

# Report

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## Testing and CFD Study of Airius Destratification Fans

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**Carried out for: Airius Europe Ltd**

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# 1 INTRODUCTION

Airius Europe distributes a range of novel destratification fans. These fans are thought to be unique in that the fan is enclosed in a casing, which incorporates guide vanes and a nozzle so that the air is thrown in a narrower jet.

This report presents the results of tests carried out on the model 10 and model 25 fan as well as computer simulations of the fans in operation.

The test work firstly involved measuring the flowrate through the fans, so that these could be accurately set in the CFD models. The flowrates were measured in accordance with ISO 5801, in a Type A configuration (free inlet and outlet).

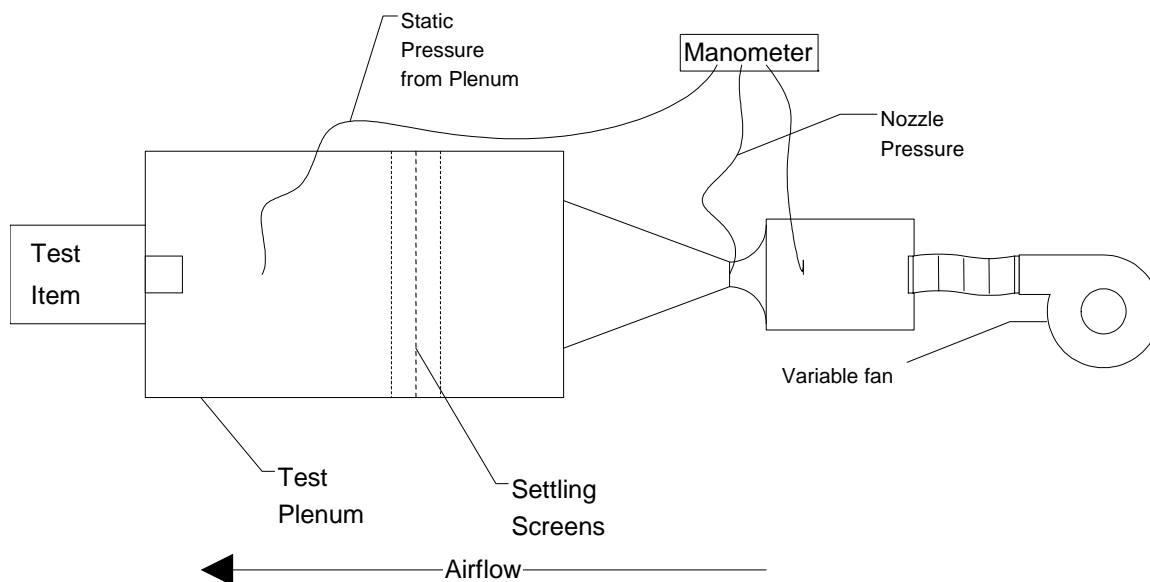
The jet of air from the fans were then measured to ensure the throw from the fans was correctly represented in the CFD simulations. These measurements are beneficial since the geometry of the nozzle and the presence or absence of swirl can influence the jet spread.

## 2 VOLUME FLOW MEASUREMENT

### 2.1 TEST METHOD

The fans were tested in accordance with ISO 5801, in a Type A configuration (free inlet and outlet). The test arrangement is in Figure 1 shown below.

**Figure 1 Airflow test arrangement**



The Airius unit was mounted on the plenum, with its inlet within the chamber. The variable speed fan was used to adjust the pressure in the plenum. This allowed the flow to be measured with a range of pressures across the test item.

