Ventilation for Energy Efficiency and Optimum Indoor Air Quality
13th AIVC Conference, Nice, France
15-18 September 1992

Poster 18

Odour Threshold of Kitchen Exhaust Air During Typical Cooking Situations In A Dwelling.

M. Luoma and K. Kovanen

Technical Research Centre of Finland (VTT), Laboratory of Heating & Ventilation, P O Box 206 (Lämpömiehenkuja 3), SF-02151 Espoo, Finland.

ABSTRACT

The odour threshold value of kitchen exhaust air was experimentally determined during typical cooking situations and tobacco smoking in a dwelling. During cooking, air from the exhaust duct was taken into a sample bag. The odour threshold concentrations of the samples were determined by sensory evaluation using olfactometer and untrained odour panel. Experiments were made both in laboratory and field settings.

The largest odour threshold concentration of 168 o.u./m^3 was determined during the frying of herring. In accordance with the definition, here 50 % of the panellists do not observe any odour when the sample gas is diluted 168 times. Thus, the highest permitted exhaust air proportion in supply air would be 0.6 %. The results of the odour tests are used in a study, where the prerequisities for the extraction of exhaust air through the outer wall of multi-storey residential buildings are examined.

1. INTRODUCTION

Within the framework of the LVIS 2000 research programme, in the project "Ventilation systems for the dwellings of the future", the alternatives for ducting away the exhaust air of ventilation systems for individual dwellings in apartment buildings were examined /1/. It was noted that by extracting air directly to an outer wall many of the problems at present occurring are avoided, like disturbances in pressure differences and air flows caused by thermal forces. The space requirement for ducting is reduced as the exhaust ducts do not need to lead to the roof from within the building. The drawback with extraction through an outer wall is the possible migration of exhaust air odours to the open windows or supply air terminal devices in the wall, and via these into the apartment.

A project has been initiated with funding from the Technology Development Centre (TEKES) where the extraction of exhaust air through the outer wall is examined with calculations, as well as wind-tunnel and full-scale testing. Knowledge of the odour threshold for exhaust air is necessary in assessing the exhaust air dilution ratios at the building's outer wall and thus in the supply air based on theory and measurement. As the fumes produced in cooking generally create the odour found in the exhaust air of apartments, it was decided to examine the odour threshold values of exhaust air during the cooking of common foods when strong odours are produced.

2. LITERATURE SURVEY

The literature survey looked for research projects where common or permitted exhaust air concentrations in supply air were presented. Table 1 shows the literature references found.

Permitted leakage values from the outlet side to the supply side for heat recovery equipment were found in the literature. The permitted proportions were 3-10 %.

The re-entry of exhaust air into supply air in an apartment-based ventilation system has been investigated using tracer gas in test houses in Kuopio, Finland. The proportions measured ranged from 0 to 2.3 %. On occasions, the amount of re-entry rose to almost 6 per cent.

However, no fully comparable material concerning odour threshold values nor target values for exhaust air proportions were found from the literature.

3. SUBJECTS OF RESEARCH

The cooking situations examined were boiling cabbage, frying onion, making pancakes and frying herring, in addition to smoking. The rate of extraction of the exhaust air flow from the kitchen was 20 dm^3/s, which corresponds to present official regulations /2/. Experiments were carried out both with test equipment constructed in the laboratory (Figure 1) and under field conditions. The construction of the test equipment is such that it efficiently draws in fumes from food being prepared.

4. RESEARCH METHODS

In the performance of the tests, the aim was to simulate the cooking situations so that they corresponded to reality as closely as possible. In frying, the food was put into a hot frying-pan containing cooking oil. In boiling, the food was placed in boiling water.

During cooking, air from the exhaust duct was taken into a sample bag. Five samples were taken in each food-preparation situation. The first sample was taken from the exhaust duct before the start of cooking to determine the background concentration. The next sample was taken immediately after the addition of food. The last sample was taken after the food had been prepared. The sample bags were delivered to the Chemical Laboratory of the Technical Research Centre of Finland for the determination of the odour concentrations. The volume of the sample bag was around 20 dm^3, while the filling of the sample bag took around one minute.

