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**Occupant Response to Passive Stack Ventilation: A UK
Postal Survey**

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OCCUPANT RESPONSE TO PASSIVE STACK VENTILATION: A UK POSTAL SURVEY

SYNOPSIS

A study was set up to compare the effectiveness of passive stack ventilators (PSV) with mechanical extract fans (MEF) in providing adequate ventilation in UK homes. New build and refurbished homes with PSV and MEF were identified and questionnaires posted to 3000 households of which 1223 were returned.

The survey showed that in homes installed with a PSV system, only 7% of those in the kitchen and only 8% of those in the bathroom were reported as blocked up. There were also few cases in which the MEF was blocked up or disconnected: 1.5% in kitchens and about 5% in bathrooms. However, less than a half (40%) of the respondents "usually or always" used their MEFs whereas most (93%) of the PSV systems were in constant use.

The respondents were asked to rate how problematic condensation, mould and noise were in their home. Approximately one-third of the respondents had at least a moderate problem with condensation in winter (34%) and noise from extract fans (36%) and one-fifth (19%) had moderate problems with mould. Fewer occupants had problems in homes installed with a PSV system than homes fitted with a MEF, whether manually operated or humidistat-controlled.

1.0 INTRODUCTION

The new UK *Building Regulations Approved Documents, Part F* [1] explicitly allows the use of passive stack ventilation (PSV) systems as a means of providing adequate ventilation in homes whereas mechanical extract fans (MEF) were the only solution explicitly allowed in the previous version. Previous work has compared the performance of PSV with other ventilation devices, including MEF, in reducing moisture content [2]. However, occupant appreciation and the way in which occupants use such devices are also important if these devices are to be used effectively. A study was therefore set up to examine the efficacy of PSV and MEF devices in providing adequate ventilation in homes, as perceived by the occupants.

2.0 METHOD

2.2 Questionnaire

A postal survey was used as an initial means of studying views on PSV and MEF devices as it permitted the occupants of a large number of homes fitted with PSV to be approached for comment. The survey allowed BRE to discover basic information about the respondent's opinion of the adequacy of the ventilation in their home.

As the study was designed as a postal survey, the questionnaire was kept short and simple. The respondents were asked to rate how problematic a series of issues (eg condensation, mould and noise from extract fans) were in their kitchen, their bathroom, and their home as a whole. The issues were rated on a five point scale labelled "no problem" (1), "moderate problem" (3) and "major problem" (5). The questionnaire also included a separate section enquiring about the

main details of the ventilation devices (PSV, MEF or extract cooker hood) installed in the kitchen and the bathroom.

2.2 Sample selection

The sample needed to be balanced between the two methods of extract ventilation (MEF versus PSV), and also home size, type of housing, number of occupants, and geographical location. Furthermore, so that homes of similar building standards could be compared, the homes sampled all needed to be newly built or refurbished since 1985 when the previous version of the *Approved Documents* [3] was published.

A market research company (MRC) was contracted to locate the addresses of approximately 3000 homes installed with PSV and MEF systems. Addresses were obtained from local authorities (LAs), district councils, housing associations, the National House Building Council, builders and PSV manufacturers. The MRC was therefore asked to obtain a sample in which at least $\frac{1}{3}$ of the sampled homes were fitted with PSV systems and at least $\frac{1}{4}$ of the sampled homes had humidistat-controlled MEF and $\frac{1}{4}$ had manually-operated MEF. A balance of the type of ventilation system in new-build and refurbished homes was also requested.

The LAs who responded supplied a total of 5199 addresses. Unexpectedly, in many cases (53.2%) it was not known whether the home was new build or refurbished. There were also fewer homes with PSV systems (8.2%) or humidistat-controlled MEF (7.8%) than with manually operated MEF (63.0%). Thus, for the final sample size it was decided to exclude the (10.1%) homes in which the type of home and type of ventilation system was not known and to also reduce the unknown home types with manual MEF (from 36.9% to 4.7%). This results in a final sample size of $N=3000$ homes of which 14% had PSV, 14% had humidistat-controlled MEF, and the remaining 53% had manually controlled MEF. The ventilation device in 19% of the homes was unknown. Furthermore, 58% of the homes sampled were definitely new build and 18% were definitely refurbishment.

