FEASIBILITY STUDY OF VENTILATION SYSTEM AIR-TIGHTNESS

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ABSTRACT

The feasibility of good air-tightness in new buildings can be determined based on the obtained air tightness classes as defined in EN 12237. In this paper a model is described which allows to calculate the energy loss caused by leak losses in ventilation systems based on the air tightness class and the feasibility of realising a good air-tightness.

The air-tightness of the ventilation system is building specific as it is preliminary determined by the lay-out of the system and thus by the air-tightness of the used components. Therefore an inventory of the ventilation system components is used to calculate the air losses. If no inventory is available, the model is able to estimate the losses based on square meters floor space and building type.

The total energy cost related to the preconditioning of supply air and the transportation of supply and exhaust air depends on a number of parameters. Some of these parameters are climate-related and therefore fixed, some are case-specific and can be altered by the user (e.g. internal humidity requirements, working hours, type of heat recovery, unity cost energy). The air leak losses have the same unity-cost for transportation and preconditioning as the wanted air.

In this paper the method is applied on three cases: a hospital wing, a rest home and an office building. The simulations show that the total energy consumption related to ventilation can be reduced by over 30% by achieving an airtight ventilation system. Good air-tightness of ventilation systems offers real added value as obtaining good air-tightness lower energy costs and a better indoor comfort. The additional investments to achieve a good air tightness of the ventilation system in new buildings are low compared to the avoided energy losses.

KEYWORDS

ductwork, airtightness, leakage, feasibility, cases

INTRODUCTION

A ventilation system has an important technical function. On the one hand the system moves treated supply air to occupied rooms. On the other hand, used air is extracted from these rooms and the extract air is discharged outside. The ventilation of rooms is required by the (Belgian) energy performance assessment legislation [1] for (new) buildings and also by the (Belgian) ARAB labour legislation.

The energy cost related to the transportation (fan power) and treatment (filtering, heating, cooling, dehumidifying and humidifying) of air is significant compared to the total energy cost when operating a building. Keeping air quality within comfort levels is the main goal of the ventilation system. Uncontrolled air flow losses may lead to unbalances in air pressure in the building, resulting in unwanted infiltration. Therefore, the effectiveness of the applied system is increasingly important in the design of buildings with a low carbon footprint. The desired amount of air has to be transported to the right rooms effectively and in a controlled way. As little ventilation air as possible must be lost. Keeping ventilation air losses to a strict minimum is thus mandatory.

It is important to emphasise that the air-tightness of the ventilation system is determined by the air-tightness of each component. This includes the air ducts themselves, but also all the accessories such as fire dampers, flow-balancing units, silencers and the connections between the elements. The air-tightness of a ductwork is described and quantified in different European standards [2][3][4]. The air-tightness class determines the size of the air leak: air-tightness class C or D indicates a very performing ventilation system, class A or poorer are systems with low air-tightness.

In order to increase the air-tightness class, a ventilation system has to become three times more performant. The leakage flow rate in a type C ductwork is thus three times lower than the leakage flow rate of a type B ductwork. Very poor systems are classified as 3A, 9A, 27A, etc..

