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PAPER 4

TRACER GAS USED TO EVALUATE HVAC EQUIPMENT

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ABSTRACT

When controlling the performance of a ventilation system it is important to investigate how the system works together with the building it ventilates. It is the performance of the complete system which is of interest, not its individual components. This paper describes the use of a computer-controlled, tracer-gas measuring system for controlling ventilation systems.

By means of 4 measuring probes the condition of the air at the intake, room injection, room extraction and exhaust is registered. On the basis of these results, the computer can calculate the efficiency coefficients for the heat exchange, the percentage of air being recirculated, the outdoor short-circuit from exhaust to air intake and the percentage of extracted air resulting from room injection.

On the basis of field measurements with the equipment, the experience gained is discussed. In particular, it it interesting to see how large a percentage of the air blown through the ventilation system into the building is refound in the extracted air. Percentages of 60-80% are quite normal. If only, for instance, 60% of the injected air is returned, the building will have an air change which is at least 1.66 times the performance of the ventilation system.

INTRODUCTION

Badly planned, badly made, badly regulated and badly maintained ventilation systems are some of the most frequently reported causes of problems with the indoor climate in office buildings and dwellings. Lacking or incorrect maintenance of ventilation systems is probably the biggest problem of them all. Having a service contract with a ventilation firm and an automatics firm may be useful, but it does not ensure that the ventilation system will work as it should do. The measurements we made in buildings where the ventilation systems were systematically maintained, revealed such serious faults that it is questionable whether the type of systematic maintenance carried out today is worth the expense.

There are many answers as to why so many ventilation systems work badly. One of them is simply that it is difficult for the people working in the building to discover the faults. Another is that the requirements laid down for checking ventilation systems are very limited. A third is that the people who look after the ventilations systems are inadequately trained.

A way in which to improve the maintenance standard for ventilation systems is to perform frequent measurements on them. It is the performance of the complete system which is of interest, not its individual components. What is needed therefore is to check how the ventilation system works together with the building it serves instead of controlling the individual components in the system. Such a performance check of the ventilation system does not distinguish between the individual types of faults, as it concentrates on the product which the system supplies. The results of such a performance control can be:

- air changes for the building
- ventilation efficiency
- contamination in the injected air
- contamination in the extracted air
- temperature levels in the building
- energy consumption for ventilation

In this article we will describe computer-controlled measuring equipment which can measure most of the above parameters automatically.

MEASURING METHOD

For the measurement of ventilation systems we have used one of the continuous air change measuring instruments from the Technological Institute. The only thing that has been changed is the software, i.e. instead of the normal program which controls the measurement with "constant concentration of tracer gas", a newly developed program has been installed which is specially designed for ventilation systems.

The measurement is made where the ventilation unit is placed, but is not made in the actual unit, only in the inlet and outlet ducts. By using 4 probes, the condition of the air in the ducts can be measured for outdoor air intake, room injection, room extraction and exhaust. As all the measurements are made close to the ventilation unit, the equipment can be set up very quickly and the time-consuming hanging up of tubes and wires is avoided. The position of the measurement points can be seen on figure 1.

