white paper

Air Flow Optimization

For In-Row Cooling Units CoolTeg Plus

Trends and best practices in data centers

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Date: 15. 11. 2013

Version: 1.15.EN

Contents

Introduction

The air-conditioning technology is becoming more and more important in data center planning since it has significant influence on their energy efficiency and operating costs. Modern air-conditioning technology provides precisely tuned solution. A correct interpretation of necessary air distribution within the data center leads to the requirement for implementation of mechanical components that rectify the air-flow. The choice of proper mechanical parts as deflectors and separators is thus the basic presumption for optimized power consumption of indoor cooling units during all their lifetime.

The measurements and further described product modifications were made on cooling units CoolTeg and CoolTeg Plus from the serial production of the company CONTEG.

Basic data:

Dimensions (H x W x D): 1978 mm x 300 mm x 1000 mm

Ventilators (fans): 5x radial ventilator, hot-swappable

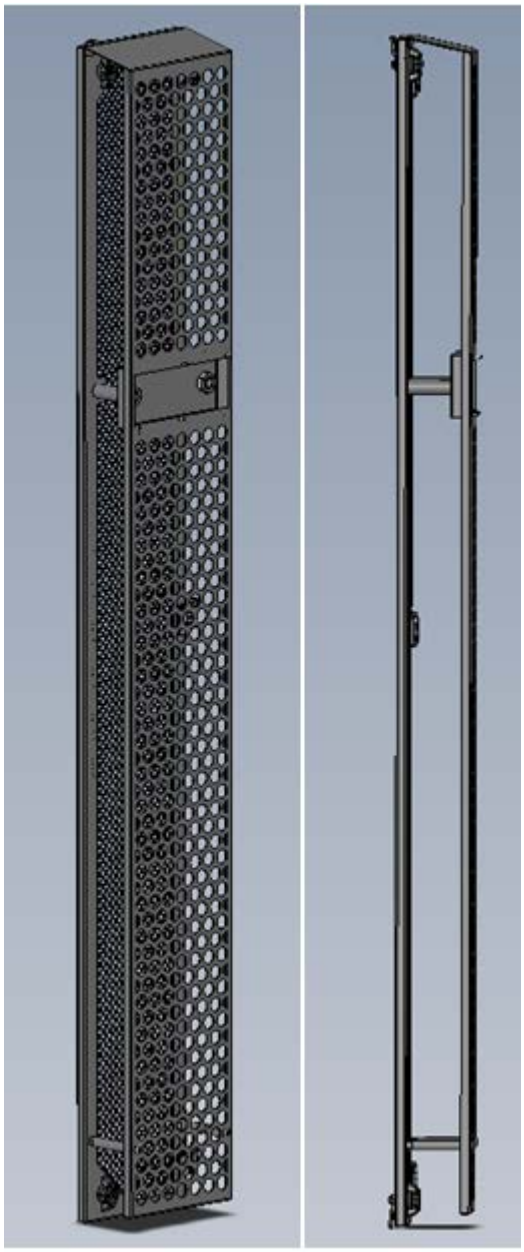
Used terminology

Rim of the door is the non-perforated area on the door wing. Behind this non perforated steel sheet is located the welded frame of swinging door.

Deflector is a cover of the front columns which ensures their better bypassing by the air-streams . It wasn´t tested in the laboratory since its benefits are obvious. It is a standard part of new cooling units CoolTeg Plus.

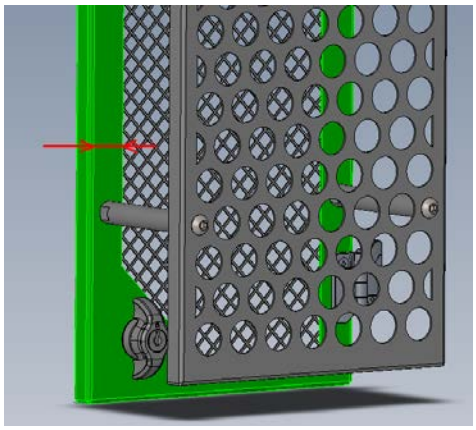
Difusor is a perforated steel sheet mounted on the front side of the door which contributes to the equalization of outgoing air stream (optional accessory). Its testing was made in the laboratory as well as on the mathematical model.

Separator – air separation plate between individual fans.

