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Humidity Controlled Exhaust Fan in a Natural Ventilated Single Family House.

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Synopsis

A humidity controlled exhaust fan have been tested during the winter season 1991/92. The test have been carried out in a detached one storey house with a flat roof. The relative humidity (RH) have been measured in the following modes:

* natural ventilation only
* wall mounted fan, setpoint 70 % RH, and natural ventilation
* fan in the exhaust duct, setpoint 70 % RH.

The relative humidity levels have been monitored in the shower room and in the other part of the dwelling. The temperatures have been measured in the exhaust duct and in four places in the dwelling.

It is concluded that a wall mounted fan can keep the relative humidity close to 50% RH, causes backdraught in the exhaust duct, and usually has to be switched off manually. A fan mounted in the exhaust duct gives a higher average RH than natural ventilation only.

Background

In Sweden as well as in many other countries attention has been paid to a too high indoor relative humidity (RH). The risks are:

* House dust mites can grow if the RH is kept on a level over 55 % RH during longer periods, more than a month.
* Mould groth in the shower-room or bathroom (wet rooms) if the RH is kept above 75 % RH. This gives a "safety factor" not to exceed 80 - 90 % RH at the surface in colder corners in the wet rooms.
* Condensation on double glazed windows during wintertime causing higher maintenance cost and inconveniences.
* The risk for interstitial condensation because of imperfectness in the water vapour barrier.

The moisture production in a dwelling is very much dependent on the occupants' activities. The number of people and their age may give an indication of the probability of having a high RH indoors. About 3/4 of all single family houses in Sweden have natural ventilation. Local exhaust is normally installed in the kitchen as a kitchen hood above the stove and only used when preparing food.

the shower-room. No bath in the tub takes place and there is a separate laundry-room.

As the air supply through leakage was not sufficient extra supply air devices were installed in the bedrooms and the living room. The devices are closable.

The fan installed starts or stops at the setpoints, which is said to be either at 55 or 70 % RH. The power is 15 W and with a capacity of 22.2 l/s (80 m^3/h). The sensing element is a 1 mm thin triangular piece of wood (beech, Fagus Silvatica) glued on a copperplate. The water vapour absorbed in the wood gives a mechanical action and at the setpoint the fan is switched on.

From the beginning the intention was to test at both setpoints, but at the setpoint of 55 % RH the fan never stopped and caused to much noise. This mode was than excluded from the test. Even at 70 % RH the running time tended to be very long. To give the occupants the possibility to have a silent home a manual switch also was installed.

The tests have been carried out in the following modes:

1. Natural ventilation, as constructed from the beginning
2. The fan mounted in the exhaust duct, setpoint 70 % RH
3. The fan mounted on the inside of the external wall, setpoint 70 % RH, and the original natural ventilation.

Monitoring

An automatic monitoring system has been used in the house. The sampled values have been collected as hourly mean values. The indoor temperature is the mean value of four termistor sensors located in four rooms, see Figure 1. The outdoor temperature is measured at a house 200 m away. The data collected is sent by the telephone net every working day to a central computer. The hourly values are the basis of the analysis.

The RH is monitored by capacative sensors (Lee-Integer CH 15) located in the shower-room and in the kitchen, see Figure 1. The sensor located in the kitchen represents the average value of the house as it is central in the house, not directly affected by opened entrance doors, and not to close to the stove.

The measuring faults according to the manufacturers are estimated to be:

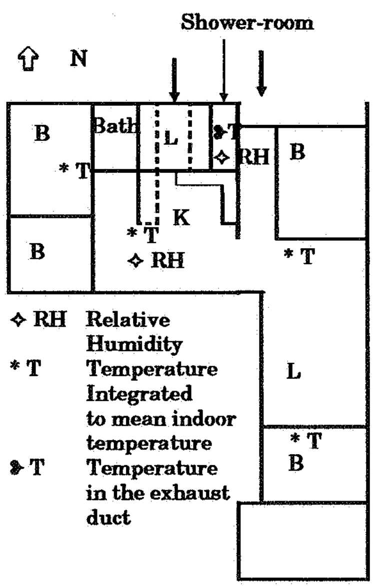
* for measuring RH - +-2 %
* for measuring temperature - +-0.2 %

The overall purpose with the project was to use electricity more efficient in single family houses heated with electrical radiant panels. About 1/4 of all the electricity used in Sweden is consumed in the 1.8 million single family houses. Saving electricity should not lead to indoor air quality problems. An acceptable level have to be maintained.

