

THE SITUATION OF COMPULSORY PERFORMANCE CHECKING OF VENTILATION SYSTEMS AFTER 6 YEARS IN FORCE

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ABSTRACT

The Swedish Parliament decided 1991 that ventilation systems in all non-industrial buildings should be regularly inspected in intervals from 2 to 9 years. The systems are checked to fulfil the requirements when installed.

The goals of the evaluation were to give estimated rates for how many systems that were approved at the end of 1997 and the cause of the faults that made the system either not to be approved or to be remedied before next inspection. The evaluation had three approaches:

1. A questionnaire was sent to a selected number of municipality authorities
2. A questionnaire was sent to housing organisations
3. Analysing totally 10 300 complete inspection protocols

The estimated approved rate was: Schools 85 – 90 %, Day nurseries 90 – 95 %, Hospitals ≈ 40 %, Offices ≈ 40 %, Apartments 65 – 70 % (condominiums 85-90 %, public owned 75-80 %, private <50 %). Stack ventilation has far more faults than any other system. Repeated inspections decrease the number of faults and increase the approved rate. The most frequent fault was insufficient flow rate.

BACKGROUND

The Swedish Parliament decided 1991 that ventilation systems in all non-industrial buildings should be regularly inspected. The exception was single family houses with mechanical exhaust and natural ventilation. The checking intervals are depending on the occupants and on the system principles. There are five classes with inspection intervals from 2 to 9 years:

The main reason for the compulsory inspection was the increased number of oversensitive reaction amongst people, in particular children. Indication showed also that ventilation systems were not working according to the designed intention.

METHOD

The goals with the investigation were to estimate the frequency of approved systems at the end of the year 1997 and the cause of the faults that made the systems to fail. At an inspection faults can occur in many different places in a system. A fault can be of two dignities.

1. A fault that must be remedied before next inspection - called **Fault/Approved (FA)**.
2. The worst case is a fault, that must be corrected and followed by a new inspection before the system is approved, and a certificate is issued - called **Fault/Failed (FF)**.

The three ways approach to estimate the percentage that passed the regular inspection was:

1. A questionnaire was sent out to 68 municipalities. Interviews with responsible employees
2. The number of approved ventilation systems was asked for in three housing organisations. Two are representing most of the condominiums and 21 % of all apartments. The third is representing the municipality owned companies and 40 % of all apartments.
3. Totally 10 300 complete inspection protocols have been analysed to identify the frequency of faults for different ventilation systems, occupation use, and comparing 1995 and 1997.

Abbreviations for ventilation systems

MSEX = Mechanical Supply and Exhaust ventilation with heat recovery

MSE = Mechanical Supply and Exhaust ventilation

MEO = Mechanical Exhaust Only ventilation

PSV = Passive Stack Ventilation

STATISTICAL DATA

To get a brief idea of the representation of the data gathered and the situation of both dwellings in multi family buildings and for non-domestic buildings some statistical data is presented. Dwellings stands for 75 % of all non-industrial built areas. Of the remaining 25 % hospitals, schools and day nurseries, and offices represent 2/3. The distribution of the 4.1 million dwellings between apartments and single family houses (houses) show us that 50 % of the apartments are found in the three larger city areas of Stockholm, Göteborg, and Malmö, see figure 1. Here are also located 40 % of the non-domestic areas. In Sweden are 33 % living in the three greater city areas, but also 27 % are living in small municipalities with less than 27 000 inhabitants, see table 1. The population in Sweden was 8.9 millions (1996).

Table 1 Inhabitants in different sizes of municipalities

Size	%
Cities. Stockholm, Göteborg, Malmö	16
Suburbs to the above cities	17
> 90 000	15
27 000 – 90 000	25
< 27 000	27

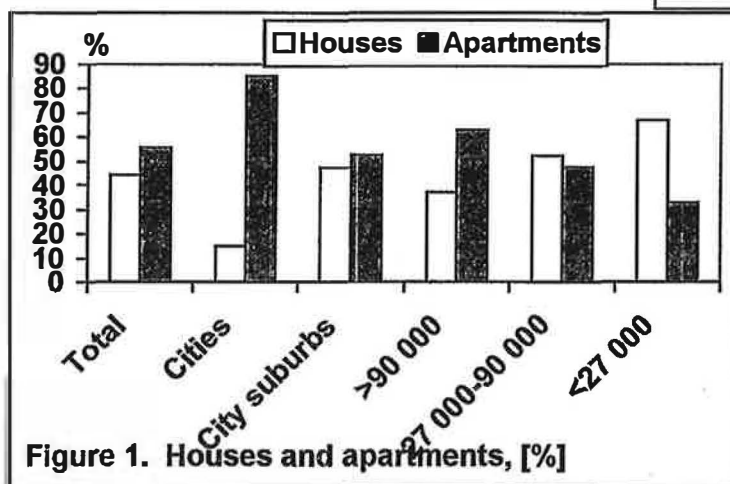


Figure 1. Houses and apartments, [%]

