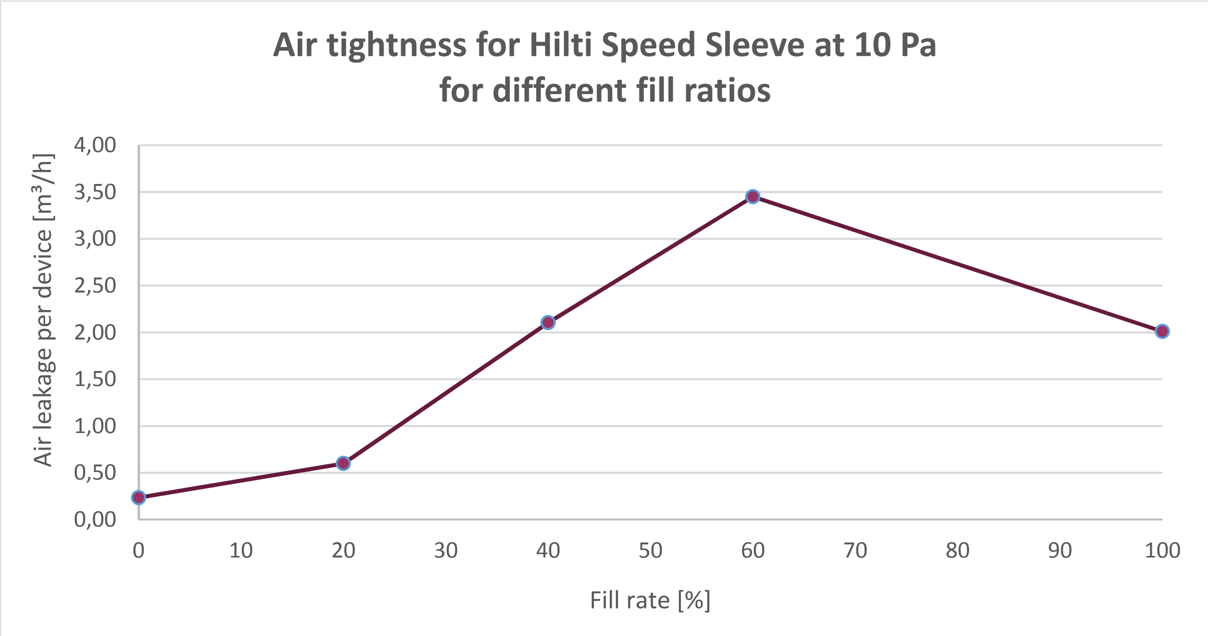
- cable size, shape and position inside penetration
- ambient conditions (especially humidity and temperature)
- room pressure

This means that the same test conduced with a pressure differential other than 75 Pa could lead to significant differences in air leakage. Although the L-rating is a valuable measurement to compare the air tightness of firestop products, it is limited in its ability to predict actual leakage performance in varying operating conditions.

4. Covering a wider pressure range to help select the best firestop products for airflow control

There are several methods of measuring the air leakage of construction products. The EN 1026 is an internationally recognized standard which defines a conventional method to determine the air permeability of construction elements when submitted to positive or negative test pressures. In contrast to the L-rating acc. to UL 1479, this standard covers a wide range of pressures and thus allows a better understanding of a product's suitability for specific applications. [9] Data centers operate at differing pressure ranges depending on their design. Pressure will also vary depending on the facility area and/or activity performed (e.g. commissioning overpressures versus normal operating overpressures for server rooms).