3.0 RESULTS AND DISCUSSION

3.1 Final sample

Questionnaires were posted to 3000 occupants and 1223 completed questionnaires were returned resulting in a response rate of 41%. A recent BRE postal survey achieved a response rate of 38% and 20-30% is generally considered typical of postal surveys [4]. During posting it was found that the information supplied by the LAs was not particularly accurate and it was not clear how many of the addresses were unoccupied or unbuilt, which may have reduced the recorded response rate.

Table 1 shows the proportion of new-build and refurbished homes with each type of extract ventilation device. The table shows that the number of PSVs and humidistat-controlled MEF is less than anticipated in the original sample frame. Furthermore, the proportions of refurbished and new-build homes with the various ventilation devices are not as similar intended as there are more MEFs in new-build homes and more PSVs in refurbished homes.

Ventilation device →	PSV (%)		Manual MEF (%)		Humidistat MEF (%)		Don't know (%)		Total	
	LA	OR	LA	OR	LA	OR	LA	OR	LA	OR
New-build	5.1	2.2	35.2	36.5	2.9	2.0	18.5	21.0	61.7	61.7
Refurbished	9.2	5.9	16.8	9.3	0.0	2.4	0.1	8.4	26.1	26.0
Don't know	0.4	0.4	8.3	5.1	3.7	2.4	0.0	4.4	12.4	12.3
Column Total	14.7	8.5	60.3	50.9	4.6	6.8	18.6	33.8	100.2	100.0

Data source: LA = Local Authority, OR = occupant response,
Percentages are of total sample (N=1223) for each data source.

Table 1. Ventilation devices installed in new-build and refurbished home

Table 1 includes figures based on the information collected from the LAs and the occupants. The information from both sources is similar and there is close agreement on which homes are refurbished or new. However, according to the occupant response there are fewer PSVs and fewer manually operated MEFs than predicted by the LA. If the "don't know" categories are excluded, and manual and humidistat MEFs are grouped together, then concordance is quite high (80.7% matching). As mentioned earlier, it was found that the LA records were not as reliable as expected when it came to identifying the addresses of existing homes, thus reducing confidence in the supplied data. The majority of the following analysis is therefore based on occupant response and not the LA data.

3.2 Description of homes

Most the sample were houses (73.3%) or flats (19.9%) with a few bungalows (6.7%). Approximately one-third (37.1%) of the houses were semidetached and another third (35.9%, 331) were detached. These figures are of similar proportions to those in the whole UK housing stock ie one-fifth (19%) flats but mostly (80%) houses and bungalows of which one-third (33%) are semidetached and one-fifth (20%) detached [5]. The sample therefore covered a good range of dwelling types built or refurbished since 1985 and is representative of the UK housing stock.

One-quarter (25.2%) of the homes were built between 1985 and 1992 with just over one-third (37.7%) built before 1985 and the remainder (37.1%) built after 1992. Most (61.6%) of the homes were new-build and a quarter (26.1%) were refurbished; the building status of 12.3% was unknown. As expected, most (91.0%) of the refurbished homes were built before 1985 whereas most (81.3%) of the new-build, ie non-refurbished, homes were built after 1985; of the homes built post 1992, most (93.2%) were not refurbished.

3.3 Ventilation devices

Overall, 27.1% of the occupants said that they had no main ventilation device (PSV or MEF) in the kitchen; this is possible but, of course, they would be expected to have a window. Similarly, 15.7% said there was no PSV or MEF in the bathroom, but 81.6% of the bathrooms

had a window and only 0.4% of the respondents reported having no window or ventilation device in the bathroom; these few cases may be due to the device going unnoticed (which is more likely in the case of PSV systems).