Test set up

The objective with this test of a RH controlled fan was to exhaust the air from the shower-room in order not to allow the warm moisture air to go back into the other parts of the dwelling.

The test house is situated in a suburb to Stockholm and selected in a group of 90 similar houses constructed 1972. In Figure 1 is given a short description of the studied house. In the main project this house together with five others were inspected and the insulation quality checked by thermography method, the air tightness and air change rate [h^{-1}] measured according to Swedish standard. The measured air change rate was 0.19 h^{-1} giving an air flow rate of about 17 l/s.



Living space 129 m2
1-storey woodframe
Flat roof
Double glazed windows
Natural ventilation with kitchen hood fan
Air tightness
n_{50} 6.9 ach/h
Air change rate:
Test House 0.19 h^{-1}
Mean for 6 houses 0.24 h^{-1}
Range 0.19 - 0.30 h^{-1}
The family has lived in the house since 1978.
A 4 person - family
Children: 2 girls 10 and 15 years old

Figure 1. Short description of the test house.

The family chosen were an ordinary with both parents working outside the home and two children in school 5 days a week. The husband is an engineer and the wife a teacher. All the body cleaning takes place in

Results

As the main interest was to keep the RH close to 50 % on a long term perspective and to avoid condensation on windows the results are given in mean values for weeks. In Table 1 can be seen that the RH in the kitchen always is higher than in the shower-room.

Table 1 Weekly mean RH

Mode			Shower-room RH	Kitchen RH %	Outdoors RH %
Natural ventilation			53	57	73
Fan in exhaust duct			59	60	88
Fan on wall + natural ventilation	Dec		54	57	82
"	Jan	w 1	54	56	73
		w 2	49	55	66
		w 3	50	52	77

The winter season 1991/92 was very mild resulting in one of the mildest ever registered. The mean indoor temperature, about 22°C, is slightly above the Swedish single family home average which is 21°C. In Table 2 is given the temperatures as weekly mean values.

Table 2 Weekly mean temperatures (°C)

Mode			Exhaust duct from Shower-room	Mean room temp	Outdoors
Natural ventilation			22.4	22.0	+1.8
Fan in exhaust duct			--	21.4	+5.3
Fan on wall + natural ventilation	Dec		21.5	22.4	+0.1
"	Jan	w 1	21.6	21.8	+0.5
		w 2	22.0	22.0	-0.8
		w 3	22.6	22.0	-1.2

During a period of 3 weeks there were 16 reliable indications on taking showers. If it was one person or more taking a shower is not possible to conclude, as the measurement gives hourly mean values. In addition there were 7 indications that may be a result of a very short shower giving a RH not higher than in the kitchen.

The indoor temperature range during a three week period is 21.5 - 22.3. This gives the opportunity to make the approximation and use the RH difference between the shower-room and the average in the house measured in the kitchen. In Figure 2 is shown the decay of the RH in those cases when only natural ventilation was used. As can be seen the time to reach normal level takes from 6 h to 10 h. It can be observed that when the fan in the duct is not in operation, the decay period is longer than for the case with solely natural ventilation. From Figure 3 can be seen that if a fan is used the average RH-level in the house is reached within 2 h. With a fan in the duct the time is even less.