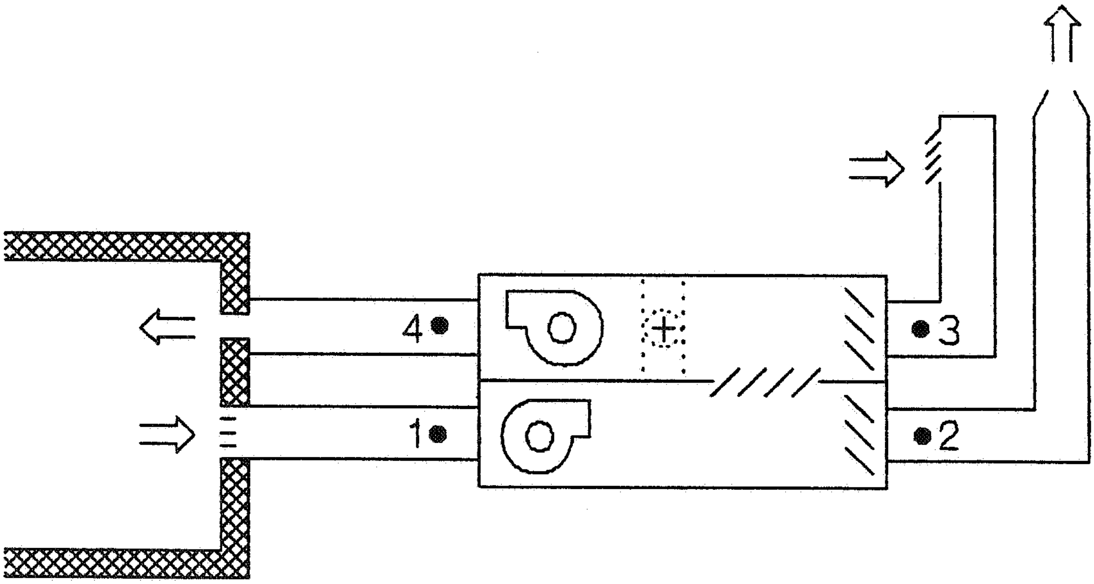

Fig. 1 Diagram of the ventilation system with the position of measurement points.

The parameters measured are:

- quantity of injected air
- quantity of extracted air
- quantity of air recirculated through mixing dampers
- outdoor short-circuit from exhaust to air intake
- percentage of injected air in the extracted air
- temperature in all 4 ducts
- air humidity in all 4 ducts
- content of CO_2 in injection and extraction
- any other interesting contamination components.

Tracer gas is used for the measurement of air quantities, recirculation percentages, outdoor short-circuit from exhaust to air intakes and percentage of injected air present in the extracted air. IR analyzers are used for the measurement of tracer gas concentrations, contamination and humidity content.

On the basis of the parameters measured, the efficiency of heat recovery, if any, can be calculated, and it is furthermore possible to calculate a minimum value for air infiltration in the building.

Each measurement probe has several functions as it can dose tracer gas, collect air samples and measure the air temperature. Due to the short distance between dosing and collection point, air samples cannot be taken at the same time as the tracer gas is being dosed at a point. The measurement of the individual flow and recirculation percentages must therefore be made in series. A measuring cycle can, for instance, be divided into the following 5 steps:

1. Measure the quantity of injected air by first measuring the concentration of tracer gas at point 4, then dose tracer gas at point 3 and measure the increase in the concentration at point 4.

2. Measure the quantity of extracted air by first measuring the concentration of tracer gas at point 1, then dose tracer gas at point 2 and measure the increase in the contration at point 3.

3. Measure the recirculation in the mixing dampers, by dosing tracer gas at point 1 and measuring the concentration of tracer gas in points 2, 3 and 4. The concentration at point 4 will be a result of the mixture of extracted air and outdoor air.

4. Measure outdoor short-circuit by dosing tracer gas at point 2 and measure the concentration at point 3.

5. Measure the percentage of injected air present in the extraction by measuring the concentration of tracer gas at point 1. On the basis of the known quantity of injected air, recirculation in mixing dampers and dosed tracer gas quantity, the mean concentration of tracer gas in the injection can be calculated. If the concentration of tracer gas measured in the extraction from the room is divided by the calculated mean concentration in the injection, the percentage of injected air present in the extraction in obtained.

In order to keep the error margin to a minimum when determining step 5, the dosing of tracer gas at point 3 must be controlled so that the injected air always contains a constant concentration of tracer gas as a mean over a cycle.

MEASURING RESULTS

The measurements were made in a 13-floor high-rise building.

The building had 96 dwellings each with 2 or 3 rooms. The measurements were carried out in the northern half of the building, serviced by a ventilation system placed on the roof of the building. The ventilation system injected air into the living rooms and other rooms of the dwellings and extracted air from the kitchens and bathrooms. The plant was equipped with a heat- recovering system transferring energy from the extracted air to the injected air. All channels from the ventilation system down to the flats were on the outside of the building.

When the measurements were being performed, the wind velocity was approx. 2 m/sec. and the outdoor temperature approx. -3 °C. The measurements were carried out while the dwellings were occupied and the occupants could thus open both windows and interior doors.

The mean values for the volume flow measurements can be seen in figure 2.