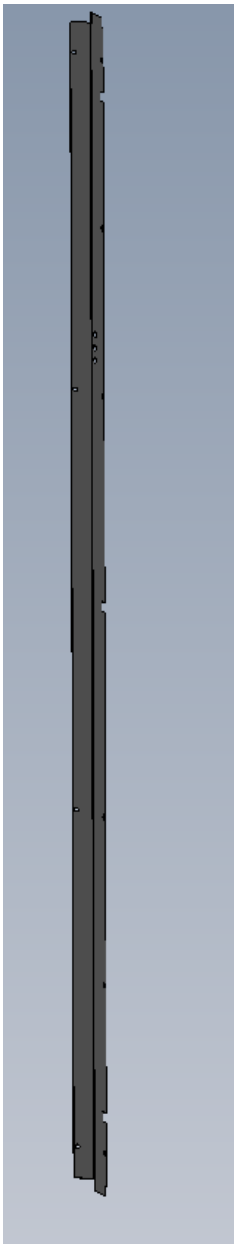


The door with the difusor

Top view of the deflector (cover of the column):



Detailed view of the door rim



Deflector

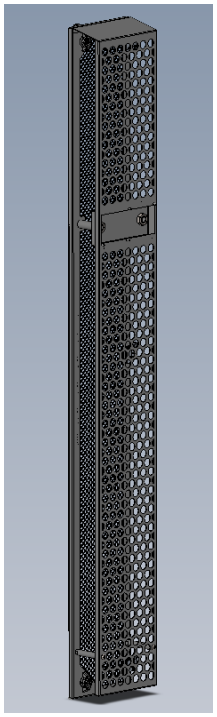
Rim of the door, reduction of its width and the impact of a difusor

The goal of this measurement was to determine how the newly designed door of the cooling unit influences the pressure parameters at the air outlet of the cooling unit CoolTeg 300mm wide. Changes were made in order to homogenize the air velocity at the outlet. The field is created by 5 radial fans located in a vertical row. Modified door has narrower rim on its perimeter and moved display. Another variant is the modified door with added difusor (sheet steel plate with holes diameter 20mm).

The homogeinity of the air velocity at the air outlet was measured as a velocity field in distance 20cm and 35cm from the cooling unit while the measurement area was bigger than the size of the unit itself. The grid was 60x60 mm (6x31 points), see the frame on photo.

Air inlet:

Air outlet, the difusor mounted on the door:



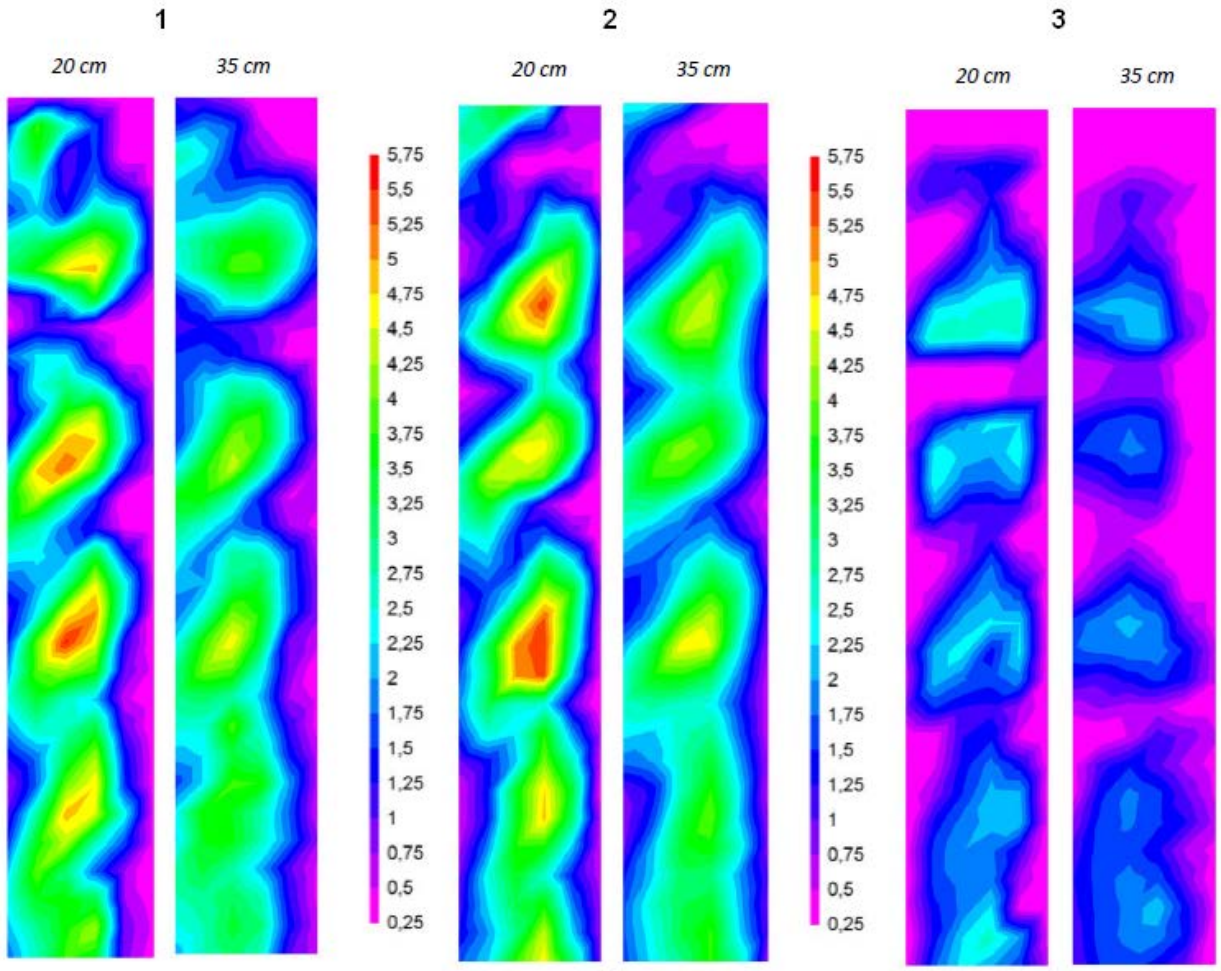
The measurement at the air intake of the cooling unit has shown that the change of air-flow will not be significant. The more narrow rim on the front door frame is not so big change to see dramatically increased air-flow.