More detailed analysis showed that in homes with a MEF in the kitchen, 60.8% are manually-operated, 13.3% are light-pull activated and 15.8% are humidistat-controlled; the operation of the remaining 10.1% is unknown. In contrast, in the bathroom 47.3% of the MEFs are manually-operated, 35.5% are light-pull activated and 10.7% are humidistat-controlled. So, as expected, light-pull activated MEFs are more common in bathrooms than kitchens. However, one-tenth (9.9%) of the homes with a manually-operated MEF did not have a bathroom window, but unexpectedly most (70.8%) of the homes with a light-pull activated or humidistat-controlled MEF in the bathroom also had a window.

Homes with PSV systems were more likely to be refurbished (73.7%) than new-build (26.2%) ones whereas homes with a manual MEF were more likely to be new-build (79.6%) than refurbished (20.4%) homes. Homes with a humidistat-controlled MEF have an equal chance of being newly built or refurbished. However, overall there were more refurbished homes in the sample with a MEF (35.7%) than with a PSV (22.9%) system. 12.6% of the homes sampled did not have any ventilation device and a higher percentage of the homes with no device were new-build, ie 14.5% of new homes compared with 6.0% of refurbished homes.

Anecdotal evidence suggests that occupants block up or switch off ventilation devices because of draughts or noise. Therefore, the occupants were asked about whether or not they used the devices installed in their home. Table 2 shows that of the homes installed with a PSV system, only 6.6% of those in the kitchen and 7.7% of those in the bathroom were reported as blocked up. Table 2 also shows that there were also few cases in which the MEF was blocked up or disconnected: 1.2% in kitchens and 4.6% in bathroom. However, less than a half (39.4 to 49.0%) of the respondents "usually or always" used their MEFs whereas most (92.3 to 93.4%) of the PSV systems were in constant use. Thus, from a usage point of view, there appears to be some advantage to installing PSV systems.

Ventilation device	Usage	Kitchen % (N)	Bathroom % (N)
MEF or cooker hood: (N = 606)	Usually or always	39.4 (239)	49.0 (412)
	Sometimes	48.8 (296)	32.1 (270)
	Rarely or never	10.6 (64)	14.2 (119)
	Disconnected or blocked	1.2 (7)	4.6 (39)
PSV: (N = 152)	In use	93.4 (142)	92.3 (229)
	Blocked up	6.6 (10)	7.7 (19)

Percentages are of homes with each ventilation device.

Table 2. Use of ventilation devices

The occupants were also asked what ventilation devices existed in their home in addition to PSV and MEF systems. In general the number of alternative ventilation devices was similar in new-build and refurbished homes. One observation was that trickle ventilators were slightly more common in new-build homes and other background ventilation devices were slightly more common in refurbished homes. However, this observation is probably due to the age of the building rather than building status *per se*.

3.4 Subjective rating scales

Table 3 shows that in general the mean rating for each potential problem issue, rated on a 5-point scale (see table key), is around 2 or less, indicating that in general they were not problematic issues. However, approximately one-third of the respondents had at least a moderate problem (ie 3 on the rating scale) with condensation in winter (34.3%) and almost one-fifth (18.6%) had moderate problems with mould.

Room → Problem issue ↓	Kitchen		Bathroom		Whole home	
	\bar{x} (σ)	% ≥ 3	\bar{x} (σ)	% ≥ 3	\bar{x} (σ)	% ≥ 3
Condensation in winter	2.2 (1.2)	37.3	2.1 (1.2)	33.9	2.1 (1.2)	34.3
Mould in winter	1.5 (1.0)	14.7	1.6 (1.1)	16.1	1.6 (1.1)	18.6
Odours	1.9 (1.1)	28.8	1.5 (1.0)	15.1	1.6 (1.0)	17.2
Noise from extract fans [†]	2.4 (1.2)	45.5	2.3 (1.3)	37.2	2.2 (1.2)	36.2

1 = "no problem", 3 = "moderate problem", 5 = "major problem",

\bar{x} = mean, σ = standard deviation, [†] for homes with extract fans and/or extract cooker hoods.