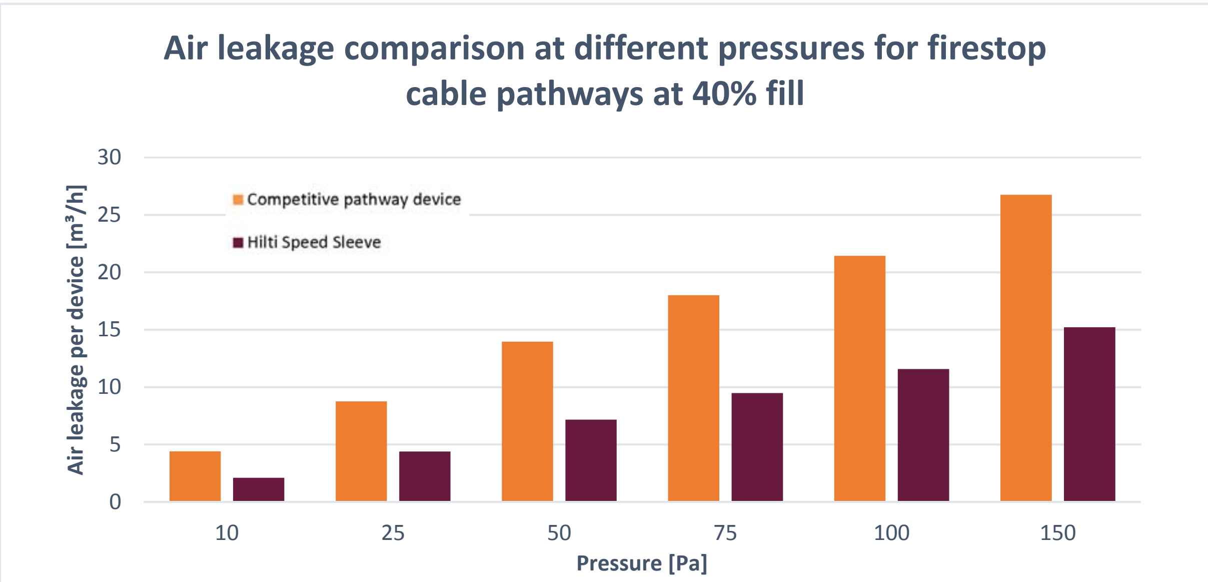
A sequence of EN 1026 testing at an accredited third-party institute measured the air tightness of similar firestop products. A series of pressure steps were examined to cover a broad range of applications. The tests also covered a variety of cable fill ratios, from blank (0%) to 100% visual fill, to represent the increasing number of cables as facilities are scaled up. The following graph shows one of the several test serie results and describes the air tightness behavior of the Hilti Speed Sleeve at different fill rates (at 10 Pa):



Testing compared 4" Firestop Speed Sleeve air tightness performance at different fill rates, device installed acc. to manufacturer Instruction for Use
Cables used: CAT6 cables (OD=6mm), end of cables sealed
Fill rate 0% = 0 cables (blank); Fill rate 20% = 28 cables; Fill rate 40% = 57 cables; Fill rate 60% = 86 cables; Fill rate 100% = 142 cables
Leakage measured @ 21 °C; 52 - 57% RH, @10 Pa and tested according to EN 1026 – test reports available upon request
Airflow in [m³/h] measured for over- and underpressure, chart displays average values

Fig. 2: Air leakage for Hilti Speed Sleeve at 40% fill acc. EN 1026 – third-party test reports from December 2016

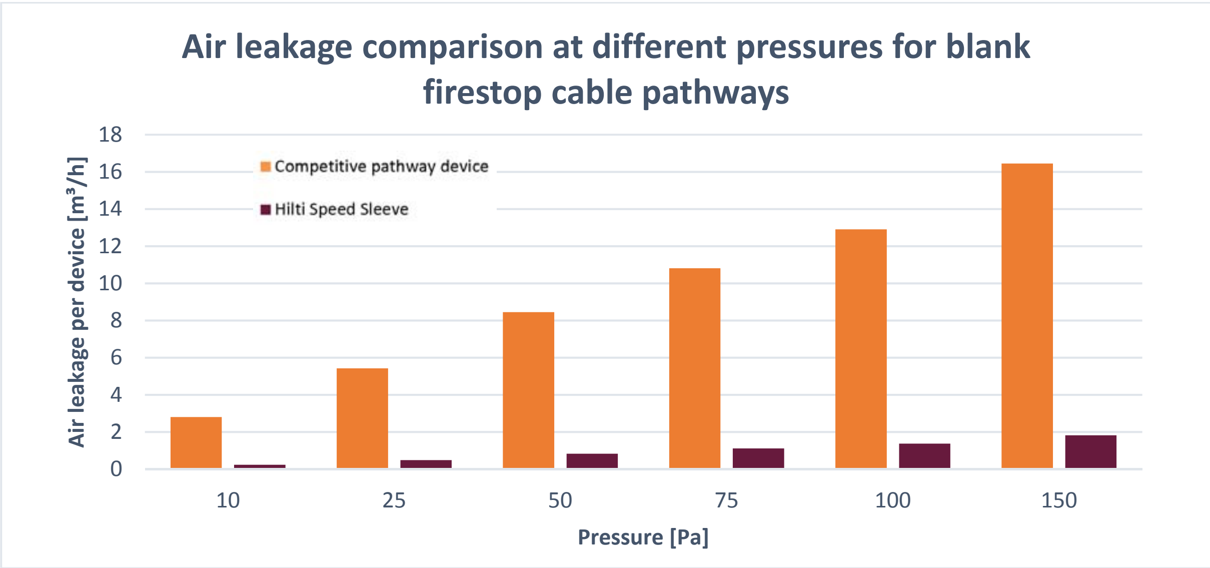
Comparative testing of similar firestop devices from different manufacturers revealed substantial differences in air leakage performance:



Testing compared 4" Firestop cable devices with 40% cable fill; both devices installed acc. to manufacturer Instruction for Use
40% cable fill = 57x CAT6 cables (OD=6mm), end of cables sealed
Leakage measured @ 21 °C; 52 - 57% RH and tested according to EN 1026 – test reports available upon request
Airflow in [m³/h] measured for over- and underpressure, chart displays average values

Fig. 3: Air leakage comparison for firestop cable devices at 40% fill acc. EN 1026 – third-party test reports from December 2016

This difference is most pronounced when the devices are left empty to accommodate for future capacity – in which case one device exhibited leakage more than 10 times greater than the other:



Testing compared 4" Firestop cable devices with 0% cable fill; both devices installed acc. to manufacturer Instruction for Use
Leakage measured @ 21 °C; 52 - 57% RH and tested according to EN 1026 – test reports available upon request
Airflow in [m³/h] measured for over- and underpressure, chart displays average values

Fig. 4: Air leakage comparison for blank firestop cable devices acc. EN 1026 – third-party test reports from December 2016

5. Differences in firestop device technologies mean significant air leakage variations

To understand the source of the differences described in chapter 4, it is necessary to examine the technologies behind both firestop products. The Hilti Speed Sleeve's superior air tightness is a result of its twist-design. When the inner fabric liner twists closed, it wraps around an extended length of cables, resulting in excellent airflow control:

Fig. 5: Hilti Speed Sleeve with twist mechanism for increased air tightness

Non-destructive testing at the neutron imaging facilities at the Paul Scherrer Institute allows a look inside the metal devices to reveal the area sealed by the fabric twisted along the cable:

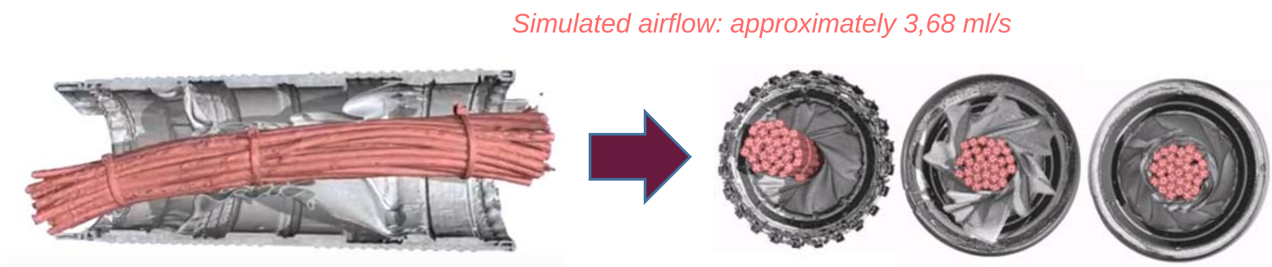


Fig. 6: Hilti Speed Sleeve CP 653 / CFS-SL with closing mechanism to increase air tightness – third-party CFD simulation by Paul Scherrer Institute from June 2016

