TEST METHOD OF HEAT RECOVERY UNITS IN SINGLE HOUSES

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KEYWORDS
Ventilation – Energy Management – Heat Transfer – Performance – Standard

ABSTRACT

The study was to test five units used in single house mechanical ventilation systems with heat recovery. Tests were made according to CEN project prepared by CEN TC 156/WG2/AH7 including air tightness, pressure-airflows curves and temperature ratios. A full test on frost and condensation was also realised on one unit to determine the influence of these parameters on performances. Test results, influence of wet or dry conditions and main conclusions for using these results in dimensioning, will be given.

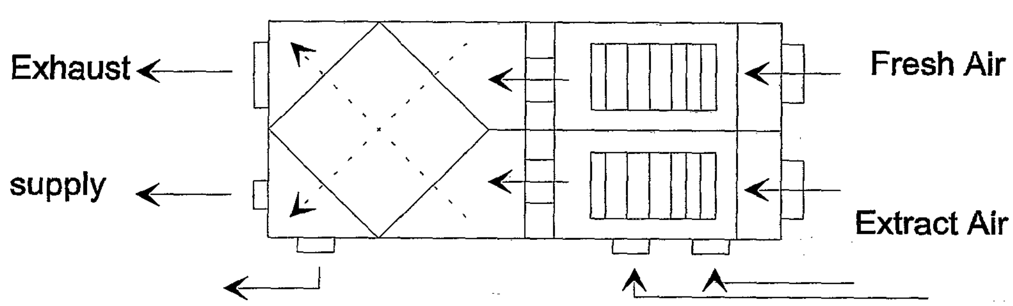
LIST OF SYMBOLS

θextr :	exhaust air dry bulb temperature
θwet, extr :	exhaust air wet bulb temperature
θdew, extr :	exhaust air temperature at dew point
θsupply :	supply air dry bulb temperature
Δθsupply :	difference of temperature on supply air
Δθinlet :	difference of temperature between both supply and exhaust air entering the unit
η :	temperature ratio (defined in EN308) in dry conditions

INTRODUCTION

This study aims a better knowledge of the performances of balanced ventilation systems with heat recovery, used in standard single houses in France.
The paper focuses on test results on :

- thermal performances of the unit
- influence of humidity and frost on efficiency
- air tightness and aerodynamic performances.



PERFORMANCES OF THE UNITS

Description of the units

Five units combining exhaust and supply fans, filters and a heat recovery exchanger were tested. Four units had double speed fans to fulfill the conditions of French regulation which imposes a nominal extract airflow and an increased one in kitchen when necessary.

Table 1. Description of the units

Unit #	**1**	**2**	**3**	**4**	**5**
Fans position					
Exhaust	downstream	upstream	upstream	downstream	downstream
Supply	downstream	downstream	upstream	downstream	downstream
Number of heat exchangers tested					
number	2	1	1	2	1
material	plastic (PVC)	plastic (PVC)	plastic (PVC)	plastic (PVC) and aluminium	Aluminium

Temperature ratio

For each fan speed, temperature ratio were determined according to EN308 [1] and CEN TC156/WG2/AH7 [2] project as follows: $\eta = \frac{\Delta\theta_{supply}}{\Delta\theta_{inlets}}$

These tests were performed without condensation, in the following conditions :
- exhaust air dry bulb temperature : 25 °C wet bulb temperature : < 14 °C
- supply air dry bulb temperature : 5 °C

Results with balanced airflows

The following table (Table 2.) shows temperature ratio results of both the full unit and the heat exchanger ratio alone (calculated by substracting 80% of fan power to the unit ratio when the fans were participating to the results, see fan position in Table 1).

Table 2. Tested temperature ratio

Unit	Unit temperature ratio (%)			Heat exchanger temperature ratio (%)			Fan absorbed Power (W)	
#	Low speed	High speed	Difference	Low speed	High speed	Difference	Low speed	High speed
1 PVC 1	71	66	5	70	64	6	56	123
1 PVC 2	75	70	5	74	69	5	58	123
2	74	71	3	72	69	2	116	127
3	64	55	10	63	52	11	71	109
4 ALU	71	68	3	67	59	8	55	187
4 PVC	64	64	0	61	56	5	56	186
5	-	72	-	-	70	-	--	160

We can note that :

- increasing speed slightly decrease performance (in average, the ratio decreases of 4 points)
- fan position and absorbed power do have a strong influence on performance
- although most tested heat exchangers are built very similarly, temperature ratios are quite different (between 61 and 74%).