During the smoking test, the test person smoked continuously. To ensure the flow of cigarette fumes into the kitchen hood, a sheet of plastic film was placed above the smoker.

The odour threshold concentrations of the samples were determined by sensory evaluation using the Ströhlein olfactometer according to the German standard VDI 3881 /3/. The olfactometer creates increasing concentrations from neutral air and the sample gas until the test person acting as the detector can distinguish an odour in the sample gas flow. On the basis of the test persons' findings, the olfactometer calculates the odour concentration of the sample in the form of odour units/m^3 (o.u./m^3). The odour concentration refers to the number of times the sample gas flow must be diluted for 50 % of the odour panel members not to observe odour in the sample gas flow.

The acceptability of an odour was determined by asking members of the odour panel how they perceived the odour at the moment it was detected. The odour panel comprised 6-8 persons, all members of staff at the VTT Chemical Laboratory.

5. RESULTS AND EXAMINATION OF RESULTS

5.1 Odour threshold values of exhaust air

The odour threshold values determined from the air samples taken during various cooking situations are presented in Figure 2. The temperature of the exhaust air was 24-29 °C.

The panel members' assessments of odour acceptability are shown in Table 2. Some of the panellists considered the strong odour values found during the frying of onion to be acceptable, while the strong odour values found during the cooking of pancakes and herring were generally considered unacceptable. Acceptability is a subjective assessment.

The largest odour threshold concentration of 168 o.u./m^3 was determined during the frying of herring. In accordance with the definition, here 50 % of the panellists do not observe any odour when the sample gas is diluted 168 times. Correspondingly, 84 % of panellists did not note any odour when the same sample gas flow was diluted 219 times.

The herring frying test was repeated in the kitchen of a single-family house. The air sample was taken from the kitchen's exhaust duct. The odour threshold concentration of the air sample was smaller than that found during the corresponding laboratory test (Table 3). This difference was due to the kitchen hood in the single-family house kitchen not efficiently extracting the food fumes, part of these fumes migrating to elsewhere in the kitchen.

The test in the single-family house indicated that increasing the exhaust air flow to 45 dm^3/s did not have a significant effect on the odour concentration of the exhaust air.

5.2 Permissible proportion of exhaust air in supply air

For each food preparation situation, the largest odour threshold concentration was chosen from the results to represent the situation in question. From these results, the largest permitted proportion of exhaust air in supply air was calculated from these values so that no odour was discernable in the supply air. The exhaust-air proportion is the reciprocal of the odour threshold concentration. The results are shown in Table 4.

The largest permitted exhaust air proportions in the supply air according to Table 4 are between 0.6 and 2.3 % depending on the quality of the exhaust air. Here it has been assumed that the exhaust air of the apartment does not contain any odour other than that caused by cooking.

5.3 Dilution of exhaust air on the outer wall of the building

The dilution of exhaust air on the outer wall of a building was investigated initially with full-scale tests in one office building. Tracer gas was fed from one point at the building's facade, and tracer concentrations were measured at eight points in the same facade to determine the dilution ratio. An aim was to locate the measurement points at the worst places according to smoke observations. A total of five situations were investigated.

The highest instantaneous value for the exhaust air proportions measured in different wind conditions was 1.6 %. According to the measurements, the local exhaust air concentration fluctuated rapidly and over a wide range according to the nature of the wind. Thus the concentration peaks were short-lived and from these the quality of the supply air cannot be considered measurable. The 2-minute mean values obtained for the exhaust air proportions were lower than the highest permitted exhaust air proportion found in the worst case of the odour tests (frying herring) of 0.6 % (the highest 2-minute mean was 0.5 %).

6. CONCLUSIONS

On the basis of the cooking tests performed, up to 0.6 % exhaust air can be permitted in supply air without food odour being observed in the supply air. The exhaust air proportions determined from full-scale tests in the wall of a building were generally lower (the highest instantaneous value being 1.6 % and the highest 2-minute mean value being 0.5 %). No fully comparable material on odour threshold concentrations nor on target values for exhaust air proportions were found from the literature.