The well-designed difusor installed on the front door of the cooling unit also has only limited impact on the air-flow. It occurs no crucial pressure drop, the expected air-flow decrease for the arrangement with difusor reaches approximately only 1 % which is within the measurement error range.

The electrical power consumption of the cooling unit for all variants is shown in the chart below. After the modifications the power consumption decreased by tens of Watts. It means that the fans are working with slightly better efficiency.

Variant	Description	Mean air velocity (m/s)	Air flow m^3/hour	%	Apparent power (VA)	%
1	serial production unit	3,75	3550	100,0	972	100%
2	with narrower rim on the door	3,76	3558	100,2	954	98%
3	w. narrower rim and the difusor	3,72	3516	99,0	945	97%

The graphs of the velocity field at the air outlet displayed significant differences between the direct air-flow from the fans and from the mid-area between 5 radial fans (picture 1). Better located display and narrower rim of the door bring certain improvement but the air-flow velocity at the cooling unit outlet did not change much (picture 2). But the variant with added difusor (picture 3) shows essential equalization of the air-flow velocities at the cooling unit air outlet. Part of the air-flow is sideways declined since the difusor represents an obstruction and part is going through the difusor. Higher air-flow velocity behind the fans is still notable but it reaches only approx. 50% compared to the previous variants.



Serial production unit with narrower rim on the door w. narrower rim and the difusor

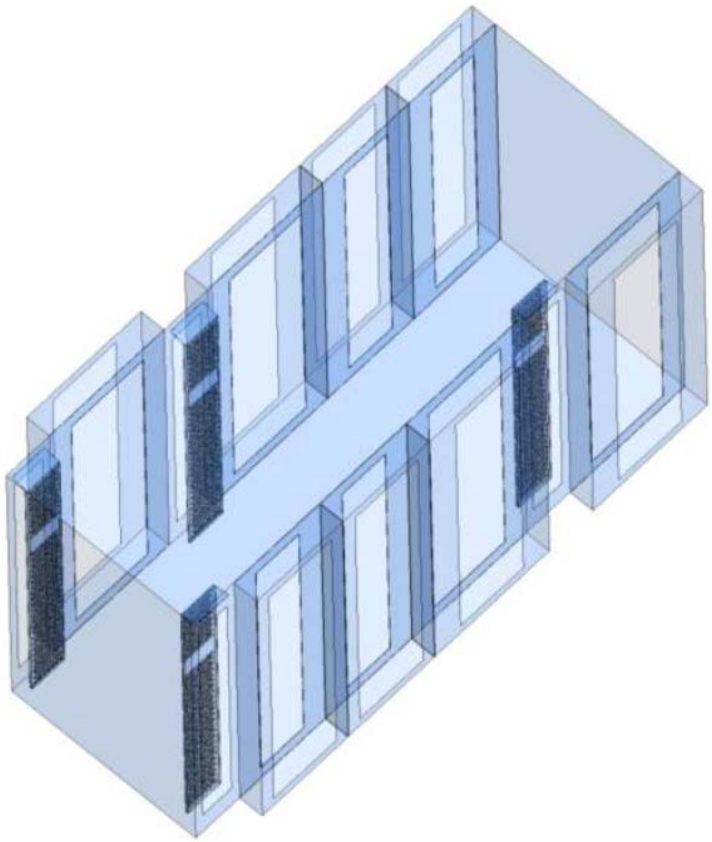
Conclusion 1 – Narrower rim of the door and the use of difusor

The measurements confirmed that the positive impact of the narrower door rim cannot be easily proven due to given accuracy of the measurement. Nevertheless some improvement was achieved – we received bigger air-flow volume at lower power consumption which means confirmation of theory.