As we are to discuss the ventilation the main concern is what type of systems the Swedish non-industrial buildings are equipped with. Most of the houses have PSV, even though nearly all have a kitchen fan. For the apartments only the old buildings have PSV and over 60 % have a mechanical ventilation system. For the non-domestic buildings nearly all have mechanical ventilation or about 80 %, see also figure 2

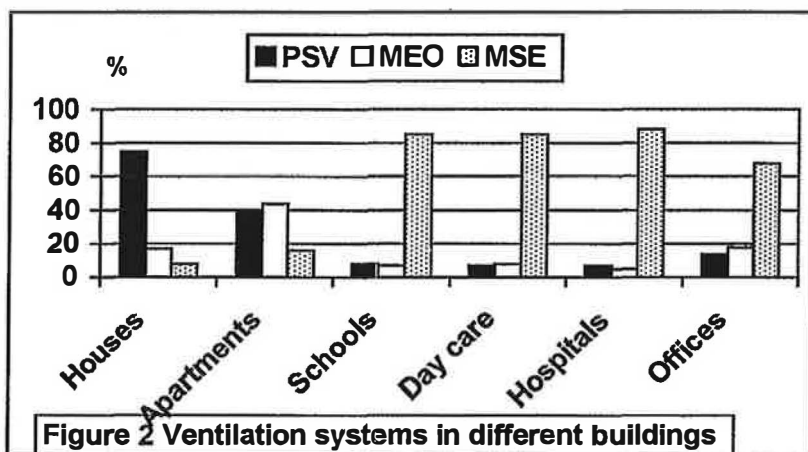


Figure 2 Ventilation systems in different buildings

RESULTS

Municipality approach

A questionnaire was sent out to 68 municipalities and answers received from 46 (68 %). It was asked for the percentage of buildings reported to the authorities approved at the inspections. As the municipalities owns most of the schools and day nurseries the reports from those are most accurate. It

should be observed that all the schools and day nurseries should have been inspected at least twice by the end of 1997. As the questionnaire was sent out in May 1997 still another 7 months of checking and renovation could be carried out before the end of the year. In particular the summer holiday from June to mid August is used for different measures.

In the distribution of questionnaires non of the three largest cities were included. Many of smallest municipalities were included. Here the number of apartments are lowest. If compared to the number of inhabitants the questionnaire is giving quite a good representation of both apartments and schools and day nurseries. However, it must be questioned the quality of the data for the apartments like: No data from the cities are given, in some municipalities only approved were registered, some didn't know the number of apartments in their municipality.

Table 2 Percentage of buildings (blds) approved at the inspection. Comparison between 1995 and 1997 of the number (no) of municipalities (mnp)

Comparison	Schools		Day nurseries	
	1995, Dec	1997, May	1995, Dec	1997, May
Total, approved, %	86 %	61 %	92 %	75 %
No mnp better 1997 than 1995		8		4
Equal 1995 and 1997	20		20	
All blds approved, no. mnp		11	14	
No. mnp 100 % approved 1995 & 0 % 1997		5		4
No. mnp 0 % approved 1995 & 100 % 1997		1		0

In total Sweden has 5200 schools and 15 000 day nurseries. The number that have passed the checking May 1997 is not that high as for December 1995, see table 2 However, the work continued during the whole year and as most of the buildings had been approved at inspections before half of the year had passed it was estimated that the situation was the same 1997 as 1995. But still there are buildings and systems that have not been checked at all since the bill passed the Parliament.

Interviews with responsible employees at 12 municipalities showed that most of them had the opinion that the politician was passively or actively supporting them. In particular the task is very tricky when the inspection has to take measures against the building management division within the municipality. In one case it has also been issued a penalty of fine unless a school had not been approved before a certain date. The policy is to have all the municipality owned buildings checked and passed before any measure is taken against other owners.

Questionnaires by the housing companies for apartments

Sweden has about 2.3 million apartments. In general there are three categories of principal ownership, see table 3. They are condominiums (condos), public companies, and private companies. Most of the private companies have a much older building stock than the others.

Only the organisation for condominiums and public owned companies participated in distributing the questionnaire to all the about 400 companies.