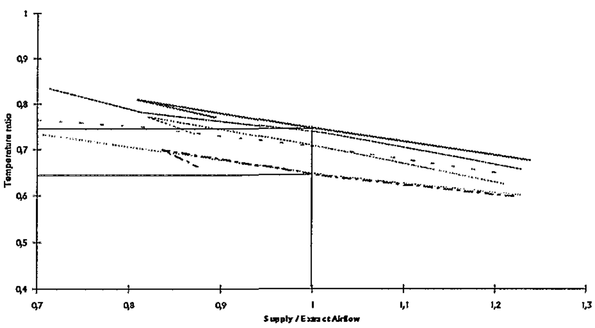


Figure 1. Unit temperature ratio - standard speed - unbalanced airflows

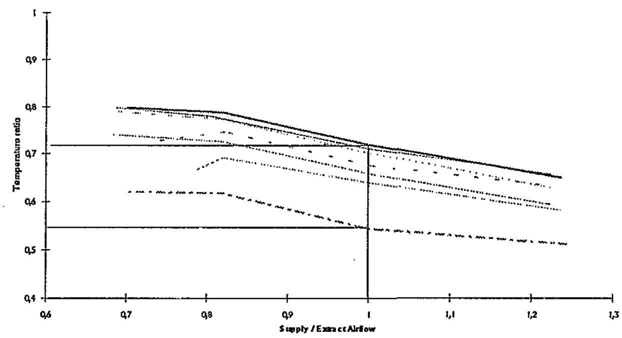


Figure 2. Unit temperature ratio-maximum speed - unbalanced airflows

Each curve corresponds to one tested unit.

Influence of humidity

On the same unit (# 1), tests were made for 4 test points with condensation of water vapor contained in exhaust air:

Table 3.

Test point	1	2	3	4
θsupply	7°C	2°C	7°C	2°C
θextr θwet, extr	20°C 12°C	20°C 12°C	20°C 17°C	20°C 17°C
Δθ = θdew, extr - θsupply	4.7 °C	9.6 °C	10.1 °C	15.1 °C
Relative Humidity	68.8%	81.3%	80.5%	84.3%

Condensation depends on :
- exhaust air moisture (θdew, extr)
- dry bulb temperature on supply air (θsupply).

Figure 3 shows the influence on the temperature ratio depending on : $\Delta\theta = \theta_{dew,\ extr} - \theta_{supply}$
We note that the increase of temperature ratio due to condensation is mainly linear (+ 1,5 %/°C).

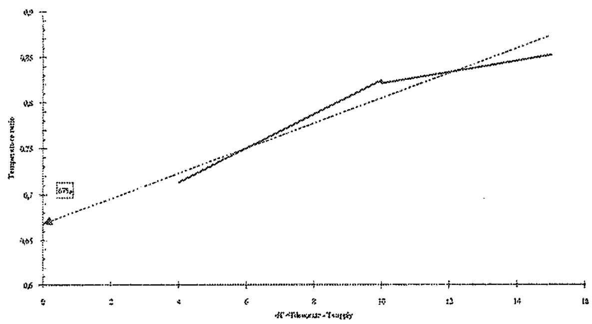


Figure 3. Influence of condensation

Influence of frost

A test has been run during 4:30 hours with the following conditions :
θextr : 20°C (θdew, extr has varied between 16 and 17.4°C during the test)
θsupply : - 7°C

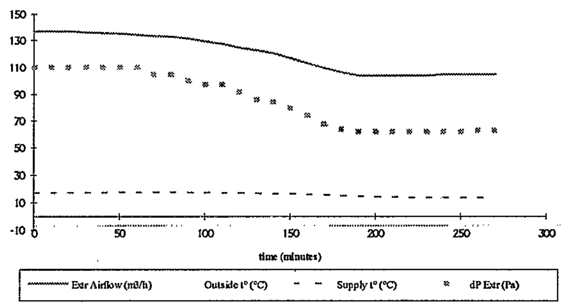


Figure 4. Loss of performances due to frost

The loss of performance was stabilised after 3 hours and the airflow had decreased of 27%. The exchanger was not totally filled in by frost. We can consider that a lower supply temperature could induce a more important loss of airflow even down to zero. A variation of the exhaust air moisture induces a variation of the time necessary to stabilise. For French climates, the risk of frost is mainly restricted to some continental areas like eastern part of France where outside temperatures are more extremes.
In this area, the use of a supplementary coil is necessary to prevent frost.

