« Testing a method for checking the performance of ventilation systems in commercial buildings, in France »

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Synopsis

Ventilation performances in existing buildings are not well known, in France. They are not often checked.

This paper shows how a method for checking the performance of ventilation could be applied in France. Such a method, mainly based on visual inspections and simple measurements has already been used for years in Sweden.

The Swedish method has been tested in France, in collaboration with a Swedish inspector, on different commercial buildings of different sizes and ages : two secondary schools, one primary school, one office building, one hotel and one bar.

The present paper is mainly oriented on the feasibility of the method : description of the checks, instrumentation to use, time for inspections, report. Only few results are given, as examples. Another paper will show the whole results on the different buildings, and will describe the ventilation defaults which were observed during these investigations.

Finally , the prospects for future applications of such method in France are discussed.

1. Introduction

Ventilation performances in existing buildings are not well known, in France. They are not often checked.

Recent studies, in Europe, have shown a lot of defaults on ventilation installations poor ductwork airtightness [RESEA], other defaults – particularly low air flows – in many building which lead to poor indoor air quality inside the buildings, and also extra energy consumption because of the bad efficiency of the systems.

Sweden put a new regulation in 1991, which imposed to check the performance of ventilation systems ; on this basis, a method was elaborated [BOVER] ; and it is clear that, today, improvements on ventilation have been made. In the same time, a European standard is being studied (soon in force) for testing the performances of new ventilation and air conditioning installations [CENEN].

The Swedish method, which has been tested for about 10 years, seems to be a good basis for first applications in France. According to the feasibility of the method, it could be the starting point for a new approach and new regulation.

Several buildings have been inspected, part in collaboration with a qualified Swedish inspector : two secondary schools (including several different buildings), one primary school, one office building, one hotel and one bar.

Many results have been collected, and they show the performances of the visited installations and the main problems which were identified.

The present paper is mainly oriented on the feasibility of the method : description of the checks, instrumentation to use, time for inspections, report.

Only few results are given, as an illustration of the method. Another paper will show the whole results on the different buildings, and will describe the ventilation defaults which were observed during these investigations.

For conclusion of this first experience, the prospects for future applications of such method in France are discussed.

2.Checking method

The Swedish checking method for ventilation performances, which has been tested in the frame of this study, is known as the « Boverket Method » [BOVER].

This method was put in force (1992) to answer to regulation requirements on periodical checking of ventilation installations, in Sweden, in residential and commercial buildings. Depending on the use of the building and the type of ventilation system, the frequency of the inspection is varying.

This checking method is mainly based on visual checks and some measurements (aeraulic, electrical). Its implementation can be separated in two main parts :

- Checks, measurements ; with photos and notes. This is the site part ; the practical part.
- Writing the inspection report and the general remarks on the building ventilation ; it is the analysis part ; it can be done at office.

A preliminary meeting with the building owner (to present and explain the inspection) and a final meeting (to present the results and discuss about optimisations) are useful.

- Checks, photos, notes

The inspection starts with *the available documents* on the ventilation installation : drawings, requirements, descriptions, maintenance, …

The second step is *a preliminar visit of the building and installations* ; in cooperation with a person in charge. This first visit is necessary for better knowledge of ventilation installation (localise the fan units, understand the ventilation control,…).

Then, the checking part can start, with :

- Checks on fan units and other air handling units ;
- Checks on air terminal units and ventilated rooms.

The visible parts of ductwork are also inspected (roof part, technical ventilation rooms,…) as much as possible : connections, supports, leakages, dampers, presence of dust inside the ducts (eventually sampling).

1/ Checking fans and air handling units :

Visual checks are made on :

- Supports, accessibility of doors ;
- Fan boxes airtightness,
- Cleanliness,
- Fan belts,
- Connections parts,

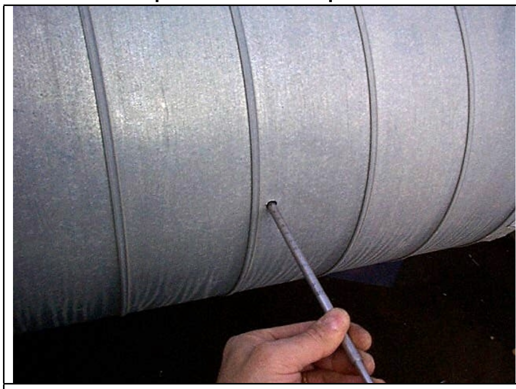
- Filters, exchangers,
- Pressure control devices
- Duct configurations upstream and downstream
- Smoke visualisations can be useful (for example at fan-duct connections).