Table 3 Structure of ownership

Ownership	Organi- sation	Apartment s	
		No	%
Condos	HSB	325 000	14
	Riksb.	160 000	7
	SBC	100 000	4
	Others	50 000	2
Public	SABO	900 000	40
	Others	40 000	2
Private		700 000	31

As
always
the
quality
of the
answers
vary
within a
large

Table 4 Answered questionnaire

Orga- nisa- tion	Quest answered %	Systems checked %	
		MSE	MEO, PSV
HSB	80	21	79
Riksb.	55	26	74
SABO	70	-	-
Total	70	-	-

range. Some contain very detailed information and some have given rough estimations. But astonishing most of the answers received were very detailed, see table 4. Only the answers concerning condominiums had distinguished between systems, see table 5.

As the data given for the condominiums was given in January 1997 and also information was given of apartments inspected but needed remedial action before approved if it is assumed that most of those actions had been undertaken during

Table 6 Approved apartments public companies (SABO). Size of municipalities	
Size of municipality	Approved %
Cities, Stockholm, Göteborg, Malmö	61
Suburbs to the above cities	78
> 90 000	85
27 000 – 90 000	83
< 27 000	74
Total	75

Table 5 Approved apartments			
Orga- nisa- tion	Dwell.s %	Ventilation systems	
		MSEX, MSE %	MEO, PSV %
HSB	63	76	59
Riksb	76	88	69
SABO	75	-	-
Total	72		

1997. Slightly less number of apartments were approved in the three largest cities, see table 6. This trend was also shown for the condominiums.

Protocol evaluation

From inspections 10 289 protocols have been collected. The main reason for the collection was to establish a data base for future building management. This means that the protocols are the ones before any remedial action has been taken. The percentage of approved systems is less than reported from the questionnaires, but it must once again be observed that in the questionnaire was asked for the approved buildings after remedies and the protocols are the step before. In table 7 is given the results from the protocols per systems (not buildings).

Table 7 Protocols usage and ventilation systems. Approved [%]						
Year and bldg type	Protoc ol, no.	Appro ved %	MSEX	MSE	MEO	PSV
Total 1997	10289	44				
Total 1995	8089	37				
Hospitals 1997	670	32				
Hospitals 1995	403	25				
Medical care -97	194	44				
Medical care -95	73	63				
Day nurseries -97	645	68	66	64	80	40
Day nurseries -95	332	48	51	40	70	38
Schools 1997	2444	58	63	53	64	44
Schools 1995	2299	34	44	27	41	23
Offices	2321	38	50	34	29	19
Shops	277	74	95	47	19	10
Apartments	2589	27	36	34	28	21
Houses	78	33				
Others	857					

The percentage of approved systems have increased from 1995 to 1997 for the categories that have had the shortest intervals between the inspections: day nurseries, schools, hospitals. See table 8 and figure 4. The general trend is also that MSEX is the most approved system and PSV the least. MSE and MEO is similar. One explanation is that while MSE systems are designed as component delivery and installed according to

drawings and older systems, the MSEX is younger and delivered as systems with responsible producer and understanding the system approach. The PSV is old systems in old buildings. Sometimes it had been claimed that PSV suffered from lack of maintenance and could be better after remedy. But this is not shown as PSV both has least approved and most faults, see

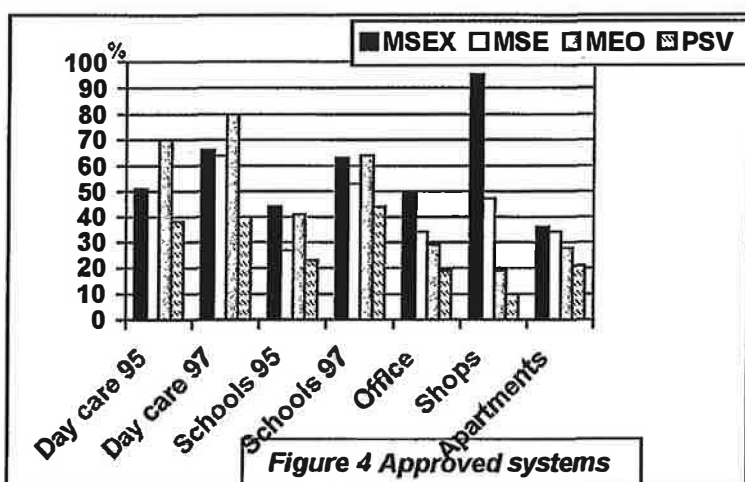


Figure 4 Approved systems

% and 30 % of the inspection. Faults failed an approval FF for the frequency of more than 30 %, 20 %, 10 %. The number has been noted and added. The total sum is given in the last line in table 8. E.g. for "Apartments, MSEX" 6 inspection positions have got more than 50 % of the inspections disapproved resulting in either FF or FA.

Table 8 Number of inspection positions giving faults.