AIR-TIGHTNESS AND AERODYNAMIC TESTS

Air-tightness

Both standards [1 & 2] indicate some air-tightness tests to determine casing-leakage as well as internal leakage.
Figures 5. and 6. show these results for positive and negative pressures.

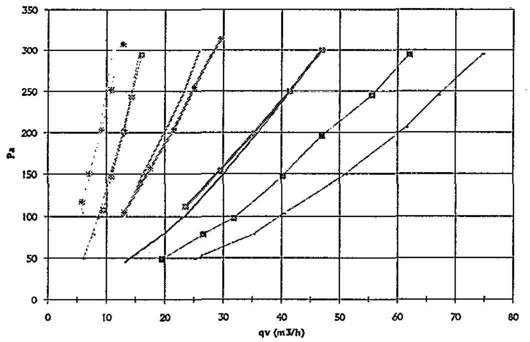


Figure 5. Case-leakage

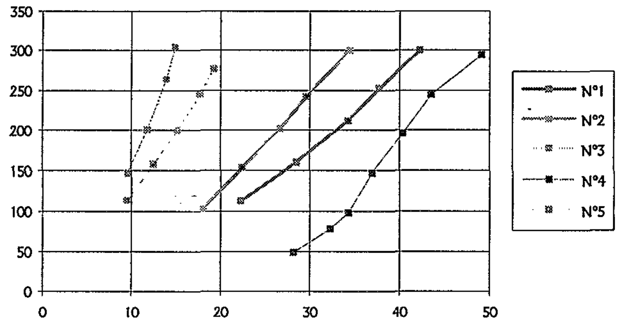


Figure 6. Internal leakage

The European project [2] defines a ratio of leakage flow out of maximum airflow of the unit. When internal leakage flow is measured at 100 Pa, case-leakage flow is measured at 250 Pa and both shall be lower than 5% of maximum airflow to continue testing.

Only two units out of five did fulfill each requirement separately and only one fulfilled simultaneously both conditions. Therefore, tests should have been abandoned on most units.

These requirements in the European project are quite conservative and based, as the project says, on "technical reasons" which are not justified. A possible explanation could be some difficulties in obtaining a good thermal balance during the test.
We did notice such difficulties on unit having the highest leakage but this was only at much higher rate.

Most TC156 working groups have chosen to deal with the leakage problem by defining classes of performances (like Eurovent 2/2). We feel that air-tightness is a most important subject that should be dealt with uniformity in all texts written by TC156.

Aerodynamic results

Pressure airflow curves were drawn for each speed and each unit and Fan absorbed power (see Table 2.) was measured simultaneously with thermal tests. Figures 7. and 8 show main results for exhaust air fan.

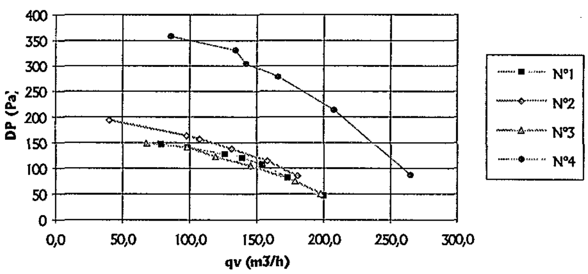


Figure 7. High speed

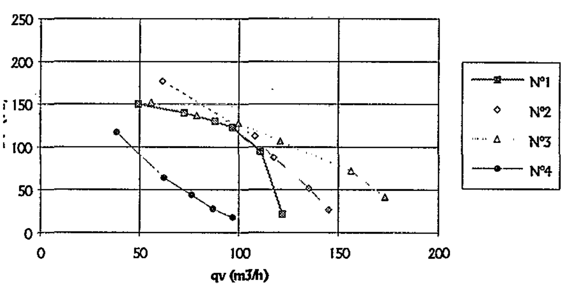


Figure 8. Low speed

The possibility to measure simultaneously thermal and aerodynamic performances reduces the cost and allows to measure several points in order to know better the unit performances and to extrapolate savings of these heat recovery systems on a full year.

These possibilities are now discussed in the CEN TC156/WG2/AH7 group to prepare the new standard [2].

CONCLUSION

Supply and exhaust systems with heat recovery can allow important savings in residential ventilation systems [3].
To really get these savings, thermal, air-tightness and aerodynamic performances must be known. If temperature ratios appear to be quite satisfying, the choice of the exchanger and fans are most important. Precautions must be taken with air-tightness and classification could be standardised.

REFERENCES

[1] EN 308 – "Heat Exchangers – Test procedures for establishing performance of air to air and flue gases heat recovery devices" – November 1997.

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