### 2.2 INSTRUMENTATION

**Table 1 Equipment used during testing**

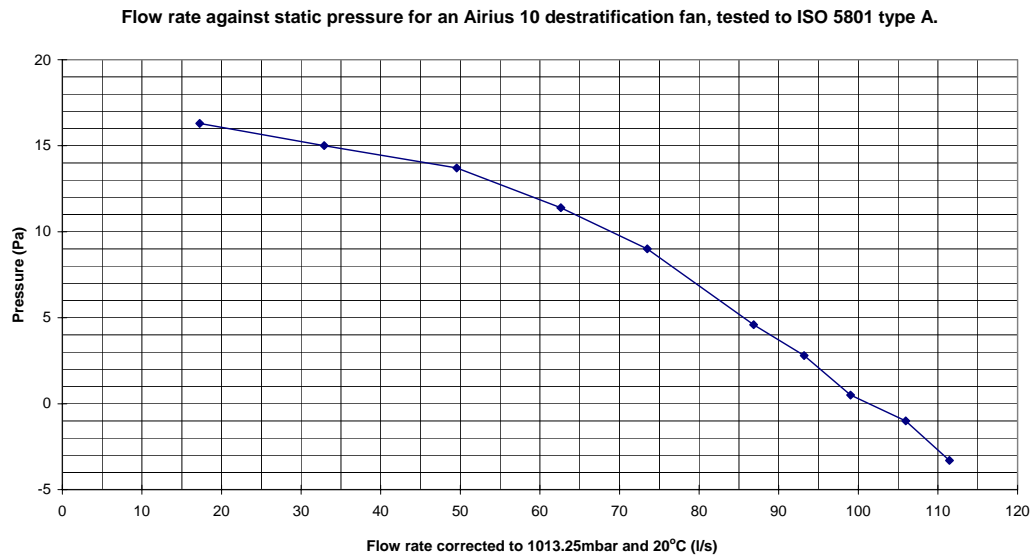
Name of Item	ID No.	Calibration Due on.
50 mm Nozzle Box	380	12 July 2008
Selection box – pressure tapping selection	369	24 November 2006
FCO510 Micro-manometer	374	27 March 2007
Temperature probe	481	28 March 2007
Absolute pressure sensor	482	28 March 2007

### 2.3 VOLUME FLOW RESULTS

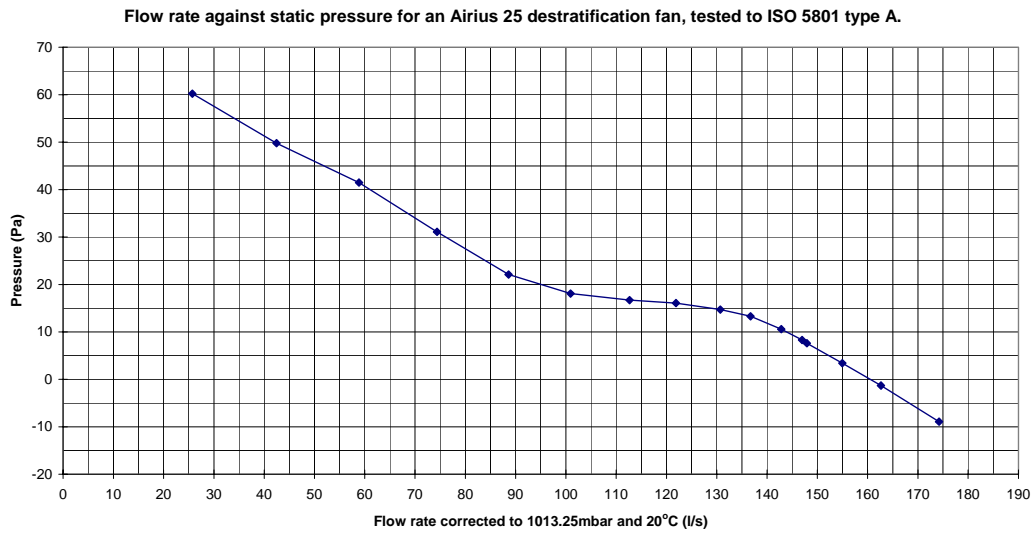
Plots of flow rate against static pressure are shown in Figure 2 and Figure 3 below.

In summary, under free air conditions the Airius 25 had a flow rate of 161 l.s<sup>-1</sup> and the Airius 10 had a flow rate of 101 l.s<sup>-1</sup>, when corrected to standard temperature and pressure.