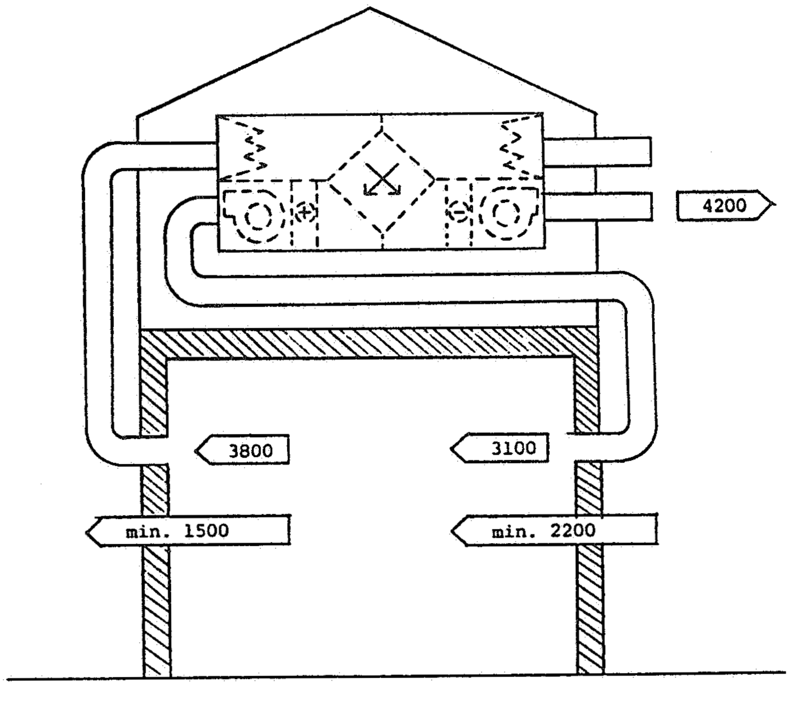

Fig. 2 Measured and calculated quantities of air in m^3/h of the 48 dwellings in the building.

The air change taking place in the dwelling which is not caused by the ventilation system, is calculated on the basis of injected and extracted volume flows as well as the percentage of injected air present in the extraction. For calculation purposes, the assumption is made that all rooms in the building have the same concentration of tracer gas as the one measured in the extraction. This assumption means that the air change resulting from airing out the rooms is underestimated. In fig. 2 the quantities of air are therefore stated as minimum quantities of air.

Main data for the measurement were:

Injected volume flow	full performance	5000 m^3/h
	half performance	2000 m^3/h
Extracted quantity of air	full performance	5700 m^3/h
	half performance	2600 m^3/h
Recirculation in ventilation unit		not measurable
Outdoor short-circuit		not measurable
Percentage of injected air in extracted air		59%
Mean air change for dwellings		5300 m^3/h 0,61 ACH
Humidity injection		3.22 g/kg dry air
extraction		4.95 g/kg dry air
Amount of energy supplied for injection air in ventilation unit		26,7 kW
Amount of energy recovered from exhaust air in ventilation unit		17,0 kW

A discovery of the measurement was that the extraction fan receives approx. 10% of its air from the control room or from the outdoor air duct in the ventilation unit. Another by-product of the measurement was that the unit was changed, because the heat recovery was not as efficient as expected.

CONCLUSION

Tracer gas measuring equipment has proved to be very efficient with regard to trouble-shooting in ventilation systems, and it is also an efficient tool as a basis for the evaluation of the indoor climate. In addition to providing information about injected and extracted quantities of air it also gives the minimum value for air infiltration in the ventilated rooms. When evaluating the indoor climate in a building it is very useful to know how large a percentage of the air change is due to the ventilation system and how large a part to leaks in the climatic shield and the rooms being aired out. In the building measured the ratio was approx. 60% to the ventilation system and approx. 40% to leaks and rooms being aired out.

The measuring equipment makes it possible to evaluate the quality of the injected air as regards the contamination, humidity content and temperature. The load on the building can also be assessed by looking at CO, CO_2, humidity content and temperature in the extracted air.

One of the disadvantages of the equipment in its present form is that it measures on the whole ventilation system, and therefore does not give much information about how well the flow is adjusted for each room.

The question of whether this type of measuring equipment is the best suited for performance control is difficult to answer. Today we only have limited experience with how much time a measurement takes and how expensive it is to perform a measurement.

The principle of carrying out performance control of ventilation systems is a very efficient control. It should therefore be made on all new systems before they are delivered. For larger systems, function control should also be made at frequent intervals as a monitoring of the operation of the system.