Example of a fan belt ; tension is low

Visualisation of a leakage between fan box and duct, using smoke

Measurements are made on :

- Total air flows at supply or extract, close to the fan unit ;
- Part air flows at different points if there is a distribution to different ductworks (for example on the roof) ;
- Fan motor electrical power (and : voltage, intensity, cosφ) ;
- Eventually, the fan rotation speed (and direction) ;
- Underpressures upstream/dowstream the fan.



Measuring the air velocity inside a duct, to determine the air flow rate

Electrical measurements on a fan motor supply

2/Checking air terminal units and rooms :

Visual checks are made on :

- Cleanliness of exhaust/supply air terminal devices ;
- Frea area for air inlets ;
- Number of terminal devices (inlets, outlets) in the rooms ;
- Eventually air flow patern near outlets or inlets, using smoke ;
- Relative positions of exhaust and supply terminal devices ;
- Air flow paterns between rooms (ex. between kitchen and restaurant).

Air quality can be appreciated, in some cases, in a qualitative way : odours, moisture,…

Looking at the frea area for air inlet, on the top of a metallic window

Air flow movements between two rooms

Measurements are made on :

- Air flows at supply or exhaust terminal devices ;
- Eventually, underpressure in rooms, or pressure differences between rooms (ex. between a corridor and a classroom).

These measurements could be done in a limited number of representative rooms (because it is sometimes difficult to visit and check all the ventilated rooms).

Air flow measurement at an exhaust ventilation device

Measuring the air flow rate transfer between two rooms

Observations can be made on the ventilation control ; for example, when the ventilation is “on” in a room which is unoccupied.

During the verifications, the maximum of notes and photos are taken.
The occupants are questioned, if possible, about their perception or feeling about the ventilation system and components.

- Inspection Report and general remarks

After inspection, it is necessary to fulfil a short report, which summarises the main remarks, observations, defaults. Swedish inspectors have elaborated a model of report which is called “Inspection report” and which indicates, among others, if the building is “approved” or “not approved” ; in the second case, the date of a new inspection is mentioned.

The inspection report (see § 5) summarises the main observations and more the main defaults which were identified, and for them, the inspector decides if a correction or improvement has to be done in a short term (the note is “2”), or from now to the next inspection (the note is “1”).

The observations and defaults are classified in rubrics : 1/Documentation, 2/ Ductwork, 3/ Fan room, 4/ Fan, 5/Regulation-controls-feedback, 6/Adaptation rooms, 7/ Tests (measurements), 8/ Others ; and under-rubrics.

The report is written by using the notes which were taken during inspection. The photos are often useful to remind different observations.

Generally, only on page is fulfilled for one building, but it depends on the number or the type of ventilation systems.

To fulfil the inspection report it is necessary to do some calculations : for example total air flow by summing the individual air flows ; or the fan ratio “power/air flow”.

After the inspection report, it is necessary to summarise on a separated paper, the general remarks about the ventilation installation. The main problems are shown.

Also, performance criteria can be calculated, and used in the discussions with the owner. These criteria could be compared to national requirements if there are. These could be :

- ventilation air flows in rooms ; to be compared to the hygienic minimum air flows ;
- ratio between the global air flow measured at the fan and the total air flow in the rooms (terminal) ; it gives information on the global airtightness of the ventilation system ;
- electrical power absorbed by the fan motors ; ratio “power/air flow”, to be compared to the reference values (for example in the new French thermal regulation 2000) [RTAN4].

These criteria represent kinds of indicators for the characterisation of the performance and the compliance of the ventilation system with the regulations.

3. Instrumentation

With a minimum number of measuring devices or other means (for example smoke generator) it is possible to do the essential checks.

The main measuring instruments which were used in the frame of this study are briefly presented below. An average cost of the minimum investment is given.

Small equipment :

Smoke generator (visualisation of air flow paterns, leakages,…), drill, stoppers, rule, screwdriver, spanners,…

Small equipment

Anemometer

Anemometer (hot wire) :

For measuring the air flow inside the ducts, and sometimes on ventilation grille. Also, the hot wire anemometer can be used with some air flow rate detector heads, cones or hoods (see below).