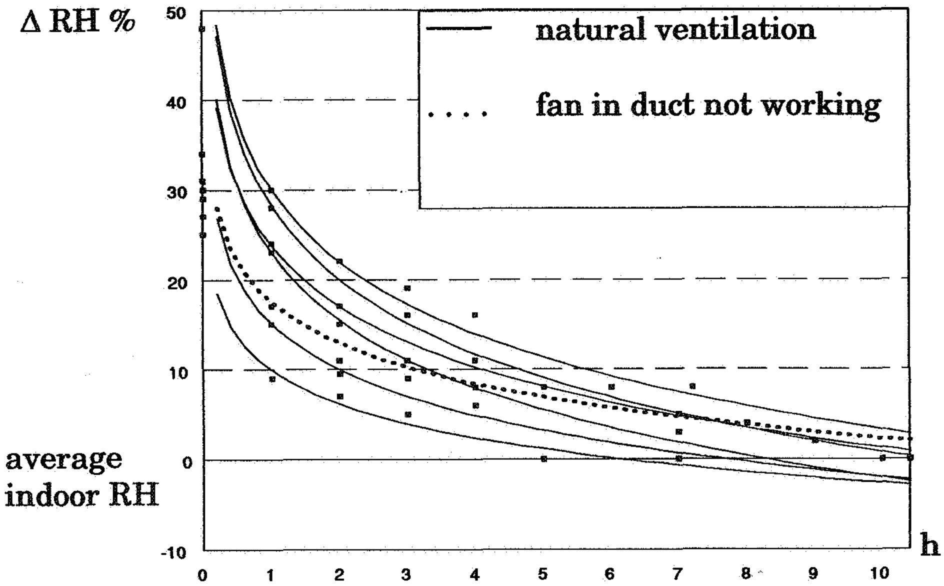


Figure 2. The decay of water vapour with natural ventilation

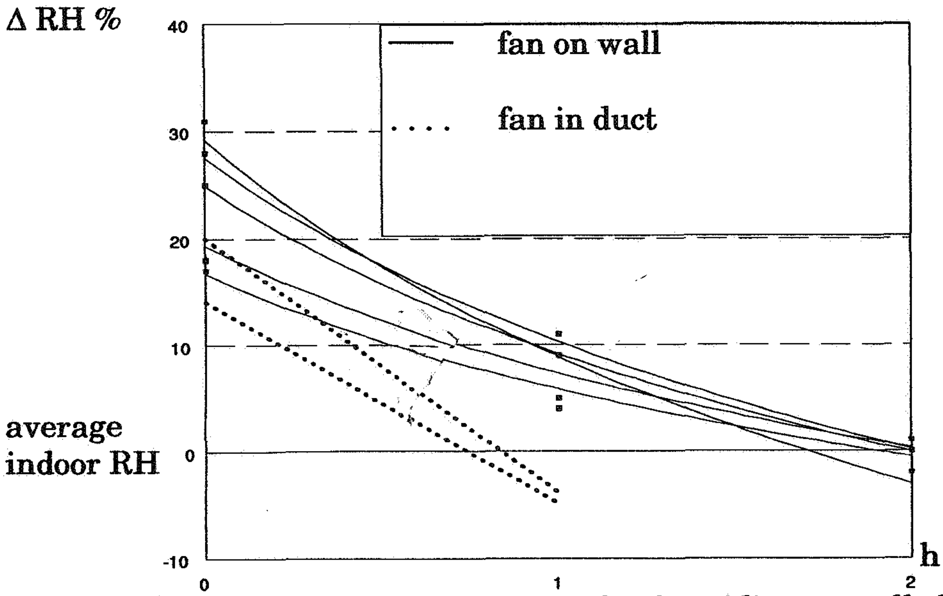


Figure 3. The decay of water vapour with a humidity controlled fan

When the fan is mounted on the wall there is a risk to perceive the cold air as a backdraught from the duct in the shower-room. However, this backdraught was not reported to be of any inconvenience at all to the occupants. The temperature drop measured was from a few °C to 10 °C or more, as can be seen in Table 3. This is of course dependent on the outdoor temperature and the running time.

Table 3. Examples of RH-differences between peak and mean values at different temperature drops in the exhaust duct and running time of the fan.

RH difference peak and mean Shower-Room	Fan operation time h	Temperature drop in exhaust duct °C	Decay from peak to 60 % RH, h	Outdoor temp °C
26	2	4	2	2.4
29	1	4	1	3.6
24	1	7	1	-1.3
36	3	14	3	-1.1
29	1	2	1	0.6
35	3	1	2	5.5
31	1	12	1	-0.3
24	1.5	11	2	1.5

In Figure 4 is given the water vapour content of the air in the kitchen, the shower-room, and outdoors during a period of three weeks. As can be seen the kitchen has the higher level during most of the time, but at the end of the period it is the same. This coincides with less use of the fan in the shower-room.

