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# TEST REPORT

**REPORT NO. 26-11-09**

## TESTING OF ECOPOWER 400 UNDER EXCESSIVE HEAT CONDITIONS

Physical tests have been conducted to investigate the cooling capacity of an ecopower 400 operated under excessive internal thermal and dynamic weather conditions on a small building enclosure.


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## Part 1 -AIR FILTER RESISTANCE TESTING

**Aim:** To define appropriate sizes and types of airfilters which could maintain required indoor temperatures in a small building ventilated by an ecopower 400 operated under excessive internal heat and external dynamic weather conditions.

**Introduction:** An airfilter on the air supply inlet creates an additional amount of static pressure a fan must overcome. This pressure drop across an airfilter in this application should be measured as air is sucked through an airfilter at a given air velocity. However, CSR Edmonds does not have the appropriate facilities at hand to conduct this type of experiment. An alterative existing experimental set up for measuring pressure drop when air is blown through the filter has been used. In this situation, an airfilter creates an obstruction to the flow of air and this static pressure drop adds the impedance to the system which works to resist the flow. These tests do not comply with standard procedures and can be used only for indoor investigations.

**Customer:** External ("Ventfair", Germany)

**Test methods and specifications**

The tests have been conducted on inhouse experimental facilities situated within the Research and Development Department of CSR Edmonds on 12-30 November 2009.

The equipment used for measuring the pressure drop of the filter units is shown in figures 1. It is an inlet side test chamber fan test rig built in accordance with ISO 5801 (clause 26.10 and 70 b)). It has an inlet orifice plate with piezometer ring corner taps for flow rate determination. The inlet duct diameter is 400mm with the chamber hydraulic diameter being 1000mm.