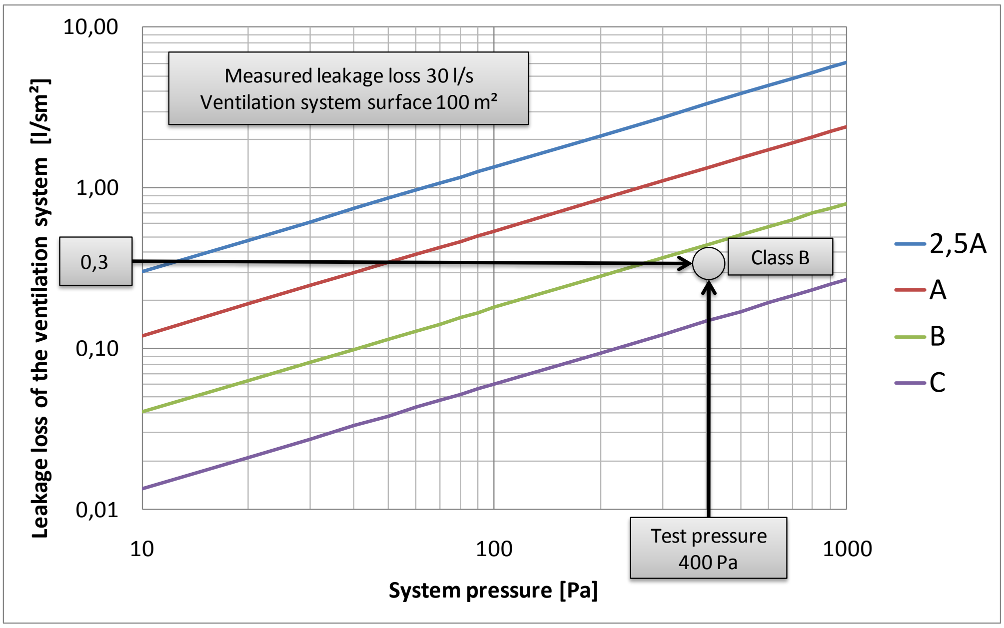

Figure 1. Example of air-tightness class determination, Ingenium, measurement 2010

BELGIUM IS LAGGING BEHIND

Standard Specifications 105 published by the Belgian Buildings Authority [5] is the primary work of reference for designing and installing ventilation systems in Belgium. This report recognises the importance of good air-tightness of the ventilation system as the specifications impose a minimum air-tightness class. The current specifications require class A or B. After revision, the Standard Specifications will impose at least air-tightness class C [6].

In practice, however, it tends to be exceptional that representative air-tightness measurements are carried out. It is thus hardly surprising that the actual air-tightness in Belgium is rather poor. Measurements carried out during the SAVE-DUCT project confirm that the actual air-tightness in ventilation systems in Belgium does not meet the minimum requirements of the Standard Specifications. In many buildings, the air-tightness of the ventilation system is three to nine times worse than class A. Belgian buildings obtain far worse reults than comparable buildings in countries as Sweden [7].

The European standard EN15242 [8] indicates 2,5A as the default value for the air-tightness of a ventilation system. Measurements [7] show that this figure is actually still too optimistic for the current stock of Belgian buildings. In real cases measurements up to 27A are not exceptional.

CALCULATION METHOD

The total airflow is calculated first, both for supply air and extract air. The total air flow is the sum of the wanted air flow and the air losses due to bad air-tightness of the ventilation system. The wanted air is in most buildings well defined and known. The air losses are calculated based on the duct surface, an air-tightness class and a system pressure. AHU casing leakage is not yet included in the model. Default values, based on building type and building surface, are available in the calculation model if no detailed info on the duct system is available.

The model calculates the unity cost to treat the total airflow. This cost, related to the transportation and treatment of air is calculated in five ‘energy modules’, as shown in figure 2. Two modules calculate the transportation: supply fan, exhaust fan, or both. Three modules calculate the required energy to treat the outside air into indoor air conditions for one specific purpose (heating, cooling, etc.). The preconditions (eg humidity, working hours, type of heat recovery, fuel, unity cost) are related to the building type. For example, in a resthouse, the module ‘cooling’ is not activated in the default calculation.

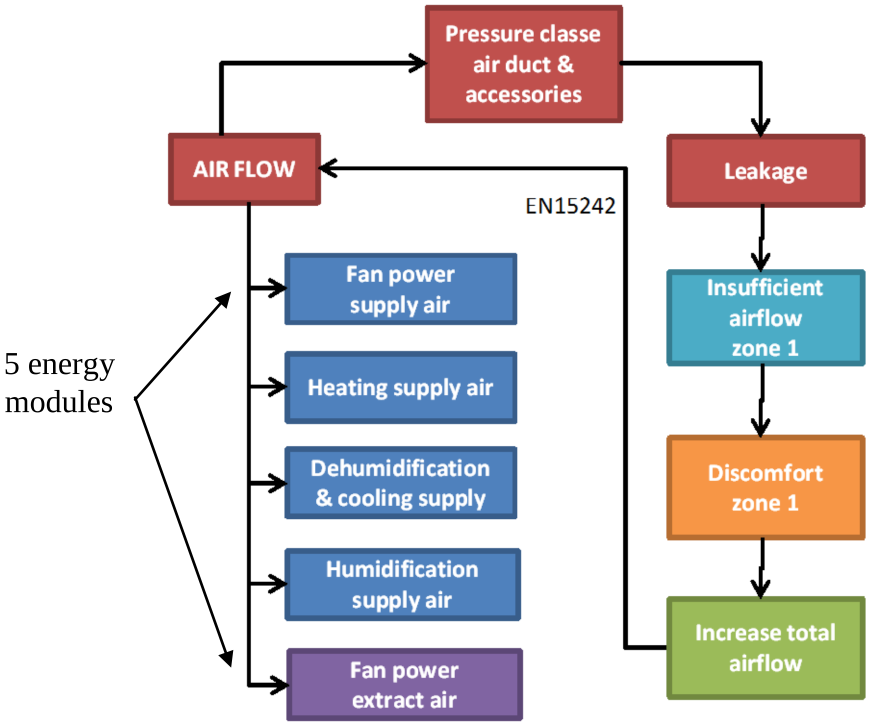

Figure 2. Calculation Method - Energy consumption linked to leakage losses in the ventilation system

The energy gain is supposed to be directly proportional to the avoided leakage loss compared to installations with lower air-tightness.