Table 3. Ratings of ventilation-related problems

Table 3 also shows that a third of occupants had problems with noise from extract fans, ie 36.2% of those who had at least one MEF or cooker hood. Furthermore, almost one half (45.5%) of the respondents in homes with an extract fan or extract cooker hood had at least a moderate problem with noise from extract fans in the kitchen. The table also shows that approximately one-quarter of the occupants reported having some problem with odours in kitchens (28.8%). Overall, 22.7% of the respondents said that they had a major problem (ie rating 5 on the subjective scales) with one of the issues listed in Table 3 in either the kitchen, bathroom or home as a whole; 15.6% said they had major problems either just in the kitchen or just in the bathroom.

Further analysis (paired t-tests) showed that the respondents consider the issues listed in Table 3 to be significantly more problematic in the kitchen than in the bathroom ($2.7 > t > 14.4$, $1165 < df < 1175$, $p < 0.01$), except for mould which was more problematic in the bathroom ($t = 3.0$, $df = 1146$, $p < 0.01$).

3.5 Relationship between rating scales and physical properties

Table 4 lists the percentage of respondents reporting at least a moderate problem (ie rating 3 on

subjective scales) with condensation or mould in the kitchen, bathroom and whole home broken down by the type of ventilation device installed in each room.

Ventilation device	Kitchen		Bathroom		Whole home	
	Cond.	Mould	Cond.	Mould	Cond.	Mould
No main device	55.4	22.4	46.8	22.2	46.5	17.7
Manual MEF	37.1	15.5	31.9	15.3	35.4	21.2
Cooker hood	16.4	2.0	n/a			
MEF + cooker hood	16.3	5.5	n/a			
Humidistat MEF	39.5	15.9	39.3	18.1	40.7	22.5
PSV	29.9	12.6	30.1	14.0	17.0	11.1
Other combinations	27.9	8.9	24.4	12.1	29.8	14.5

Cells show % of respondents reporting at least a moderate problem (≥ 3 on rating scales) in homes with corresponding devices.

Table 4. Percentage of respondents with a moderate mould or condensation problem

Table 4 shows that in homes reported not to have any main ventilation device, the occupant is more likely to report a condensation or mould problem. The table also shows that fewer occupants have problems in homes installed with a PSV system than in homes fitted with a MEF, whether manually-operated or humidistat-controlled. The difference is minimal for condensation and mould in the bathroom and for mould in the kitchen, but larger for condensation in the kitchen and mould and condensation in the home as a whole. Kitchens fitted with an extract cooker hood, or PSV and extract cooker hood, are considerably less problematic than those without cooker hoods. Overall, one-third (34.3%) of all the homes had at least a moderate problem with condensation and one-fifth (18.6%) had problems with mould.

Table 5 is similar to Table 4 but shows the mean rating on the subjective scales, rather than percentages, and the results of an analysis of variance (ANOVA). The ANOVA tests whether the subjective ratings are significantly affected by the ventilation device present in the home. Table 4 shows that, on average, condensation and mould are most problematic if the home does not have any ventilation device (the ANOVA statistics are included in the table). Overall, homes with PSV systems were rated to have significantly fewer mould and condensation problems than those with manual or humidistat-controlled MEF. Cooker hoods were also shown to produce the lowest level of problems in the kitchen and are significantly better than standard MEF devices. PSV systems and cooker hoods are therefore considered better for reducing mould and condensation problems, however as mentioned above there were actually relatively few homes with problems.