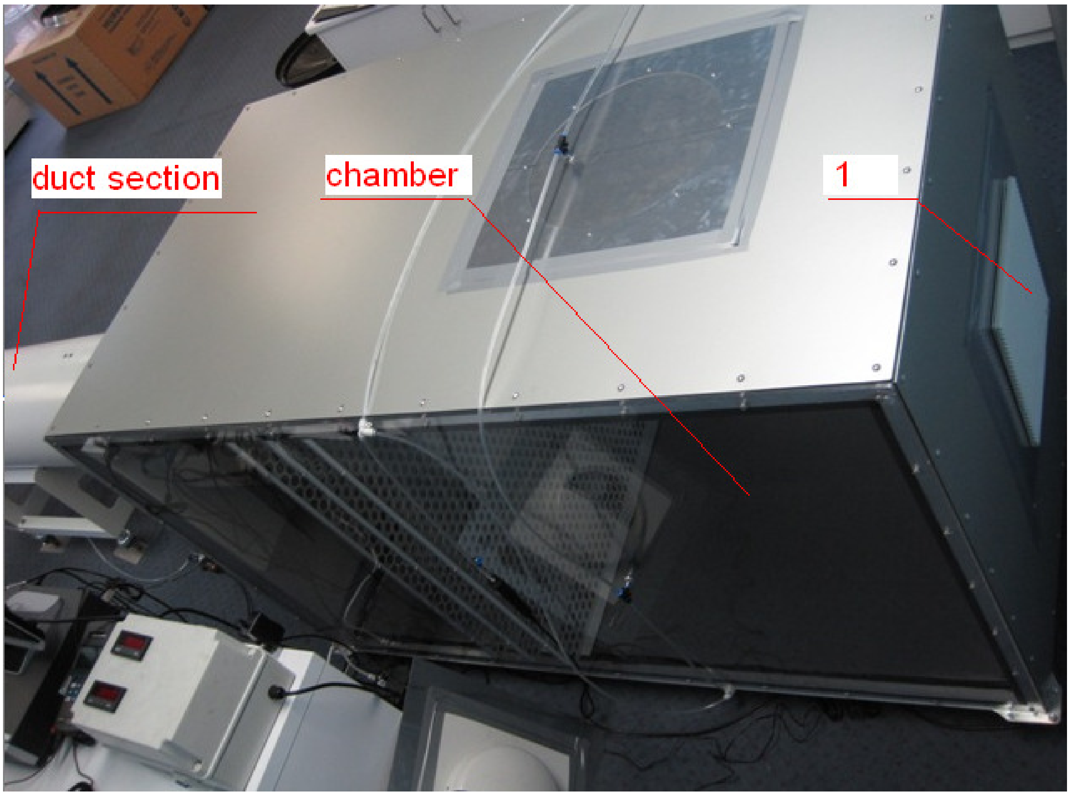


Figure 1 –Experimental set up

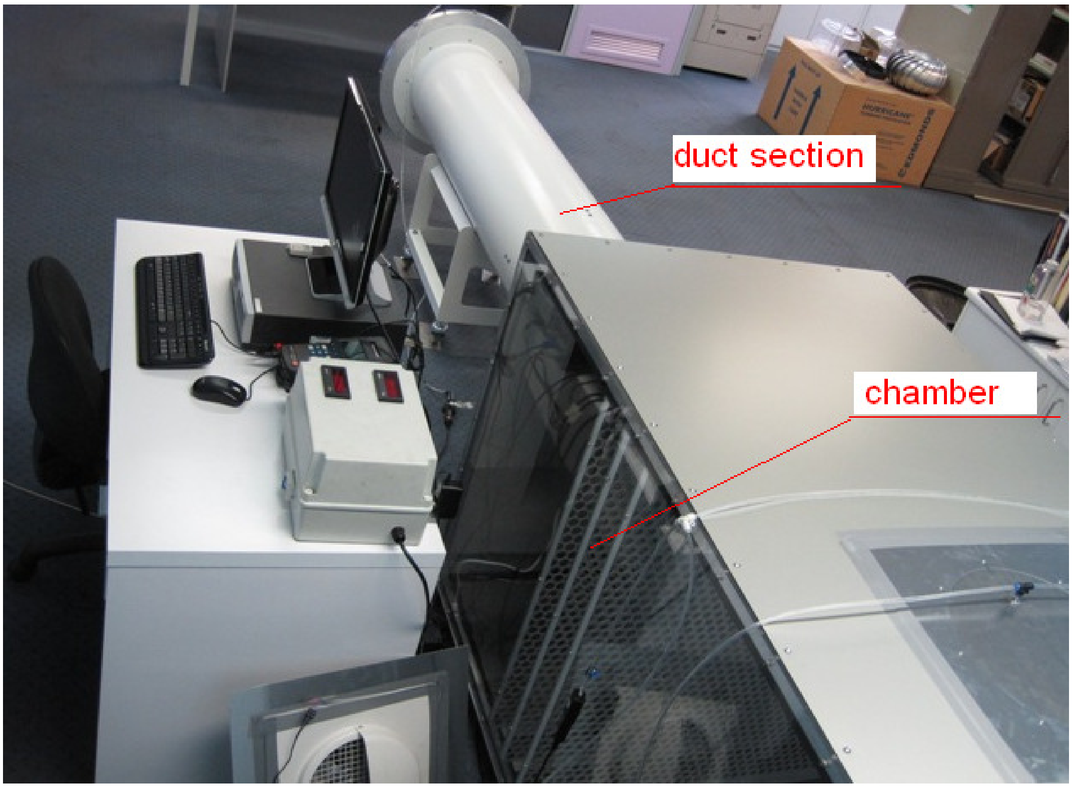


Figure 1 –Experimental set up (continuation page)

The grille assembly SK 3326.207 (Rittal) with an airfilter (1) to be tested was mounted to a face plate at the end of the chamber as is shown in Figure 1. This filter has an area of 250x250mm. Figure 2 depicts the grille assembly and used dirty Rittal filter element. Four different types of airfilters Rittal, G2, G3 and G4 have been tested for comparison.

Figure 2 –Grille assembly and dirty Rittal filter element

Test for all filters at a range of flow rates were conducted with measurements of the following made.

-the differential pressure across the orifice plate for flow determination;

-the differential pressure between atmospheric and chamber pressure for pressure drop determination.

Several readings were taken to obtain an average value.

The obtained values of downsteam pressure have been converted into the air flow rate as it described in ISO 5801(clause 26.10).

**Test results**

Figure 3 provides an indication of the resistance of the various filter elements as a function of the flow velocity across the filter.