More convincing is the difusor functionality at the air outlet. The difusor strongly contributes to the overall better air distribution. The installed difusor does not decrease the cooling capacity of the cooling unit, it does not increase its power consumption. The difusor contributes to more homogenous output air-flow and thus also to better cooling of racks neighboring with the cooling unit. From the air-flow point of view is the difusor recommendable for data center applications.

Use of multiple difusors in the aisle of IT racks

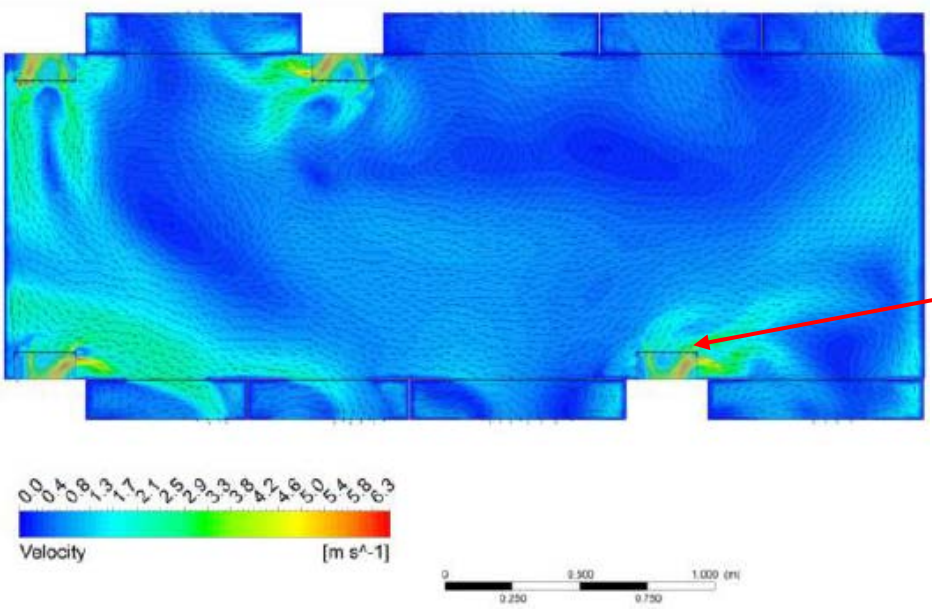
Another interesting application is the usage of multiple air difusors on cooling units in a row of racks. Again, the difusors have full height and width of the rejection area of cooling units and we tested perforated steel sheet with round holes 20 mm in diameter. Approximately at ¾ of the height of foresitting deflectors are installed the cooling unit´s control panels.



The mathematical model of the contained cold aisle, which was created and investigated to confirm measured data, is shown on the 3D picture.

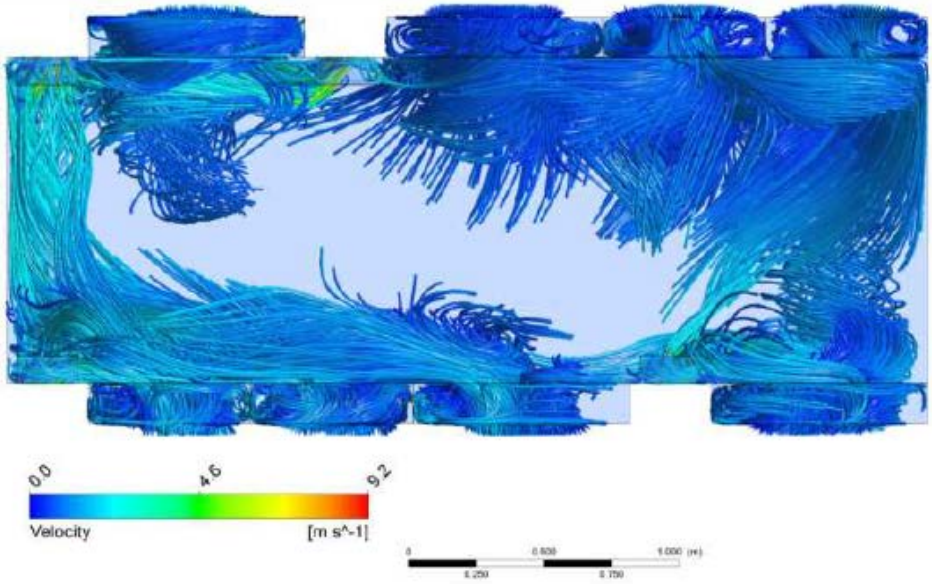
The focus is taken on the airflow streams within the corridor which shows in-row cooling units equipped with difusors (mounted in front of the cooling units) while the air intake of simulated IT equipment in the racks is 15cm behind the front door surface. The perforation rate of the doors in the racks is 83%.