**Figure 2 Airius 10, flow vs pressure chart**



**Figure 3 Airius 25, flow vs pressure chart**



### 3 AIR JET MEASUREMENTS

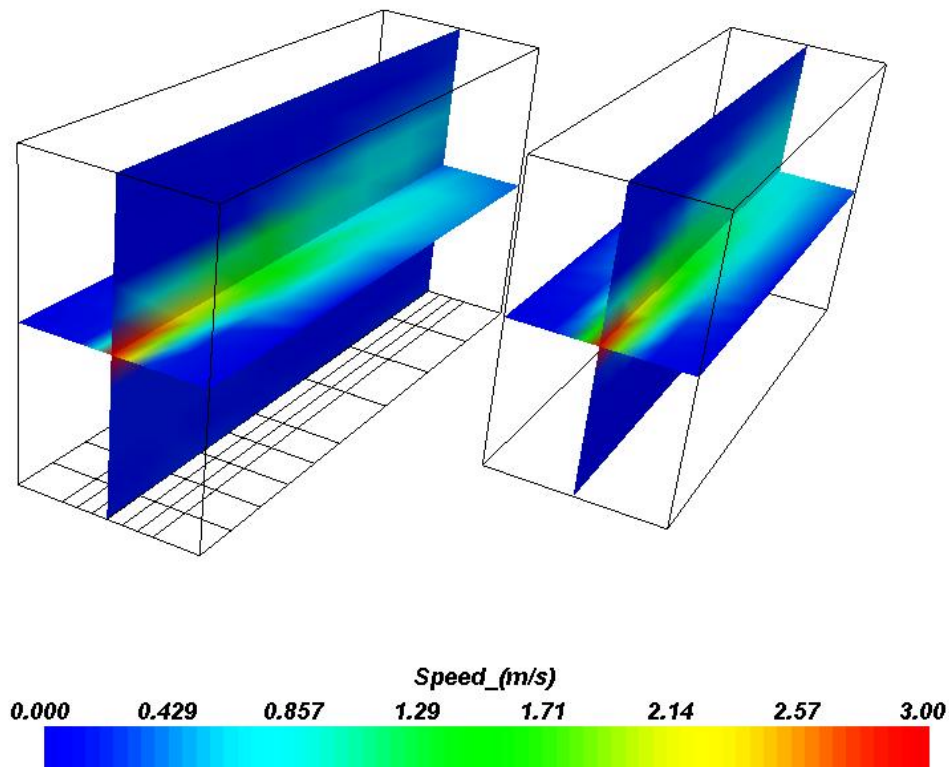
#### 3.1 TEST METHOD

The jet of air created by the model 10 and model 25 destratification fans were measured using hot wire anemometry. Close to the fan discharge where airspeeds were highest, a vane anemometer was used since these speeds exceeded the range of suitability of the hot wire anemometers.

The tests were conducted under approximately isothermal conditions and the fans were tested in a horizontal position. Eleven anemometers were attached along a vertical pole. A grid of points (9x10) was marked out on the floor, covering an area of 1.2 x 4.2 m. The pole of anemometers was then moved from grid point to grid point and all eleven readings were taken at each pole location. This gave a total of 990 air speed measurements (9x10x11). Both fans were tested in this manner.

In order to check the CFD code can correctly predict the spread of the jet, comparisons were made between the measured air speeds and isothermal CFD calculations. Figure 4 shows a comparison of air speeds using colour coded planes through the axis of the jet. The left side show the experimental measurements (grid points are marked on the floor), the right side shows the CFD calculations. A very close correspondence is seen.

**Figure 4** Measured airspeeds (left) and calculated air speeds (right) for model 10 fan



## 4 CFD MODEL SETUP

The flovent CFD code was used to simulate airflows and temperatures three-dimensionally in the example buildings. Steady state results are presented (ie temperatures and airflow patterns after sufficient time for all values to stabilise to constant values).

### 4.1 LABORATORY (SHED TYPE BUILDING)

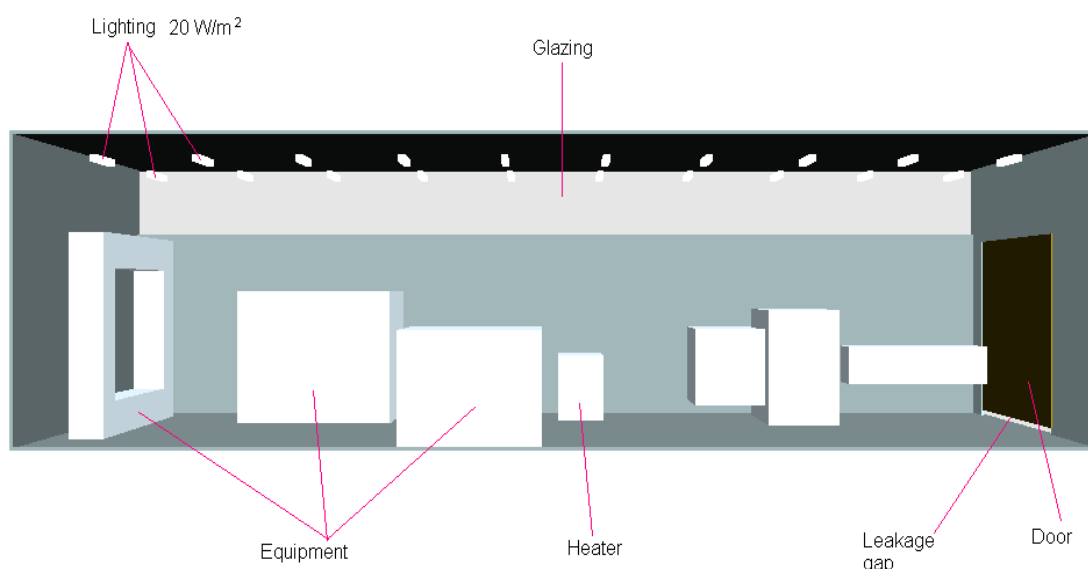
The geometry of the building used to test the model 25 fan is shown in Figure 5. The building is loosely based on one of the BSRIA test laboratories. Floor plan dimensions are 10m x 30m and fan height is 7.5 m. Various test rigs are distributed around the space. One side of the building is glazed at high level.