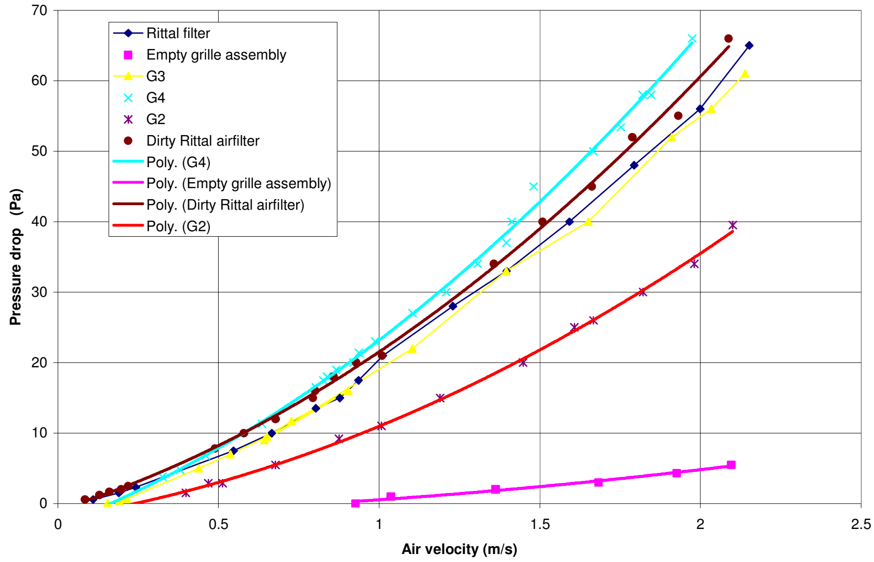


Figure 3 – Air filter resistance


Figure 4 – Characteristics of airfilters (Source: ASHRAE 52.1-1992 or EN 779)

It can be seen from Figure 3 that the change in pressure drop for G3 is very similar to the pressure drop for the Rittal airfilter. For further experiments it was assumed that the Rittal airfilter is identical to G3.

The pressure drop across G3 can be defined from ASHRAE 52.1-1992 or EN 779 as is shown in Figure 4.

The comparison between Figure 3 and Figure 4 reveals that all functions obey a parabolic law and the highest pressure drop across the airfilter corresponds to G4 and the lowest value was found for G2. Assuming that there are correlations between these two situations, the pressure drop across the grille assemblies unit can be found from Figure 3 by multiplying the values from Figure 3 on the corresponding correlation function.

Actual flow rates for tested solutions can be found from Figure 5. The highest value of air flow rate of 1080 $m^3$/hour was found to be for an empty grille assembly with no filter element and the lowest value of 220 $m^3$/hour for a used dirty Rittal filter.

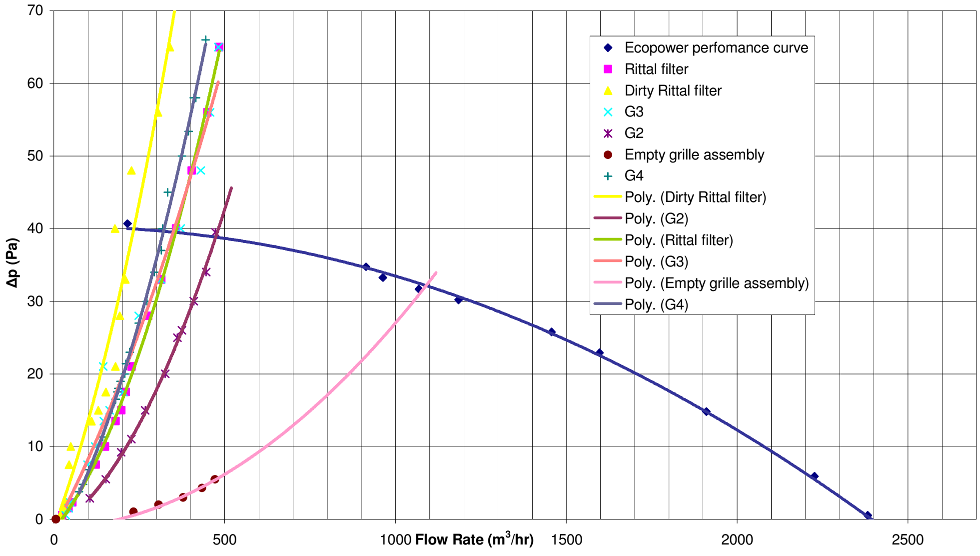


Figure 5 – Performance curve of Ecopower 400

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## PART 2 –AIR FILTER BUILDING TESTING

**Aim:** Assess the performance of the ecopower 400 to remove excessive internally heat for different levels of inlet area resistance under various climatic conditions

**Customer:** External ("Ventfair", Germany)

**Test methods and specifications** The building is designed for the purpose of comparing various insulation/ventilation solutions. The building contains various monitoring equipment, including type K thermocouples and Vaisala Temperature and humidity Probes. The data is recorded using Datataker DT 85's. The buildings can be seen in Figure 6 below.