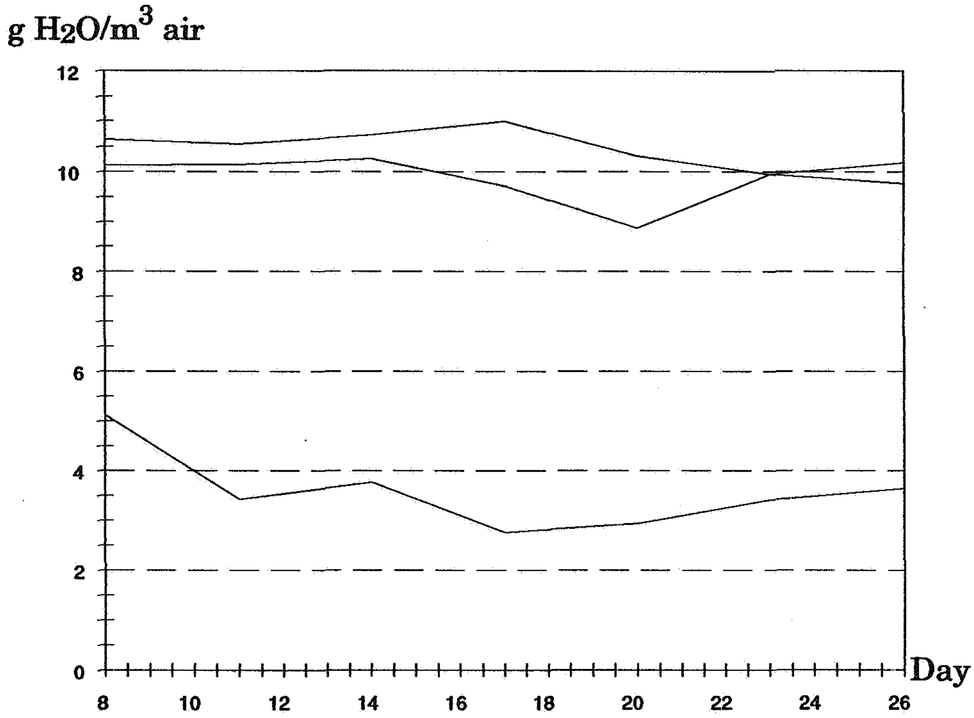
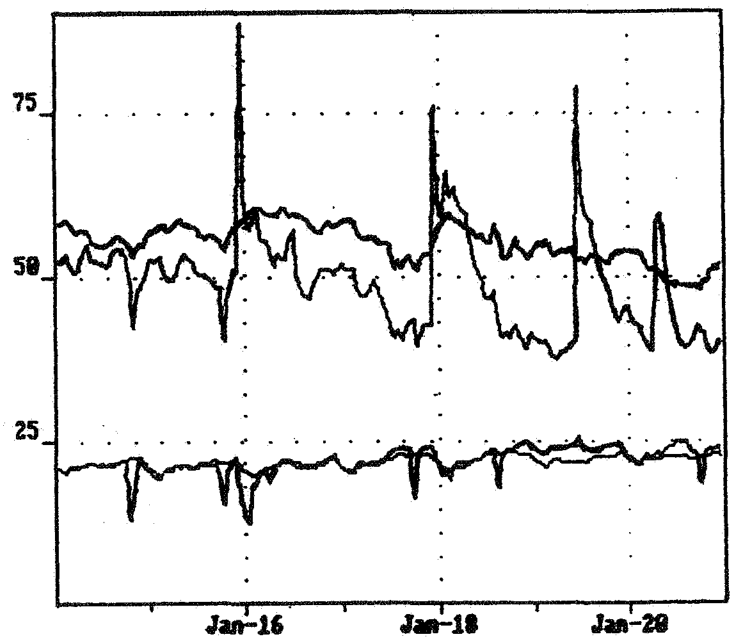


Figure 4. Water vapour content during a three week period with the fan mounted on the wall

In Figure 5 is given an example of the measured values during a week. It can be observed that there are shower-periods with and without the use off the fan in the wall.