The pictures on the next pages show the velocity field and the streamlines within the containment.

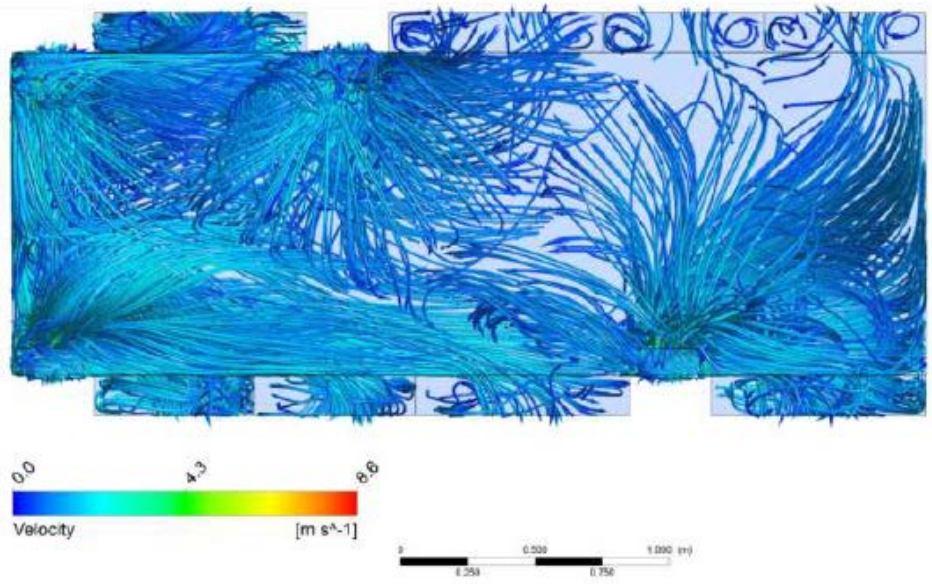


Tested concept:

The picture shows the velocity field at height 1m above the floor, for cooling units equipped with air-difusors.