Figure 6 -Testing building

The building wall section is shown in Figure 7.

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Figure 7- Testing building wall section

The building faces north with a roof pitch of five degrees. The building external dimensions are 2120mm wide x 2120mm long and 2450mm high on the tallest side.

The ecopower 400 ventilator (CSR Edmonds) and the T5 400 mm damper (CSR Edmonds) were fitted to the roof. Two electric oil heating radiators (De'Longi) were placed in the building. Heat output of each radiator was 1.5 kW. During this testing time, the average heat output was 2.8 kW. One of the heaters turned off for short periods of time during the day as it had reached its internal thermostat set point. This reduced the average heat output from 3.0kW to 2.8kW.

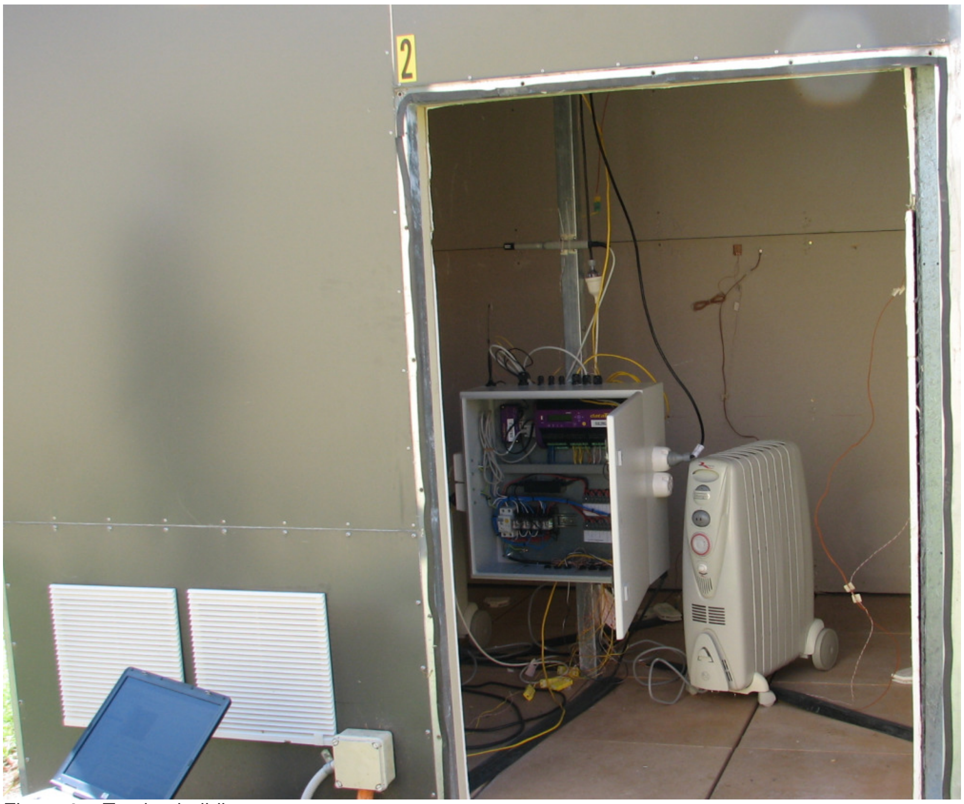

Figure 8 – Testing building

Figure 9- The Ecopower 400 and the T5 400 mm damper

Two filter units SK 3326.207 (Rittal) were installed into the inlet area . From the 15 October to 28 October, airfilters have been installed into the grille assemblies (first airfilter solution) and from the 28 October to 23 November experiments have been conducted with one empty grille assembly and one section with installed airfilter (second airfilter solution).The indoor environment has been analysed for different levels of solar radiation and ambient temperatures.