On the other hand, the pathway device shown in the previous chapter (Competitive pathway device - Fig. 3 and Fig. 4) relies on a rubber band to compress the intumescent liner pads around the cable/bundles. This rubber band only seals a very short length of cable and cannot adapt to the shape of the penetrants, creating voids through which the air can flow freely:

Simulated airflow: approximately 1880 ml/s

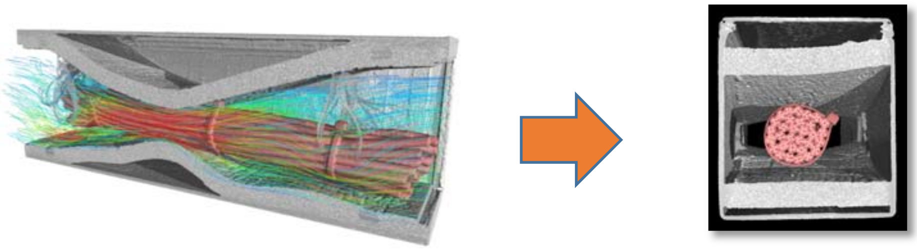


Fig. 7: Competitive pathway device with rubber band around intumescent liner pads to adjust to cable penetrants – third-party CFD simulation by Paul Scherrer Institute from June 2016

Even if cables are more loosely bundled, the rubber band technology cannot adequately seal the resulting voids:

Simulated airflow: approximately 32,8 ml/s

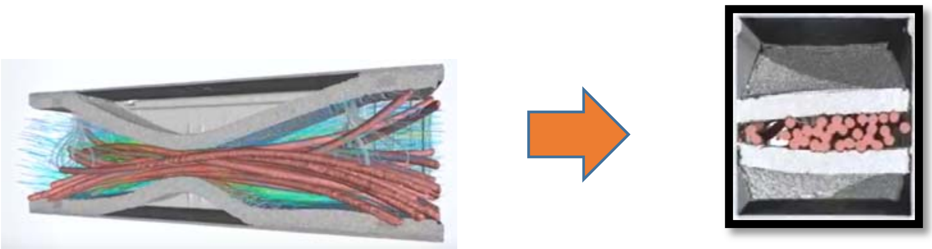


Fig. 8: Competitive pathway device with rubber band around intumescent liner pads to adjust to cable penetrants – third-party CFD simulation by Paul Scherrer Institute from June 2016

6. Conclusion

Proper air management is a critical factor in ensuring energy efficient data centers. Although sealing all gaps within the cable bundle itself may not always be practical or feasible, it is possible to significantly minimize the overall leakage of penetrations by selecting products with improved airflow control technologies:

- Reduce turbulence to deliver air to the right destination with less mixing
- Achieve higher chiller and economizer efficiencies by preventing the escape of hot return air, since efficiency increases with warmer return air temperatures
- Reduce bypass for lower supply airflow volumes, creating CRAC unit fan savings up to 75%
- Increase underfloor air pressure to reduce hot spots at the top of racks
- Increase air temperature uniformity throughout the white space

The considerable differences in airflow performance between sealing technologies of various firestop products can substantially impact a facility's overall cooling efficiencies.

Ensure airflow delivery where it is needed by selecting firestop products with improved airflow control.

About the Author:

Livia Nogueira Divino received her M. Sc. Chemical Engineering at the University of Mannheim, where she specialized in environmental management. After gathering professional experience at different companies in various assignments related to product development, production planning and quality management, Livia joined Hilti as a development engineer in the Technical Service team in 2015. She currently works developing Firestop Solutions for mission critical facilities and for challenging Energy and Industry environments, like Data Centers.

About Hilti:

Hilti was founded in 1941 as a family-owned company and its team includes nearly 20,000 members in more than 120 countries. Together with nonstructural field engineers, fire protection specialists and third-party agencies, Hiltis in house fire protection engineering teams test every firestop product to the highest standards. Hilti has over 1000 tested systems that provide firestopping solutions for joints and penetrations through fire-rated walls or floors.

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