Fabric losses are based on an outdoor temperature of 2°C and U values of the structure set to coincide with Part L of the 2002 building regulations. To further help the space to stratify a 1.5 cm gap is modelled under the loading door and a similar open area is assumed at high level. By including these openings in the model, cold air tends to flow under the door and contribute to the stratification. Lighting is assumed to amount to 20 W/m<sup>2</sup>. This is implemented as 20 heated blocks at ceiling level, each one releasing 300 W.

An oil-fired heater provides further heating. This is assumed to supply 60 l.s<sup>-1</sup> of air at 80°C. In actuality the heater provides a much greater flow at a lower temperature, but this creates a strong jet that helps to mix the air and reduce stratification. The objective of this work was to investigate the ability of the Airius fans to destratify the space, so the modelled building was deliberately set to encourage stratification.

When simulating the influence of the fans, three, model 25 fans, were arranged along the centre line of the building. Hence a floor area of 100 m<sup>2</sup> per fan, is tested. A further simulation was then carried out with four fans (hence 75 m<sup>2</sup> per fan)

**Figure 5** Modelled geometry

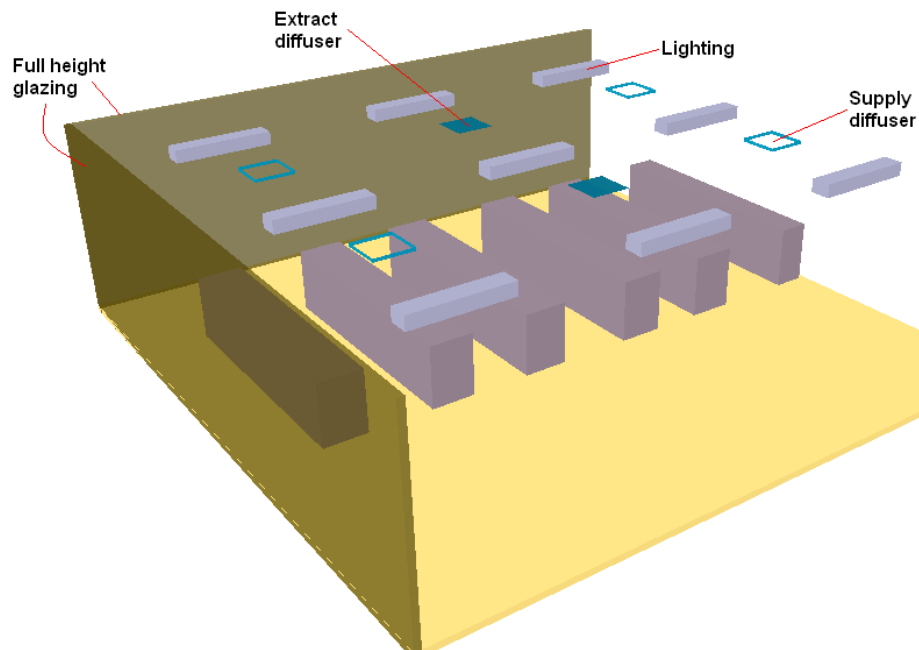


## 4.2 RETAIL OUTLET

The building selected to test the model 10 fan, was one corner of a retail outlet. The geometry is shown in Figure 6. An area 10 x 10 m is modelled, with a ceiling height of 3 m. In order to limit the model to a floor plate of 10 m x 10 m, airflows between the modelled region and the rest of the store are prevented (ie the corner is partitioned off from the rest of the store for modelling purposes). Lighting is modelled using nine heated blocks distributed along the ceiling, each one releasing 133 W. This gives a lighting load of 12 W/m<sup>2</sup>. To encourage stratification an outdoor temperature of 2°C is modelled and full height glazing is set along both external walls. U values of the building are set to correspond with the requirements of Part L of the 2002 building regulations.