REFERENCES

/1/ Luoma, M. & Kohonen, R., Demand controlled ventilation systems for dwelling houses of the future. Technical Research Centre of Finland. LVIS-2000 Research Programme. Report 8. Espoo 1990. 103 s.

/2/ National building code of Finland, Indoor climate and ventilation in buildings. Regulations and guidelines 1987. The Ministry of the Environment.

/3/ Olfaktometrie, Geruchsschwellenbestimmung, Verein Deutscher Ingenieure, VDI 3881, May 1986.

TABLES

Table 1. Permissible proportion of exhaust air in supply air. Literature survey.

Proportion	Explanation	Reference
5 %	Leakage between supply and exhaust air streams in heat recovery not more than 5 %.	Canadian Standards Association, Residential Mechanical Ventilation Requirements.
3 %	If the carry-over exceeds 3 %, the pressure difference shall be determined before carrying out the efficiency tests.	CEN ENV 308:1991, Heat exchangers.
10 %	Leakage between supply and exhaust air streams may not exceed 10 %, when the pressure difference between exhaust and supply is 200 Pa.	Quidelines for type approval tests for heat recovery devices. 6.5.1983. Finland.
12...36 %	Infiltration between apartments at the pressure difference of 50 Pa, 3 apartments measured.	Levin, P. Air leakage between apartments, 9th AIVC Conference, Gent, 12-15.9.1988.
0...2,3 %	Re-entry from exhaust to supply air, short-term measurements in a test house.	Savolainen, T. etc., Neulamäki test houses: Ventilation and indoor air quality. University of Kuopio, Department of Environmental Sciences. Report 4/1988.

Table 2. Panel members' assessments of odour acceptability.

Frying onion	Odour concentration o.u./m^3	Acceptability		
		Yes	Do not know	No
1. Background	2	2	2	2
2. 0 min	28	2	2	2
3. 2 min	31	1	2	3
4. 5 min	34	2		4
5. 10 min	56	3		3

Making pancakes	Odour concentration o.u./m^3	Acceptability		
		Yes	Do not know	No
1. Background	0			
2. 0 min	28	3		3
3. 3 min	48	1	1	4
4. 6 min	107	2		4
5. 12 min	41	1		5

Frying herring	Odour concentration o.u./m^3	Acceptability		
		Yes	Do not know	No
1. Background	3		2	4
2. 0 min	48	1	1	4
3. 3 min	73	1	1	4
4. 6 min	72	2		4
5. 10 min	168			6

Table 3. Permissible proportion of exhaust air in supply air (frying herring).

Exhaust air flow	Test site	Odour concentration o.u./m^3	Permissible proportion %
20	Laboratory	168	0,6
20	Single-family home	54	1,9
45	Single-family home	43	2,3

Table 4. Permissible proportion of exhaust air in supply air (laboratory tests).

Cooking situation	Odour concentration (P50) max o.u./m^3	Permissible proportion $\frac{1}{(P50)max} \cdot 100\ \%$
Boiling cabbage	43	2,3
Frying onion	56	1,8
Making pancakes	107	0,9
Frying herring	168	0,6
Smoking	48	2,1