The applied calculation method incorporates standardised calculation rules from the E-level calculation, as imposed by the Flemish government for office buildings [1]. For non-office buildings, the same methodology is used, buth with other parameters.

All calculations are based on monthly basis.

Building type		Hospital	Resthouse	Office	Other
ventilation rate	(-)	2	1,8	1,5	1,5
average space hight	m	3,1	2,8	2,8	2,8
air flow	/ 1000 m²	6200	5040	4200	4200
duct surface	/ 1000 m³/h	75	65	55	55
number circular ducts	%	0,25	0,25	0,25	0,25
number of circular fire dempers	/ 1000 m³/h	7	6	0,8	0,8
number of rectangular fire dempers	/ 1000 m³/h	3	3	1,6	1,6
average dimension circular fire dempers	mm	160	125	200	200
average dimension rectangular fire dempers	mm	400	400	500	500
heat recovery		60%	60%	60%	no
cooling		yes	no	yes	yes
humidification		yes	no	yes	yes
moisture recovery		no	no	no	no
energy flow for humidification		fuel	elektricity	elektricity	elektricity
speed control fans		no	no	no	no
total fan power (pulsie + extractie)	W / m³/s	3400	2800	3100	3100
unity price electricity	EUR/MWh	120	130	130	140
unity price fuel	EUR/MWh	40	45	45	50
static system pressure	Pa	300	250	200	200
correction factor heating (time factor)	(-)	1	1	0,3	0,6
correction factor cooling (time factor)	(-)	1	1	0,3	0,6

Table 1. Default values calculation

The second step consists of determining the additional investments. The calculation model is based on information obtained from prior studies and from a number of producers (fire dampers).

UP TO 30% SAVINGS ON THE VENTILATION ENERGY

The calculation method was applied to three cases: Case 1 : Renovation of a hospital wing; Case 2 : Rest home; Case 3 : Office building.

Figure 3 shows the results of the simulations. The simulations show that the total energy consumption linked to ventilation can be reduced by over 30% in case 1.

		Hospital wing	Rest home	Office building
Building surface area	m²	11,380	8,830	11,200
Ventilation flow	m³/h	57,450	43,305	53,940
Duct surface (supply and extract)	m²	5,094	2,400	2,480
Percentage of round ducts	-	25%	15%	15%
Fire dampers, number	-	476	496	90
Flow-adjustment units, number	-	527	398	407
Flow adjusters (CAV, VAV), number	-	133	0	77
Silencers, number	-	17	14	19

Table 2. Properties of technical installations

		Case 1 **Hospital wing**	**Case 2** **Rest home**	**Case 3** **Office building**
Annual energy savings	EUR/y	10,175	6,750	6,750
Investment cost	EUR	14,862	11,068	11,068
Pay Back Time (dynamic)	years	2	2	2

Table 3. Profitability if the ventilation system's air-tightness improves from class A to class C