To heat the space, air at 24°C is supplied through four ceiling mounted diffusers. Two extract diffusers remove air from the space. The supply diffusers are of a four way throw type and supply 160 l.s<sup>-1</sup> each (extracts therefore remove 320 l.s<sup>-1</sup>). This results in an air change rate of 7.7 ACH.

**Figure 6** Modelled geometry



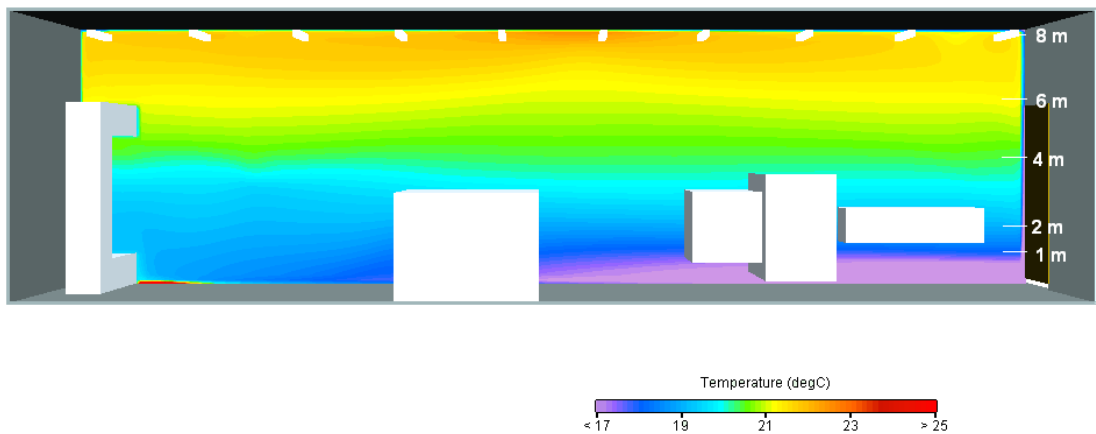
## 5 CFD RESULTS

### 5.1 LABORATORY (SHED TYPE BUILDING)

In Figure 7 temperature contours are plotted. A colour coded vertical plane through the building shows how temperatures vary with location. The colours relate to temperatures as indicated in the legend. Cold air leaks under the door and spreads along the floor, creating a large region under 17°C. A stratified temperature distribution is predicted with warm air floating towards the roof.

Figure 8 shows the corresponding result with the three fans operating. Since the contour plane passes through the fans, the warm jets can be seen projecting downwards. At the opposite side of the building from the door, destratification is almost complete. Close to the door, the steady flow of air into the building maintains a cold spot at ground level, but the improvement is obvious.