FIGURES

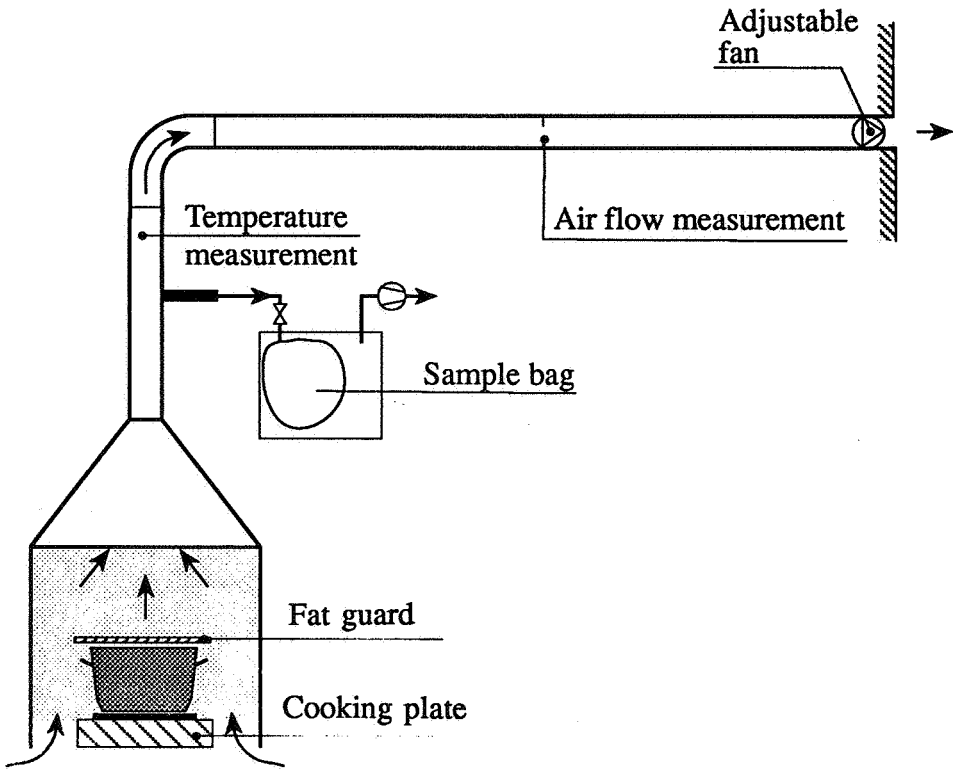

Figure 1. Arrangement for the laboratory tests.

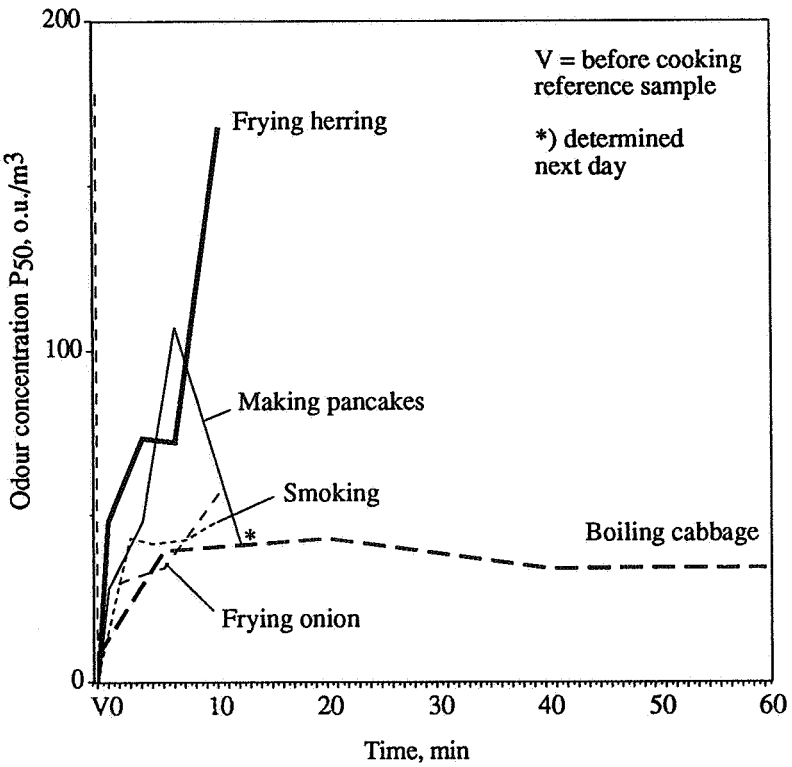

Figure 2. Odour threshold values of exhaust air during the cooking of common foods.