RH %



Temperatures [°C]	
Indoors	21.9
Duct	22.0
Outdoors	-0.8
RH[%]	
Kitchen	52
Shower-room	49
Outdoors	77

Figure 5. Fan on wall, one-week-example of measured values on temperatures and RH

Discussion

When comparing the mean room temperature and the temperature in the duct from the shower-room, it is observed that sometimes the temperature is higher in the duct sometimes lower. When counting the peaks and the running times of the fan it can be concluded that the backdraught caused by the fan in operation decreases the temperature to be below the room average. It is also an indication of the use of the fan as it can be manually switched off. At weeks with lower RH-peaks and frequency of showering the use of the fan is lower giving a higher temperature in the duct.

When only natural ventilation is used the temperature in the exhaust duct seems to be slightly higher, less than 0.8 °C, compared to the mean room temperature. This may be caused by the slightly higher temperature in the shower-room and that the house is not airtight enough to get backdraught when using the kitchen hood.

The RH in the shower-room is always slightly lower than in the kitchen as an average during a period of more than a day. It is only with the case of a fan installed in the duct the RH goes up to the same level as for the kitchen. The level is also higher than for other cases during wintertime. In the case with a fan in the duct the natural ventilation can not work, thus causing more humidity inconveniences than with solely natural ventilation.

When comparing Figures 2 and 3 can be seen that the time with high humidity is considerably cut down when using a fan. Even if the natural ventilation doesn't work when the wall mounted fan is in operation the stack effect begins again after the fan is switched off. This gives a very short decay period, thus making a lower risk for condensation and mould growth.

Even if the water vapour content in the air is higher than is wanted in order to avoid any growth at all of house dust mites, the RH-level is well below the range of 55-85 % RH when a greater population of house dust mites can be expected. To avoid it completely the water vapour content must be lower than 7.0 g water per kg dry air. The margin is not very big but it seems that RH is kept just below the critical level for growing house dust mites especially when it is kept at a dryer level during the two winter months February and March.

The temperature drop in the exhaust duct can be more than 10°C within an hour. This can occur even if the outdoor temperature is around zero. However, this has not caused any draft problem to the occupants.

As the main purpose was to get a better controlled indoor humidity in a longer perspective, a week for mould growth and a month for house dust mites, it was not necessary to have a sensor in the fan well calibrated and excellent accuracy. However, the sensor doesn't seem to have any good accuracy at all as it was impossible to use it at the set point of 55 % RH and that it stopped around 60 % RH at the set point of 70 % RH.

The temperature rises immediately after that the fan on wall has stopped. This implies that the natural ventilation works and that the RH is decreased to an average level of the house. In fact, a set point at the expected average RH may lead to a too low RH, thus wasting energy.

Conclusions

The installed fan mounted on the wall gives the occupants a tool to control the indoor environment with respect to RH. At a level of slightly above 50% RH the family perceive comfort. At this level there is no condensation on windows, rapid decrease of RH in the shower-room, the backdraught is not recognized, and the fan is easy to use.

The accuracy of the sensor in the fan is not very good and is the main reason why the lower set point of 55 % RH could not be used. But if the fan is mounted on wall it is not necessary to have the set point at

55 % RH because the natural ventilation can give this level even if the set point is chosen to be higher, at least at winter conditions. Which set point to be chosen is, however, dependent mainly on the temperature difference.

When the fan is installed in the duct the RH is slightly higher compared to natural ventilation and a fan on wall mounted application. The inconveniences were greater with the fan mounted in the duct than with natural ventilation.

The recommended solution is to have the fan mounted on the wall giving the occupants the best way to control the RH and allowing the natural ventilation to work when the fan is stopped.

Acknowledgments

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References

1. G. Hoffmann. House dust mites as vectors for human diseases. Proceedings from Luftqualität in Innenräumen edited by K. Aurand, B. Seifert, J. Wegner. ISBN 3-437-30376-7. (In German).

2. I. Andersen, J. Korsgaard. Asthma and the indoor environment assessment of health implications of high indoor air humidity. Proceedings Indoor Air 1984 Stockholm, Vol. 1. Edited by B. Berglund, T. Lindvall, J. Sundell. ISBN 91-540-4191-0

3. Annex 14 Condensation and energy, Source Book

4. Annex 18 Demand Controlled Ventilating Systems, Source Book.

5. Annex 18 Demand Controlled Ventilating Systems, Case Studies.