**Figure 7** Temperature contours along centreline



**Figure 8** Temperature contours with three fans installed

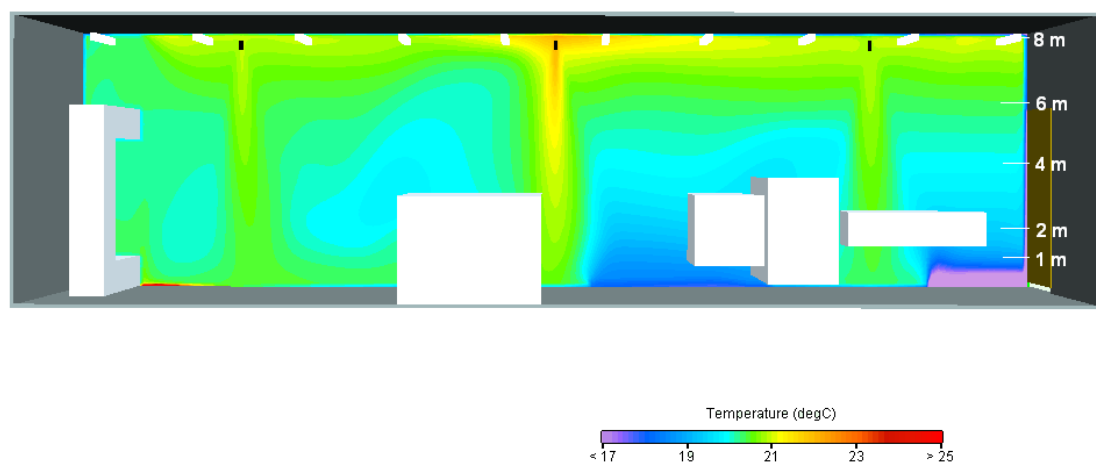
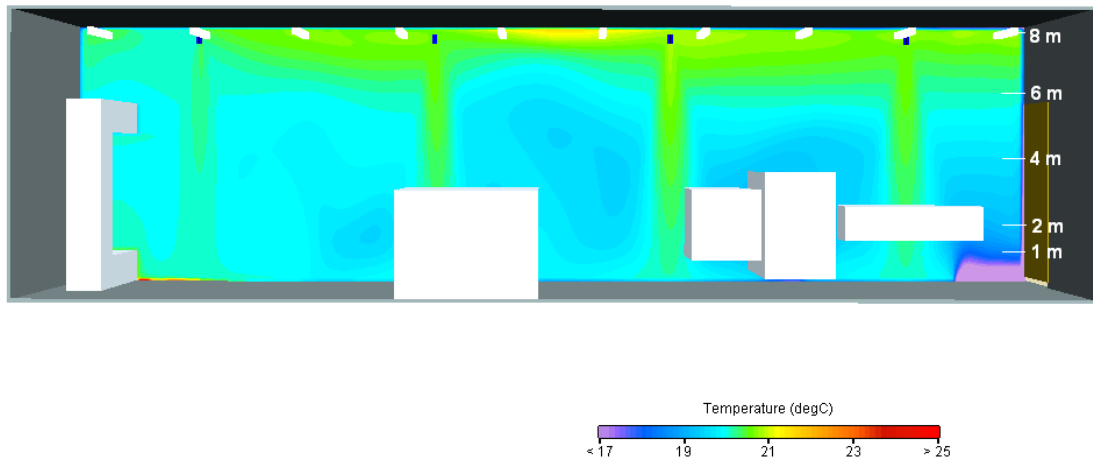


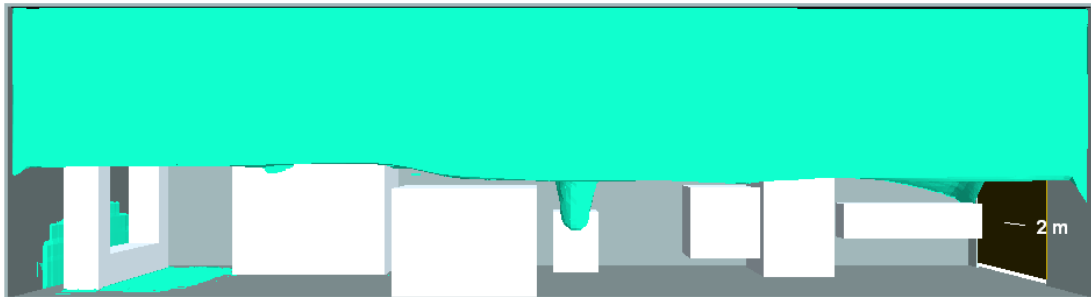
Figure 9 below shows the same building with four fans operating. A further improvement over figure 8 is seen; with an even more uniform temperature distribution.

**Figure 9**      **Temperature contours with four fans installed**

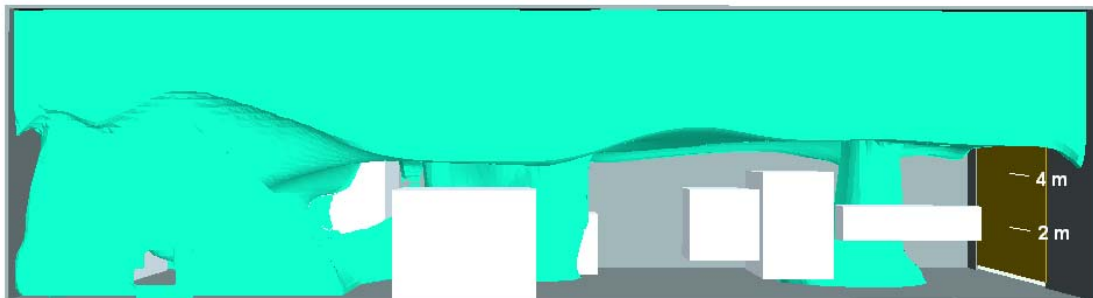


In Figure 10 the region with temperatures above 20°C is marked in green. This warm air is seen to float towards the top of the space and most of the occupied area is less than 20°C. The corresponding picture with three fans operating is shown in Figure 11. The layer of warm air, floating above occupants is reduced. Some of the columns of warm air from the fans are seen pouring down onto the floor. In figure 12 the scenario with four fans operating is shown. The blanket of warm air floating above the heads of the occupants is further reduced and the columns of warm air from the fans are clearly seen. The plume of warm air from the heater is also clearly visible.