Schematics of the testing assembly are shown in Figure 8 and Figure 9.

Actual flow rates for both solutions can be estimated from graph 11, for first airfilter solution actual flow rate is 685 kg/hour and for second is 1000 kg/hour.

The parameters being measured:

- Interior and exterior wall temperature, for every wall and roof
- Interior air temperature of the building
- Interior air relative humidity of the building
- Ambient temperature (outside)
- Interior inlet temperature (near the ventilator throat)
- Interior outlet temperature (near the inlet area)
- Wind speed (measured in 20 second intervals and averaged for every 5 minute time cycle)
- Solar radiation

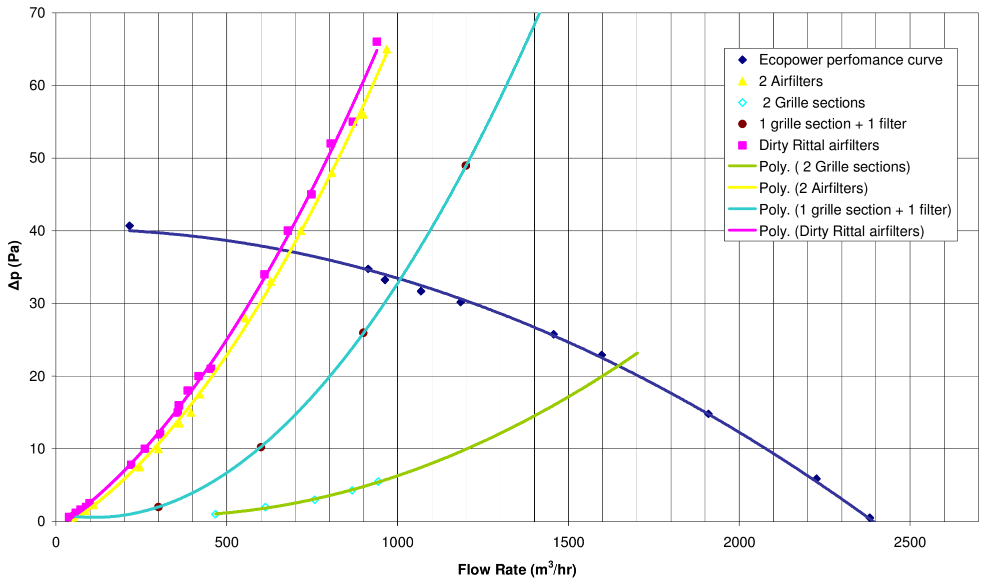


Figure 11 – The performance curve of Ecopower 400

The data was logged continuously over the period 15 October 2009 – 23 November 2009, in 5 minute intervals.

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## Test results

The below charts illustrate the internal thermal behaviour of the building for the different levels of solar radiation and ambient temperatures.