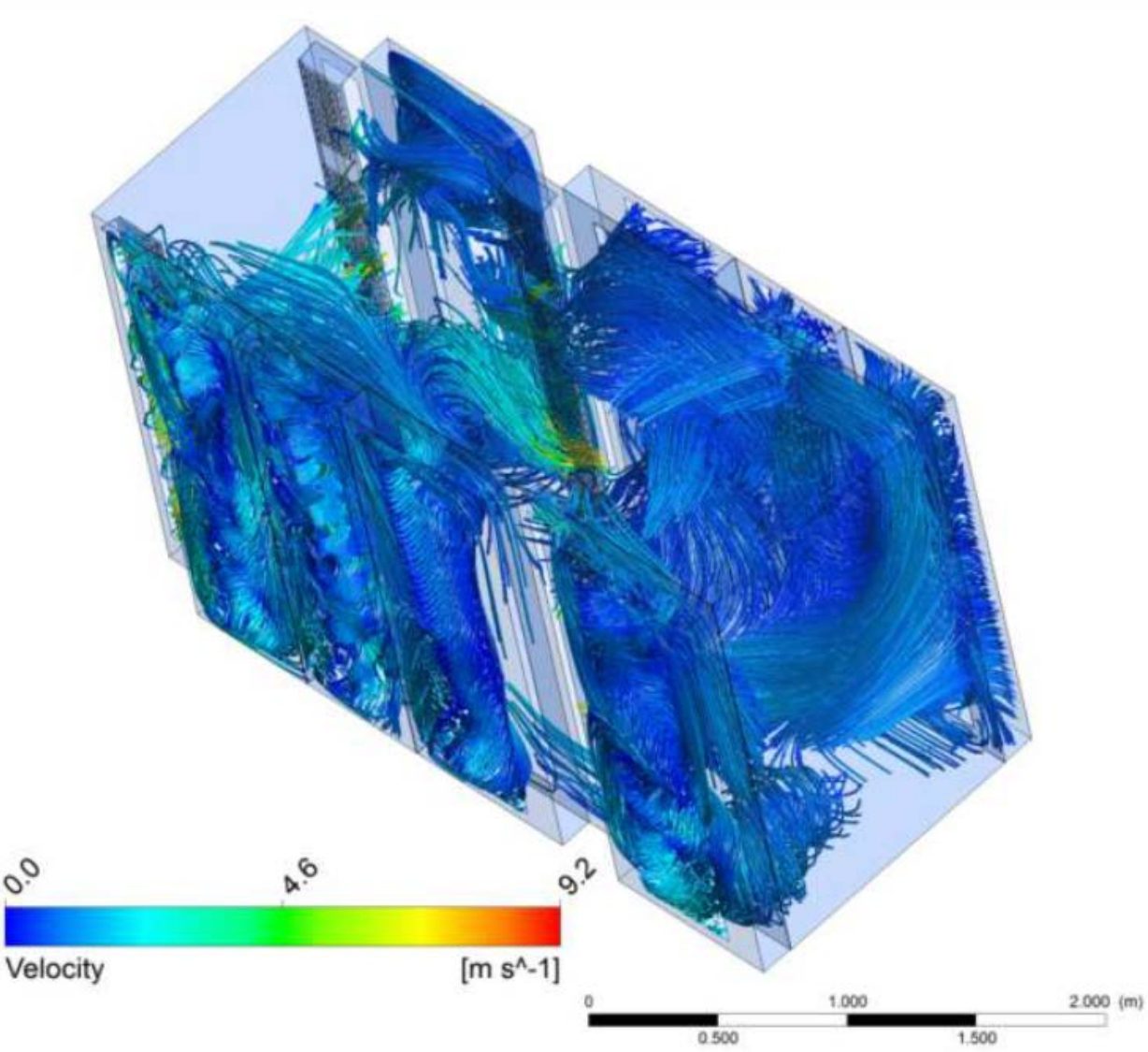


The picture shows air streams within the confined aisle for cooling units with difusors.



... and the comparison with existing solution:

The picture shows air streams within the confined aisle for cooling units **without** difusors.



Picture shows general view on streamlines within the confined cold aisle.

Conclusion 2 – Use of the difusors in a row of racks

The air-difusors for In-Row cooling units proved their benefits in the numerical simulation as well as in the real measurement made on the prototype. The presence of air-difusors in the aisle results in more equalized distribution of air streams and thus better delivery of conditioned air to all IT racks.