**Figure 10** Zone with temperatures above 20°C (no fans)



**Figure 11** Zone with temperatures above 20°C (with three fans)



**Figure 12** Zone with temperatures above 20°C (with four fans)

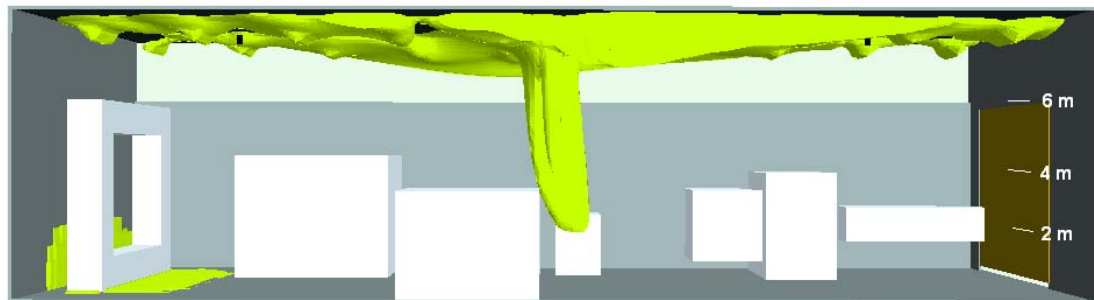


Figure 13, Figure 14 and Figure 15 shows the regions with air temperatures above 21°C without fans, with three fans and with four fans respectively. These again show how the quantity of warm air near the ceiling is reduced due to the fans. With the four fans running air temperatures above 21°C only arise near lights or in the warm air plume from the heater.

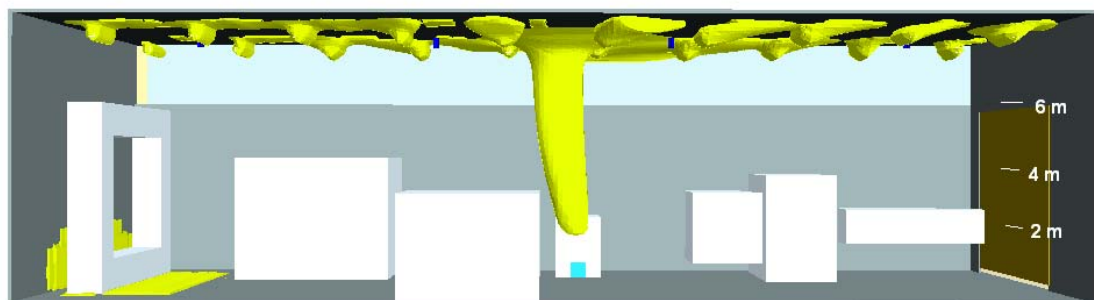
**Figure 13** Zone with temperatures above 21°C (no fans)



**Figure 14** Zone with temperatures above 21°C (with three fans)



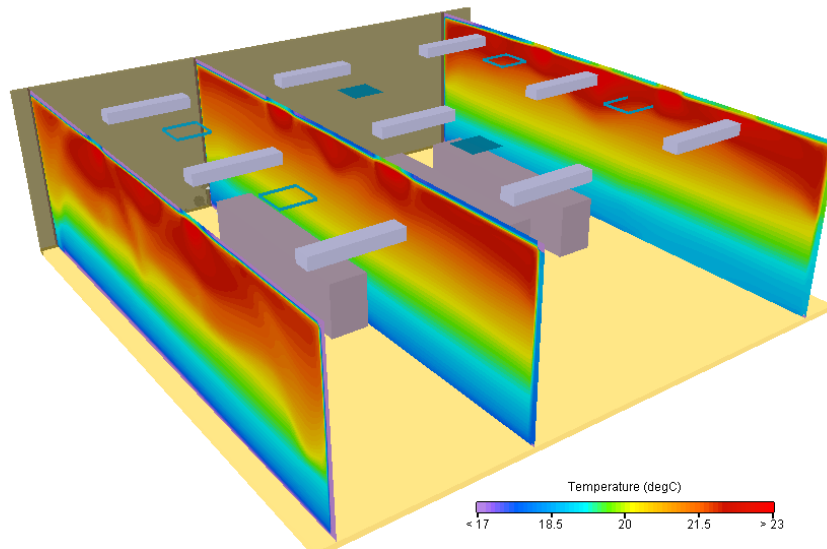
**Figure 15** Zone with temperatures above 21°C (with four fans)