Table 8 Number of inspection positions giving faults.																				
Apartments				Schools				Day nurseries				Hospitals	Med. care	Shop		Office				
MSEX	MSE	MEO	PSV	MSEX	MSE	MEO	PSV	MSEX	MSE	MEO	PSV			MSEX	MSE	MSEX	MSE	MEO	PSV	
Fault. Incl both fault that cause failure (FF) of approval + fault to be remedied before next inspection (FA)																				
No. insp pos. >50 %	6	11	5	11	3	4	2	5	3	4	4	7	5	3	1	8	4	5	7	10
No. insp pos. >30 %	6	21	18	13	5	8	5	9	4	5	9	9	12	4	3	19	10	20	16	13
Fault, failed to give approval of systems (FF)																				
No. insp pos. >30 %	5	7	4	8	0	1	0	1	0	0	0	3	1	1	0	2	1	2	3	9
No. insp pos. >20 %	5	9	4	9	1	1	1	3	1	2	0	3	4	1	0	3	2	3	9	11
No. insp pos. >10 %	9	19	8	11	2	5	3	9	1	2	2	4	9	3	0	11	7	15	15	12
Sum of insp pos. failures	31	67	39	52	11	19	11	26	9	13	15	26			4	43	24	45	50	55

The number of faults FA+FF in general was 5.3 faults/system for 1997 compared to 5.7 faults/system for 1995. If a system is not approved it has in general more than 3 faults that each caused a disapproval of the system. In order to judge or rank the systems the evaluation has been made from different points of views. It is a qualitative ranking based on the inspections giving the number of approved systems and the frequency of faults for each inspection point. The ranking is from "1" (best) to "4". Then the rank is added and a sum given. See table 9. The result of this sum gives a fault ranking sum in the proportion

1 : 2 : 3 = MSEX : MEO, MSE : PSV

To be read as: the ranking with regard to the number of faults for inspection positions and overall approval of systems. This gives that PSV has three times as high fault index compared to MSEX. Or that PSV can be expected to have faults in that magnitude compared to MSEX.

The most frequent faults, FF or FA, have been identified for each inspection positions by the frequency intervals. In table 10 is given the ranking and the score. This score is given by: If the inspection point has resulted in either FA+FF in the frequency 50 %, 30 % or FF in the frequency 30 %, 20 %, 10 %. Every building usage and every system is included. If an inspection point fails for all building usage and all 4 systems the maximum number is "20". As there is 5 different frequency indication the total can be 100. In the table 10 is the most

Table 9 Ranking ventilation systems				
Building use	Vent. system			
	MSEX	MSE	MEO	PSV
With regard to % appr. systems				
Day nurseries 1997	2	3	1	4
Day nurseries 1995	2	3	1	4
Schools 1997	2	3	1	4
Schools 1995	1	3	2	4
Offices	1	2	3	4
Shops	1	2	3	4
Apartments	1	2	3	4
With regard to inspection failures				
Day nurseries	1	2	3	4
Schools	1	3	2	4
Offices	1	2	3	4
Shops	1	2	3	4
Apartments	1	4	2	3
Sum of all above.	15	31	27	47
Sum except 1995	12	25	24	39
Sum exc -95 shops	10	21	18	31
Ranking total	①	③	②	④

Table 10 Most frequent faults		
Inspection point	Score	Place
Air flow, (function)	90	1
Other functions	72	2
Handling instruction	57	3
Air intake, (supply)	30	4
Device, duct (function)	29	5
Drawings	29	6
Ducts (exhaust)	28	7
Fan (function)	26	8
Control	22	9
Duct (supply)	19	10
Device (exhaust)	19	11
Device (supply)	17	12
Filter (supply)	16	13
Fan (exhaust)	13	14
User opinion	13	15
Others (exhaust)	12	16
Fan (supply)	10	17
Filter (exhaust)	6	18

frequent failure "the function air flow". It is a sort of resulting fault for what can go wrong in many other positions in a system. As number 2 is "other functions". Under this heading is collected such as "dirt and disorder, bad organisation".

CONCLUSIONS

The estimated approved rate at the end of 1997 are:

- Schools 85 – 90 %
- Day nurseries 90 – 95 %
- Hospitals ≈ 40 %
- Medical care ≈ 40 %
- Offices ≈ 40 %
- Dwellings 65 – 70 % (condos 85 – 90 %, public owned 75 – 80 % private < 50 %)
- Fault index are in the proportion
1:2:3 = MSEX : MSE, MEO : PSV
- PSV has far more faults than any other system regardless installed in apartments, schools or offices
- Repeated inspections decrease the number of faults and increase the approved rate
- The number of faults are 5.3 per system and the most frequent fault is the function of "air flow".
- Remaining cost for upgrading is about 450 MECU and the yearly cost is 150 – 200 MECU.

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