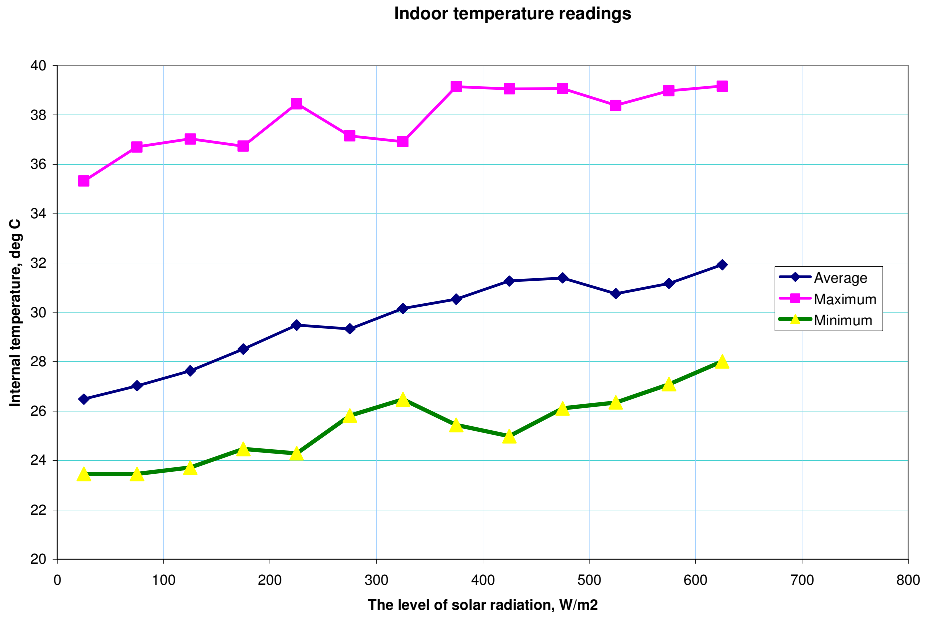


Figure10 Internal temperature vs solar radiation for first airfilter solution (2 Rittal air filters)

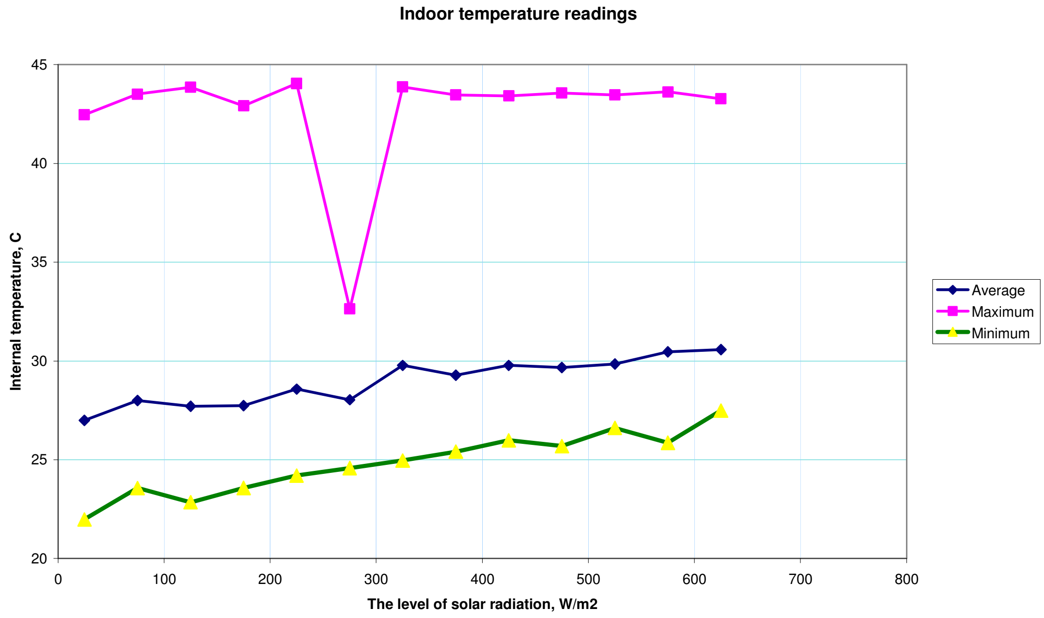


Figure11 Internal temperature vs solar radiation for second airfilter solution (1 Rittal air filter and 1 empty grille)

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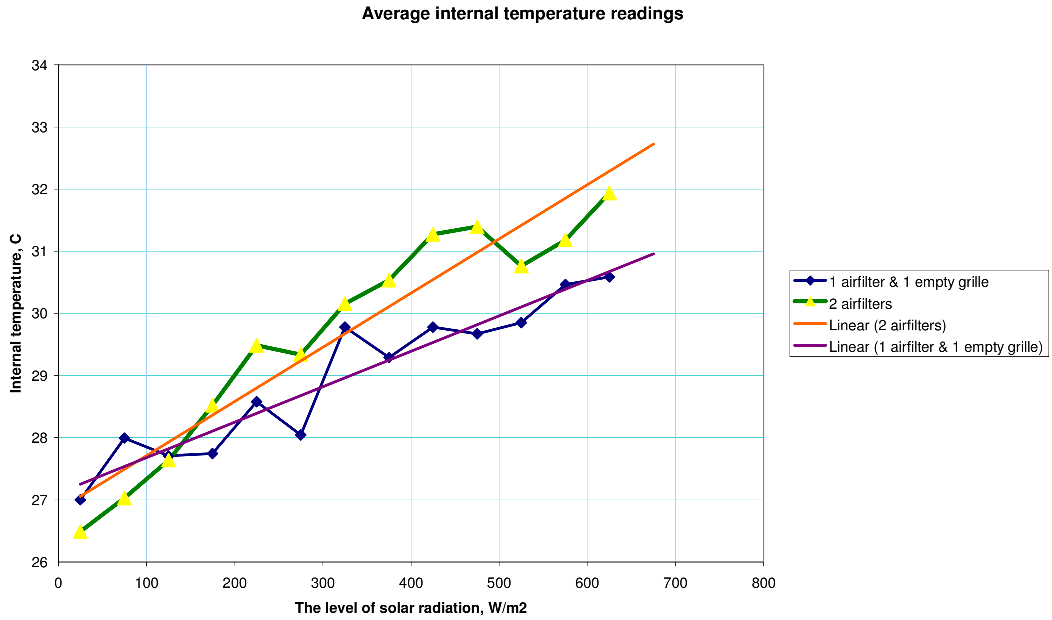