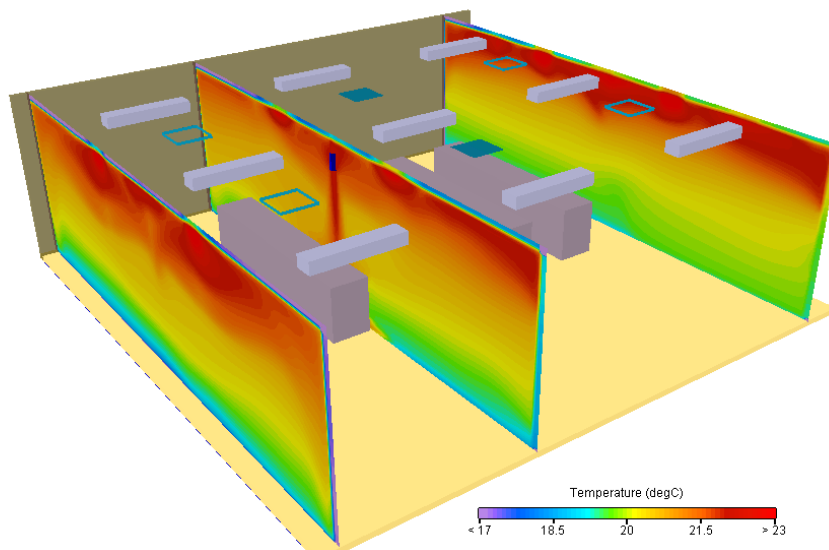
## 5.2 RETAIL OUTLET

In Figure 16 temperature contours are plotted on planes through the modelled region of the retail outlet. Due to the cooling effect of the glazing and heating from ceiling diffusers, a stratified temperature distribution is predicted. In Figure 17 the corresponding result is plotted for a scenario with a model 10 fan installed. The action of the fan can be seen in the centre plane as a warm jet descending from the ceiling. The overall effect is to reduce the stratification. The constant downdraft of cool air from the glazing means that some stratification persists especially to the left of the figures.

**Figure 16** Temperature contours (no fans)



**Figure 17** Temperature contours (with fans)



The major inputs, which gave rise to this result are:

- Full height glazing on two sides of the space
- An outdoor temperature of 2°C
- Heating through ceiling-mounted, four way throw type, diffusers

## 6 DISCUSSION OF RESULTS

Tests in accordance with ISO 5801 were conducted to determine the flowrates for the two Airius destratification fans. A flowrate of  $101 \text{ l.s}^{-1}$  was measured for the model 10 destratification fan and a flowrate of  $161 \text{ l.s}^{-1}$  was measured for the model 25 fan.

Air speed measurements were made across a grid of points in front of both fans to examine the spread of the jet and to ensure the CFD software could accurately represent this, in simulations of room airflow. A narrow jet was observed from these measurements, possibly because the fan incorporated vanes apparently designed to remove swirl. A good correlation was observed between CFD simulations and measurements of air speed.

A CFD model of a shed type building was used to examine the performance of the model 25 fan. Stratification in the test building was ensured by a combination of low outdoor temperatures, leakage under the loading door and heating via a low velocity air supply. The initial model without fans showed a stratification of  $17.0 - 22.6 \text{ }^\circ\text{C}$  between floor and roof at the centre point of the building. With four fans operating, this stratification reduced to  $19.8 - 21.6 \text{ }^\circ\text{C}$  at the centre point of the building. The extent to which stratification is reduced is dependant on the location. The best improvements are seen near the back wall of the laboratory, well away from the influence of the leaking door. The result is also dependant on the height at which the temperatures are read. This comparison is based on an ankle level measurement and ceiling level measurement.

A CFD model of one corner of a retail outlet was used to examine the performance of the model 10 fan. Stratification in the test building was ensured by a combination of low outdoor temperatures, full height glazing on the external walls and heating from ceiling mounted diffusers. With no fan fitted a stratification of  $18.3 - 22.2 \text{ }^\circ\text{C}$  was observed in the centre of the space. With the fan operating a stratification of  $19.1 - 21.7 \text{ }^\circ\text{C}$  was observed. As for the previous example, the influence of the fan varied throughout the space. Improvements were greatest furthest away from the influence of the cold glazing. As in the previous example the result is dependant on the height of the temperature measurements as well as the position in the room. Less stratification would be apparent if these temperatures were quoted at waist height instead of ankle height.

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