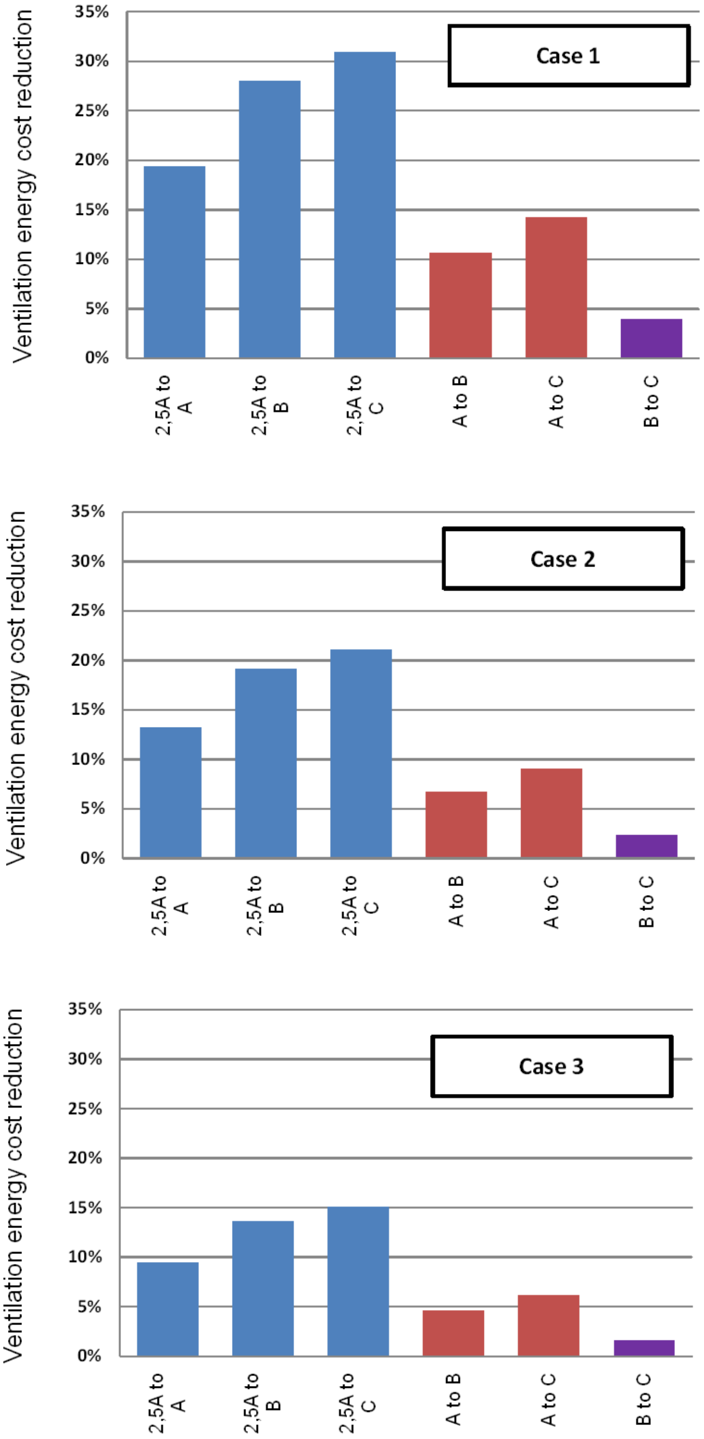

Figure 3. Results

Detailed results are presented in the paper of Peter Stroo, *Class C air-tightness: proven ROI in black and white. Up to 30% savings on the ventilation energy can be defined.*

Detailed calculations can be made for each specific project using the developed calculation model, which is public available on http://www.colorstudio.be/lindab/

CONCLUSION

Paying attention to high air-tightness of the ductwork is worthwhile. The energy related to the ventilation system can be reduced by up to 30%. Detailed calculations can be made for each specific project using the developed calculation model.

The importance of good air-tightness is also acknowledged as the Belgian Buildings Authority will impose class C. In view of the pioneering role of the Standard Specifications, we can expect the Belgian installation world to catch up so that (at least) air-tightness class C will soon be standard.

The Flemish government can also support the air-tightness of ductwork, amongst other things by revising the EPU calculation method for offices and schools. In the current calculation method, air-tightness of ventilation systems, in contrast to air-tightness of the building's shell, has not been taken into account. Revision of the EPU calculation method and thus a reward with a lower E-level for buildings with a (measured) airtight ventilation system would be an interesting incentive to support the air-tightness of ventilation systems in practice.

Nevertheless, good air-tightness of ventilation systems offers real added value. The reduction of the energy use related to ventilation will result in lower energy bills and a better indoor comfort. This reason alone justifies the limited additional cost of achieving an airtight ventilation system [9].

REFERENCES

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[2] EN 12237:2003 Ventilation for buildings - Ductwork. Strength and leakage of circular sheet metal ducts
[3] EN 1507:2006 Ventilation for buildings - Sheet metal air ducts with rectangular section Requirements for strength and leakage
[4] EN 1751:1999 Ventilation for buildings - Air terminal devices – Aerodynamic testing of dampers and valves
[5] Belgian Buildings authority *Standard Specifications 105* Central heating, ventilation and air conditioning (1990)
[6] Belgian Buildings authority Standard Specifications 105 - final draft 2010 Article E5 PAR5 measurement of the air-tightness of ducts; Article C14 Air ducts
[7] SAVE-DUCT Duct leakage in European buildings: status and perspectives; François Rémi Carrié et al.; 1999

[8] EN 15242:2007 Ventilation for buildings - Calculation methods for the determination of air flow rates in buildings including infiltration.

[9] TUV - 2008 *TUV Rheinland - Advisory opinion regarding the comparative test and* evaluation of the overall installation costs of various installed air systems