Air flow rate detector head (or cone) :

To measure the air flow at terminal devices. With a 20cm diameter cone, it is possible to do a lot of measurements (VMC exhaust type). For big exhaust or diffusers, an bigger cone or hood has to be used.

Cone, for air flow measurement (with anemometer)

Manometer

Manometer :

It is necessary to use a precise manometer, for measuring the pressures/underpressures at fan boxes, on the ductwork, and also in rooms.

Electrical power meter :

It is used for measuring the electrical power which is absorbed by the fan motor. Generally, the apparatus simultaneously gives the tension, intensity, power and cosφ.

		
Powermeter		*Tachometer*

Tachometer :
Useful to check the rotation speed of fans.

The global minimum investment for the above equipment is about : 5000 Euros.

Other measuring devices can be useful, occasionally, when specific problem are identified : sonometer, thermometer, hygrometer,…

4. Time for checking

On the basis of this first experience on different buildings, a first estimation of the necessary time to implement the checking method, and also a cost evaluation of the inspection can be done.

	Approximate time per person (in days)			
	Preparation/ Documentation	Measuring/ Checking	Analyse/ Report	TOTAL (days)
Small building (≤ 1000 m²)	1/4 j	3/4 j	1/2 j	1 j et 1/2
Medium building (1000->5000m²)	1/2 j	1 j	3/4 j	2 j et 1/4
Complex of some buildings (about **4**) (5000->20000m²)	3/4 j	4 j (env. 1 j /bât)	1 j	5 j et 3/4

Rem : for two persons, it can be considered, last column : 1j, 1j1/2, 3j.

So, a cost evaluation of 1200 to 1800 Euros (duty-free) per building, depending on the size, seems to be reasonable, according to this first approach. It should be necessary to take into account the travelling and stay on site.
It seems to be useful to take into account an additional half day working, i the global method, to present the results, with comments, suggestions to the owner ; it will allow to prepare the improving phase. Then the above cost would be around : 1500 to 2300 Euros (duty-free), depending on the size.

For example, an office building, equipped with a simple exhaust ventilation system, where the inspection would be every 6 years (this would be the case according to the Swedish regulation), such inspection would cost (only) around 300 Euros/year.

For such a building, the global cost for ventilation (heat losses, electricity for fans) could be around 6000 to 12000 Euros/year, depending on the climatic area, energy type, occupation,...

5. Examples of results

Generally, in the different type of buildings with different types of ventilation systems (simple exhaust, balanced air handling systems), a lot of defaults were found : bad maintenance, untimely worn components, bad conception, low air flows, no adapted components, switched off fans, tight ductworks, etc.

The following inspection report is about one part of a nursery school ; it shows the different categories of remarks, observations. Sometimes, heavy defaults are mentioned (see the general remarks, below).

The general remarks on the nursery school building – where other ventilation systems are present (simple exhaust ventilation for classrooms and administrative part, supply with recirculated air for the restaurant) – are :

- Big problem with air supply in the restaurant ; outdoor air intake grille is present but the air flow is zero !

- Unbalanced air flows in the central zone (game, gymnasium) (see the following report) (ratio is 1/4) ; so there is a lack of new air in this zone and more infiltrations ;

- Heavy noise at the exhaust air terminal device in the central zone ; the noise is transmitted to the other rooms ;

- No air inlets in the sleeping room ;

- Quite everywhere, the free areas for air inlets are too small ;

- Around 25% leakages on the ventilation ductwork for the classrooms and administration ;

- No drawings for the roof part of the ventilation installation.

Example : inspection report (Swedish model) on one part of the building (big room, for games and special activities, equipped with a balanced ventilation systems, with heating)

Compulsory Control of
VENTILATION SYSTEM

Inspection Report

☐ Approve to

■ New inspection at least : 30/05/2001

Certifierad av SITAC, nr

Estate designation		Controller	Competencet	Company
Estate designation **Nursery School**		Controller **PBC**	Competencet	Company
Address		Address		Tel
Construct year **1992**	Rebuilding year	Signature		Inspection date **30/11/2000**
Property-holder	Address			Tel
Pursuit responsible	Address			Tel
Earlier inspection	Type (S,F,FT,FTX) **FTX (balanced)**	Construction **One big room**		System Designation **FTX with heating**
Activity **Game, Gymnasium**	Air flow rate **2000 m3/h**	Operation **week**		Employment **permanent**