Figure12 Average internal temperature readings for both solutions vs solar radiation

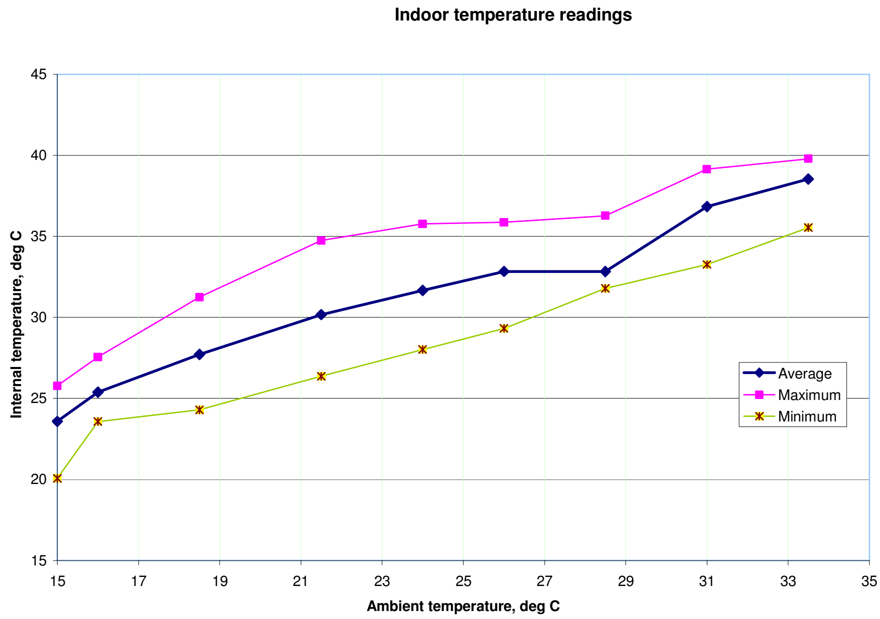


Figure 13- Internal vs ambient temperature for first air filter solution (2 Rittal air filters)

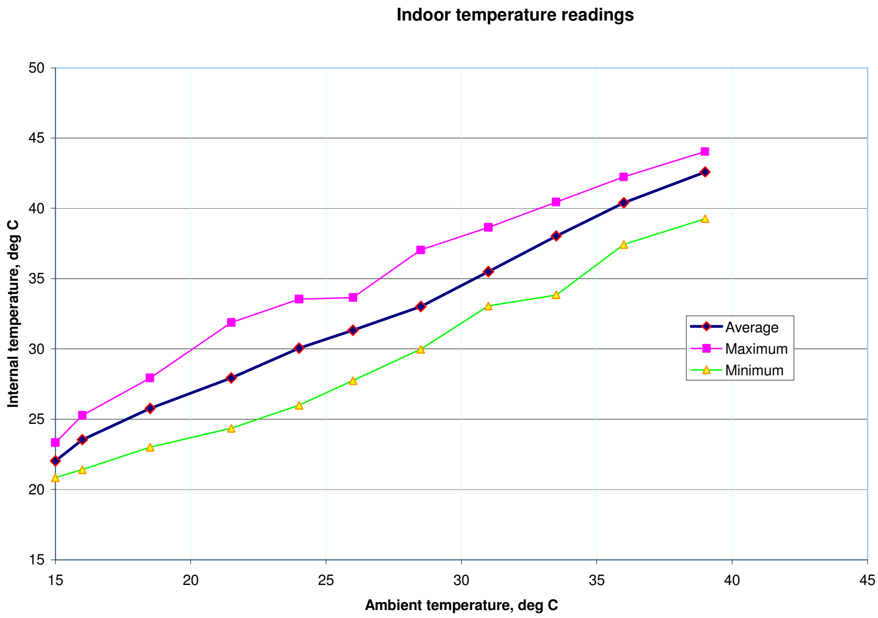


Figure 14 Internal vs ambient temperature for second filter solution (1 Rittal air filter and 1 empty grille)