Ventilation device	Kitchen		Bathroom		Home	
	Cond.	Mould	Cond.	Mould	Cond.	Mould
No device	2.7 ^{abc} _{def}	1.8 ^{ijkl}	2.4 ^{nop}	1.8 ^{qrs}	2.4 ^{tu}	1.7
Manual MEF	2.1 ^{agh}	1.5 ^{lm}	2.1 ⁿ	1.5 ^q	2.1 ^v	1.7 ^x
Cooker hood	1.7 ^{bgi}	1.1 ^{km}	n/a			
MEF + cooker hood	1.7 ^{ch}	1.2 ^l	n/a			
Humidistat MEF	2.2 ^{di}	1.5	2.2	1.7	2.3 ^w	1.7
PSV	2.0 ^e	1.5	1.9 ^o	1.4 ^r	1.7 ^{tvw}	1.4 ^x
Other combinations	1.9 ^f	1.3	1.8 ^p	1.4 ^s	2.0 ^u	1.5
Statistics: <i>F</i>	17.5	11.6	6.5	3.8	7.3	3.2
<i>df</i>	6,1148	6,1122	4,1155	4,1140	4,1151	4,1136
<i>p</i>	<0.001	<0.001	<0.001	<0.01	<0.001	<0.05

Means sharing common postscript are significantly different ($p < 0.05$).

Table 5. Mean rating of problems with condensation and mould

T-tests showed that the occupants rate new-build homes ($\bar{x}=2.2$) as having significantly more condensation problems than refurbished (1.9) homes ($t=3.3$, $df=1,1016$, $p=0.001$). However, a 2-way analysis of variance (ANOVA) of building status (new-build versus refurbished homes) and the type ventilation device installed show that both the ventilation type ($F=5.2$, $df=4,1008$, $p < 0.001$) and building status ($F=5.3$, $df=1,1008$, $p < 0.05$) significantly affect the level of problems with condensation. A further 2-way ANOVA showed that ventilation ($F=3.8$, $df=4,998$, $p < 0.01$) significantly affected the level of problems with mould whereas building status did not ($F=0.7$, $df=1,998$, $p=0.42$). Whether the property is new-build or refurbished *per se* therefore does not affect mould but the effect on condensation is additional to the effect of the type of ventilation device installed.

Odours were more problematic if there was no device in the kitchen ($F=8.0$, $df=6,1142$, $p < 0.001$). There were no significant effects of type of ventilation device on odour problems in the bathroom or home as a whole.

Table 2 lists the mean noise ratings of occupants in homes installed with an extract fan or cooker hood. However, ratings of noise were made by most respondents (80.1%), regardless of whether they had an extract fan or cooker hood, thus allowing a comparison of the noise due to the different ventilation devices. As expected, the occupants considered the noise from extract fans to be significantly more problematic if their homes had (in order of increasing problems): a cooker hood (2.2), manual MEF (2.4), MEF plus cooker hood (2.5) and humidistat MEF (2.7), and least problematic if there was no ventilation device (1.2) or a PSV (1.3) in the kitchen ($F=32.6$, $df=6,951$, $p < 0.001$). Similar ratings were made of the bathroom; there were significantly more problems with noise if there was manual (2.3) or humidistat (2.2) MEF installed rather than a PSV (1.1) or no device (1.1) at all ($F=26.8$, $df=4,1005$, $p < 0.001$). So, PSV

seem to be a more favourable ventilation system from a noise point of view, but in general the problem was at a low level (ie subjective scales were rated <3). Similar results were also found for the home as a whole ($F=31.8$, $df=4,1103$, $p<0.001$).

T-tests also showed that new-build homes (2.1) have significantly more problems with noise from extract fans than refurbished (1.9) ones ($t=4.7$, $df=1,979$, $p<0.001$). This result could be because homes with extract fans are more likely to be new-build ones (see Table 7) and homes with PSV are more likely to be refurbished.

4.0 Conclusions

The respondents of a national postal survey did not, on the whole, consider themselves to have major problems with their home due to condensation or mould. However, their responses showed that on average homes with passive stack ventilation (PSV) systems are rated less problematic than those fitted with mechanical extract fans (MEF). Further analysis showed that homes installed with cooker hoods were most effective in reducing mould, condensation and odour related problems in kitchens. As expected, there were fewer problems with noise from PSV systems than MEF (particularly humidistat-controlled MEF). Therefore, standards and guidelines can include the use of PSV systems and extract cooker hoods in new build homes and as part of refurbishment schemes.

5.0 Acknowledgement

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