The cooling units with front mounted air-difusors will be very useful especially in data centers with hot/cold aisle arrangement where the aisles are not mechanically separated by wall structures or blinds.
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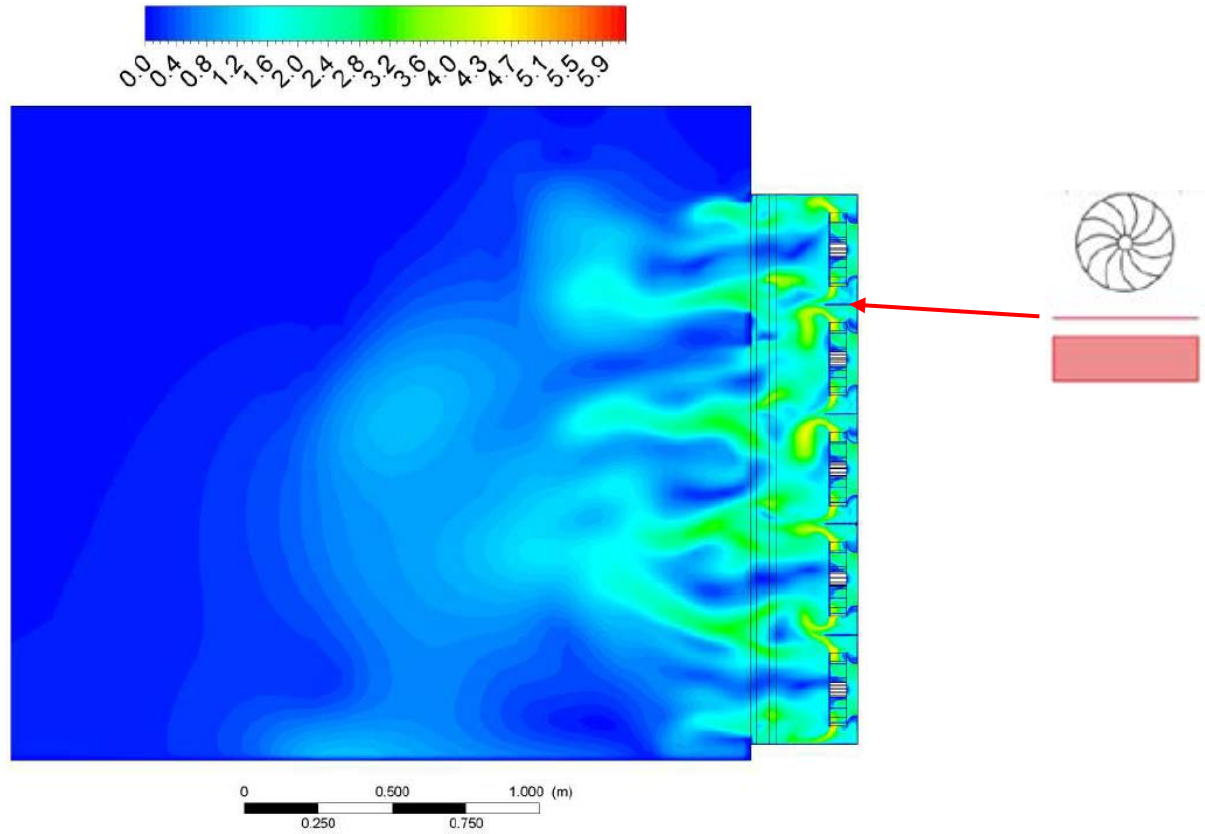
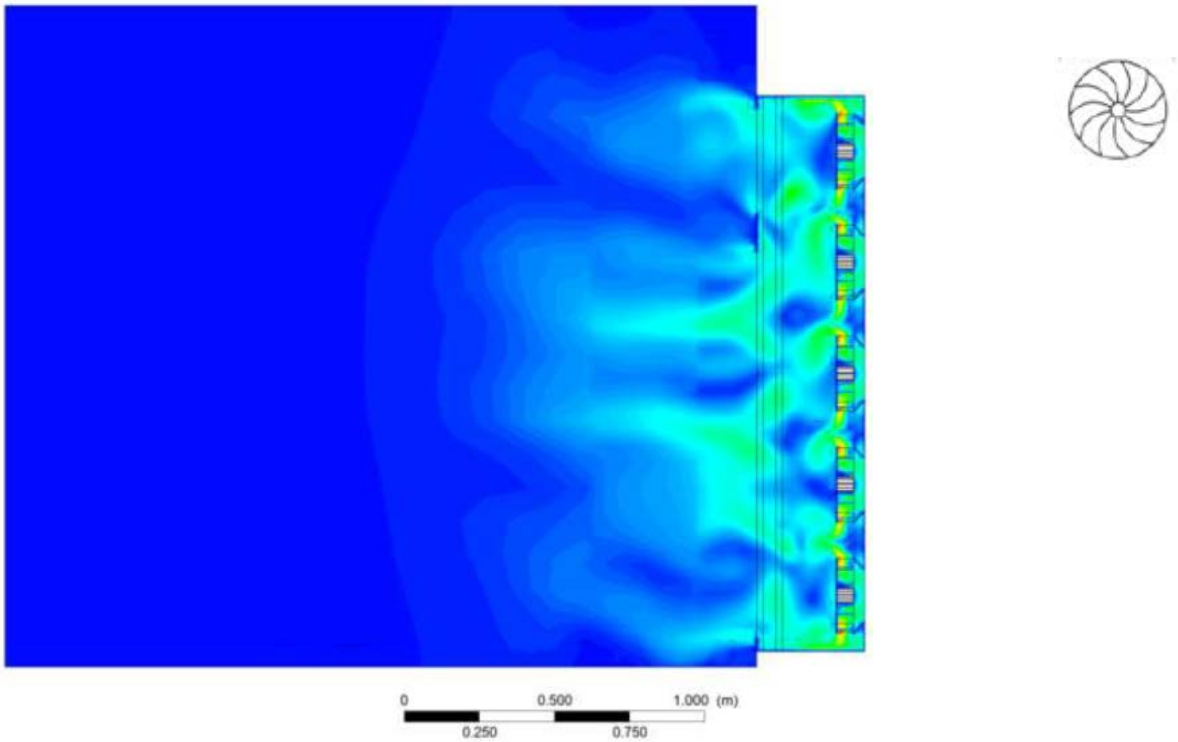
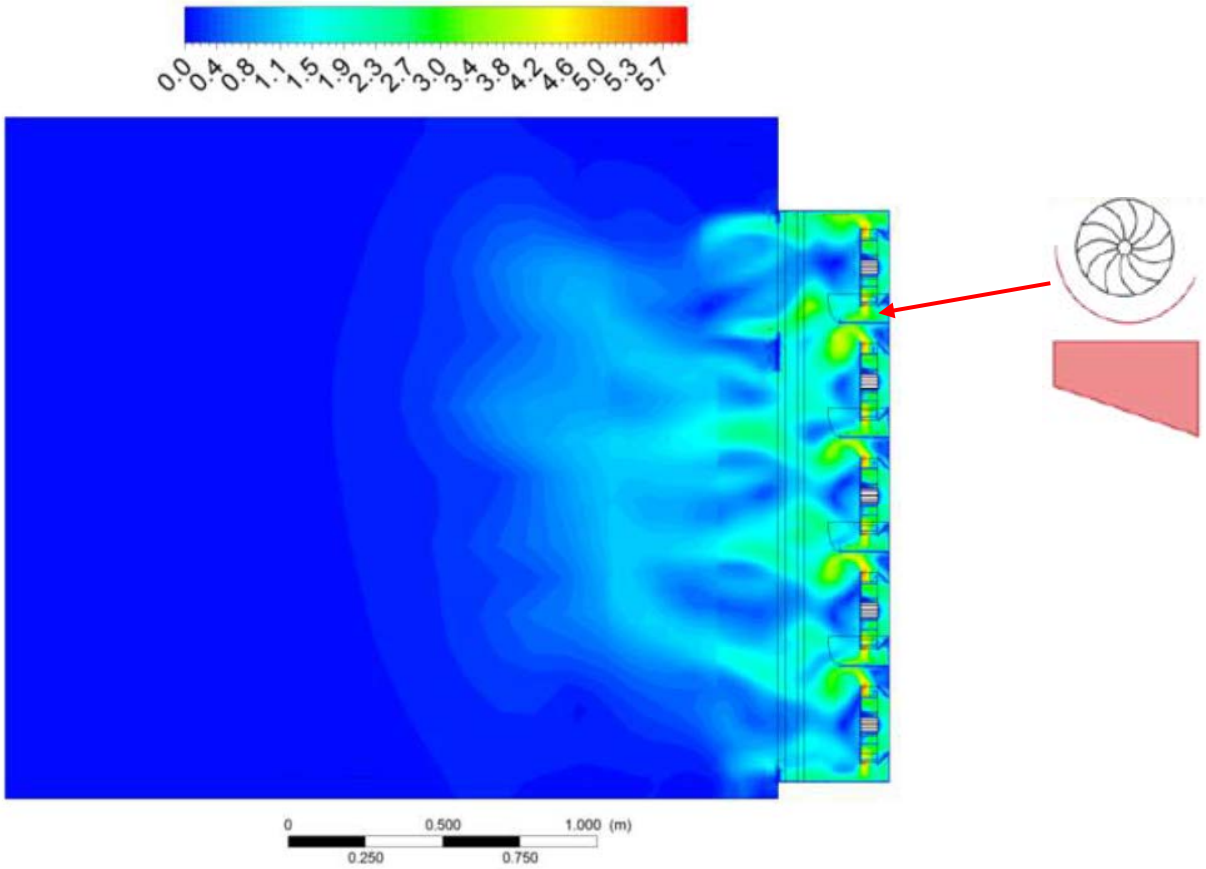
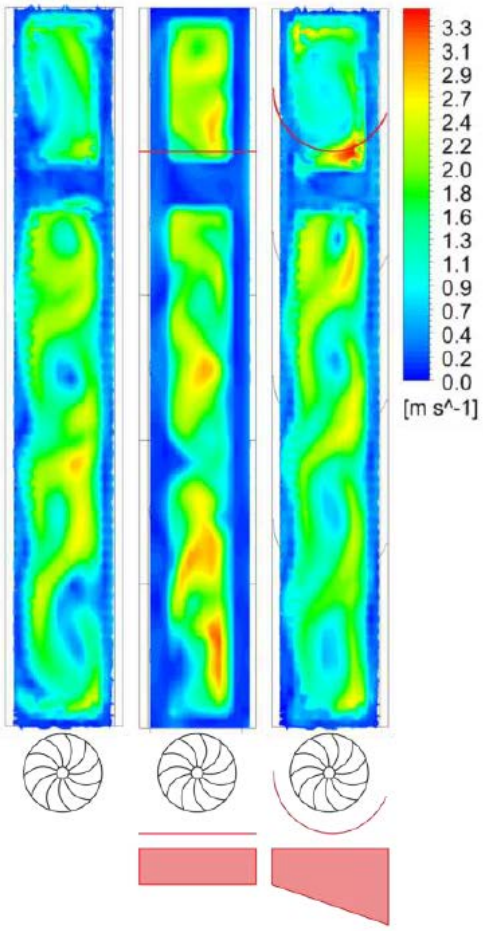
Air separation plate between individual fans

Mathematical models show the velocity of the air supply from the cooling unit with 5 radial fans. The velocity is indicated in m/s, symbol on the right side represents the shape of the air separator between individual fans. First is the standard make of the cooling unit, the second is without air separation plates and finally the third model is with semi-rounded V-shaped separators.









The specially designed air separation plates with deeper semi-rounded V-shape resulted, as expected, into a stable the air-flow rejected from the cooling unit. The goal of use of separators was to eliminate interaction between multiple air streams.

The next picture shows the air velocity field at the front door of the cooling unit, again for the 3 simulated models. The line with low air-flow bridging the diagram represents the display block in the cooling unit´s front door.

Conclusion 3 – Use of the air separation plate between individual fans

The separator of fans did not prove its benefits. The simulation results were not convincing – even for a stable air-flow the air volume, respectively the mass flow drops by tens of percents. The measurement in a specialized laboratory has shown air volume increase by approx. 1%, the homogeneity of the air-flow was not measured.

Used resources:

1) Internal documents and resources of CONTEG
2) STULZ GmbH publication library
3) Measurement reports from testing laboratories CONTEG and ATREA