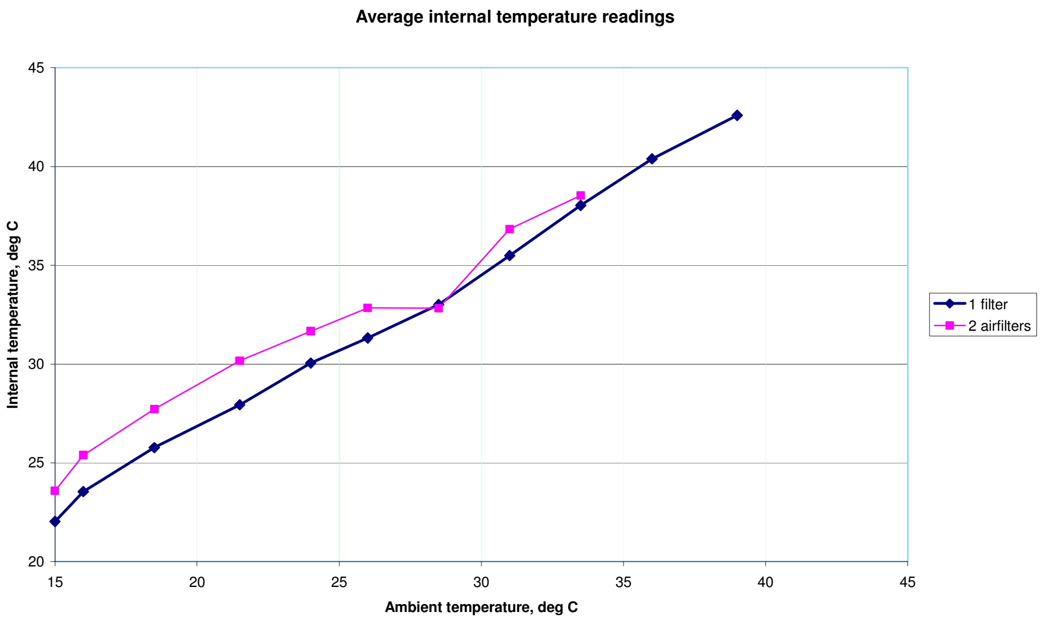


Figure 14 Average Internal temperatures for both airfilter solutions vs ambient temperature

**Discussion**

Testing of one empty grille (without filter element) and another grille with filter fitted was undertaken to increase flow rates. The increased flow rate through this removal of one of the filter element and leaving one element in place is equivalent to fitting 4 Rittal filter elements of this size (250x250mm each, 0.0625m2).

As it can be seen from Figures 10-12, indoor temperature slightly increases with increasing level of solar radiation and it can be approximately correlated by a linear function. The linear curves have different slopes which indicate that second airfilter solution in the comparison with first air filter solution provides more stable thermal indoor environment due to a lower gradient.

Figures 13,14 and 15 further reinforce that the indoor temperature is higher for the first airfilter solution and both curves linearly correspond to ambient temperatures. Obviously higher flow rates improve the heat removal rate and help maintain lower internal temperatures.

Roughness of the first solution graphs indicate that not enough data has been collected to be certain of the results and reach definite conclusions. However it can be seen that for the most part internal temperatures are able to be kept below 35℃ except during high ambient temperatures above around 30℃.

**Conclusions**

The tests show that temperatures can mostly be kept below 35℃ except during high ambient temperatures above 30℃. It is recommended that a minimum of four Rittal filter elements (G3 equivalent) with a total area of 0.25m2 (0.0625m2 each) be used.

Further field testing in the actual applications is recommended to confirm these results.

**Test officer**: Tatiana Kivva