Pos	System/component	Pos	System/component	Pos	Anm. 1= should do -, 2= must do something	Anm.
1	DOCUMENTATION	6	OPPORTUNITY/ROOMS			
.1	Drawings	.1	Outdoor air	**1.2**	**No documentation to pilot the system**	**1**
.2	Management instr.	.2	Compensation air			
.3	Support instr.	.3	Transferred air	**1.3**	**Lack of presicions in the maintenance manual**	**1**
.4		.4	Supply air terminal device		**(which is writen for several buildings)**	
2	DISTR.NETWORK	.5	Exhaust air terminal device		**(no information about the extraction part)**	
.1	Air intake	.6	Range (stove)			
.2	Joint duct	.7	Stove fan	**2.3**	**Not tight ducts (about 20% leakages)**	**2**
.3	Not tight ducts	.8	Activity			
.4	Dirty ducts	.9	Short circuit supply/exhaust	**4.4**	**No identifying plaque on the extraction fan**	**1**
.5	Short circuit	.10				
	outdoor/extract ait	7	TESTS	**4.8**	**Dirty fan box (inside)**	**1**
.6	Exctract ait outlet	.1	Total air flow rate			
.7		.2	Part air flow rate	**6.1**	**Very low supply new air (only 25%)**	**2**
.8		.3	Supply air temp.			
3	FAN ROOM	.4	Efficiency %	**7.1**	**Exhaust fan unit :**	
.1	Accessible		with t out °C		**- scheduled 2000m3/h**	
.2	Lightning	.5	Relative huridity		**- measured (terminal device) 2200m3/h**	
.3	Outlet	.6	Sound power level		**- measured on fan 2800m3/h**	
.4		.7			**Supply fan unit (window type) :**	**2**
.5		.8			**- scheduled 2000m3/h**	
4	FAN	8	RESTS		**- measured (terminal device) 500m3/h**	
.1	Airborne sound/vibration	.1	Moisture damaged			
.2	Doors	.2	Rests observations	**7.3**	**Supply temperature not controlled**	**2**
.3	Filter	.3	Users point of view		**(because low air flow)**	
.4	Fans	.4	Electric power			
.5	V-belt drive	.5		**7.6**	**Strong noise at the exhaust air terminal device**	**2**
.6	Recirculated air					
.7	Heat recovery			**8.4**	**Exhaust fan unit :**	
.8	Dirty fans				**P=360W**	
.9	Damper function				**SFP=0.46kW/m3/s**	
.10	Draining					
.11						
5	FEEDBACK CONTROL					
.1	Manouvre					
.2	Control			-		
.3	Fire control					
.4	Feedback control					
.5	Alarm					
.6	Indication					
.7	Adjustments					

6. Future applications

Firstly, these tests of a method for checking the performance of ventilation systems in commercial buildings shows :

- The systems don't often work in a completely right way ;
- Checking the main performance characteristics can be done in a relative short time and with a minimum of measuring devices ; that means for a reasonable cost ;
- Some defaults can easily be removed, some others are more difficult to solve, mainly if they are linked to the design or installation part.

Not only the air quality can be bad because the terminal air flows in the rooms are not well adapted, but also the energetic consequences can become not negligible [CONSO].

With a minimum of time and instruments for inspection, it is possible to get a good knowledge of the installations, and more to correct a lot of defaults. Then a deeper analysis can help to find real improvements, for the air quality and for energy consumption.

The checking method itself, coming from Sweden, could easily be applied in France :

the first step should be to re-write the methodology, translate and completely formalise to adapt it to the French context, form the "objectives" to the "inspection report" ;

the second step should be to define the qualification procedure for inspectors on the basis of this method. It should be interesting to give a minimum of knowledge to the people, on sites, involved in the management of the ventilation installations.

the third step should be to put an obligation for periodic checking of ventilation system, like in Sweden, with the definition of a frequency for inspections, depending on the type of buildings and type of ventilation systems. National requirements should be defined.

It seems that a compulsory inspection of ventilation systems in buildings, on the basis of a checking method (rather easy to implement), could lead to improve the responsability of the different involved people : designers, manufacturers, installers, maintenance companies, users, inspectors ; for a progressive improvement of the performances of ventilation systems in buildings.

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