Particles of smoke are heavier then the surrounding air, they influence the smoke patterns mainly under 1 pascal. It is also difficult to fix the exact size of the air inlet. An error of + or - 0.5 mm is possible. This has only a very small influence on the results.

Recommendations

It is possible to reduce the geometry of a vent without losing energy. This makes it possible to add sound absorbing materials. This phenomenon allows some freedom in the architectural design of the facade as well by integrating the vent in a window frame. Flat blades at the outside of a vent can be added without causing a significant loss of energy. Also a clean netting (with a big surface in relation to the air inlet) does not cause much loss of energy. Furthermore it is necessary to offer protection against some adverse climatical conditions, like rain and high wind velocity. In these cases, for example, a double closing system of the jet (compartment) is needed. New measurements show that there are even better results with smaller geometries, because the air flow becomes less turbulent. To get a better sound insulation it is necessary that the internal geometry of the vent has a big curve and that sound absorbing materials like rockwool are used.

Practical achievement of a healthy indoor environment

For a lot of buildings it should be possible to find a good combination of vents and an exhaust -or balanced ventilation- system to achieve a good indoor climate without too high costs. It is possible to construct an air inlet which induces the air and causes a good mixing of the air underneath the ceiling, making use of the coanda effect, even with a small pressure difference between inside and outside. In this way it is possible to use vents with a big capacity, without causing serious draught problems. These vents can be combined with a pressure controlled exhaust system. When a balanced ventilation system is used, there will still be refreshing of air, even when the vent is closed. Draught problems and a control system (air pressure regulation) will be studied in a test chamber. When the geometry of the vent is developed further, it should be possible to achieve a good sound insulation as well.

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ACCEPTABILITY OF WALL EXHAUST DISCHARGES IN RESIDENTIAL VENTILATION

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ABSTRACT

The usual way of extracting the waste air in a room is to conduct the air above the roof. However, it would be easier to install exhaust and intake vents on the outer wall of the building. This paper presents the results of full-scale experiments that were carried out on a three-storey building using tracer gas measurements and video recording. To assess the measured concentration on the building wall, the odour threshold values of exhaust air during cooking or smoking were used.

The results were in agreement with the theories underlying the use of roof exhausts near the exhaust opening, but at a greater distance (5 - 10 m) the theories indicated concentrations that were too low. The highest intake air concentration was 0.5 % of the exhaust air concentration and it was slightly smaller than the odour threshold value of 0.6 %.

On the basis of the tests performed so far, the wall exhaust system seems to be acceptable in residential buildings.

INTRODUCTION

The exhaust air from a building must be discharged outdoors in such a way that no harmful effects are caused to the building, its occupants, or the environment. The usual way is to conduct the exhaust air above the roof of the highest section of the building. However, it would be easier to install exhaust and intake vents on the outer wall of the building, particularly in renovating the ventilation system in old residential buildings, where an apartment-based mechanical ventilation system could be used. The purpose of this study was to examine whether exhaust vents could be mounted on the outer wall without polluting the intake air.

Very little information about a wall exhaust system is available in the literature. H. Niemelä et al have investigated the re-entry of exhaust air into the supply air in an apartment-based ventilation system in test houses in Kuopio, Finland (1). The proportions measured ranged from 0 to 2.3 %. On occasions, the amount of re-entry rose to almost 6 %. Re-entry was highly probable because the intake vent was spaced closely together with the exhaust vent in the same unit (distance between the vents was only 7.5 cm) and the exhaust velocity was small. Further, they found that the pressure-induced air leaks between the apartments can transport almost equal quantities of contaminants in the mechanical exhaust ventilation system. In this study the exhaust velocity was much higher and the concentrations of tracer gas were measured outside the assumed intake vents.

The full-scale experiments described here were part of a study. Also, wind tunnel experiments have been performed (2) and the odour threshold values of exhaust air during cooking or smoking have been determined (3). There is a lot of information available for estimating the air intake contaminations from roof level exhaust. In this study we have attempted to apply the ASHRAE Handbook (4) formulas for roof level exhausts to wall exhausts.

MATERIALS AND METHODS

The measurements were carried out in the building of the Laboratory of Heating and Ventilation of the Technical Research Centre of Finland. The building was suitable to model a three-storey residential building, approximately 12 m high, surrounded by numerous tall trees, and it is near a relatively tall, 10 m high, building. Figure 1 shows a plan view of the general location of the building.

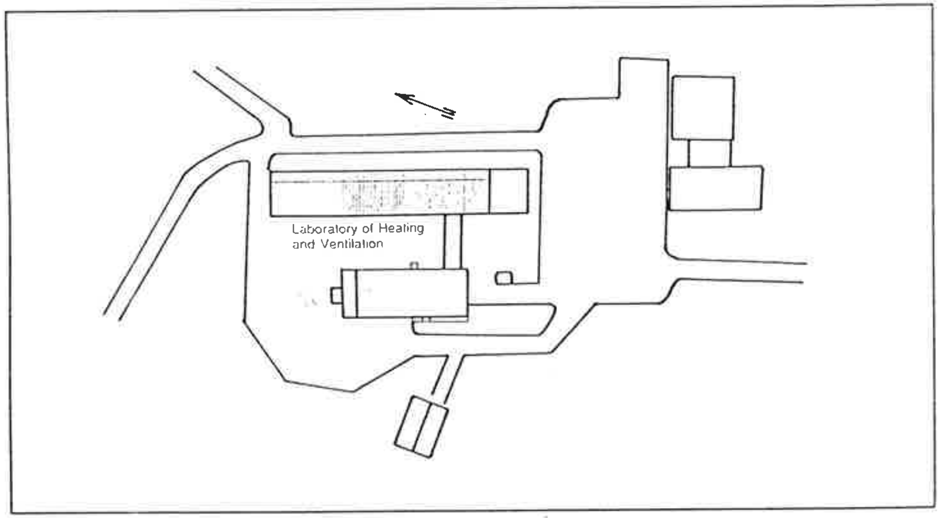

Fig. 1. Plan view of the building investigated.

The exhausts and measuring points were located on the east wall of the building, Figure 2. For comparisons with a conventional roof exhaust system, one exhaust point was placed on the roof. It consisted of a vertical pipe and a horizontal plate above the mouth of the pipe, so that the exhaust vertical velocity was zero.

Preliminary visual tests were conducted using a smoke tracer released from the exhausts to qualitatively assess the worst locations for air intakes under the wind conditions in question. The measurement points were then placed in these locations. The smoke tests also revealed the advantage of high exhaust velocity.

For each measurement test, a gas mixture from one point at the building's wall was released with a density and flow matching that of a realistic situation. The gas mixture consisted of a tracer component (dinitrogen oxide, N_2O) and air in appropriate proportions to obtain the desired initial tracer concentration. The concentration of the tracer component was then detected at eight points on the same facade using a gas analyzer. The exhaust flow was 30 dm^3/s. In this case the air change rate of, for instance, a 85 m^2 apartment is 0.5 m^3/hm^3. The exhaust opening was a cylindrical horizontal pipe with an internal diameter of 0.058 m, which yielded an average exhaust velocity of 11.4 m/s.

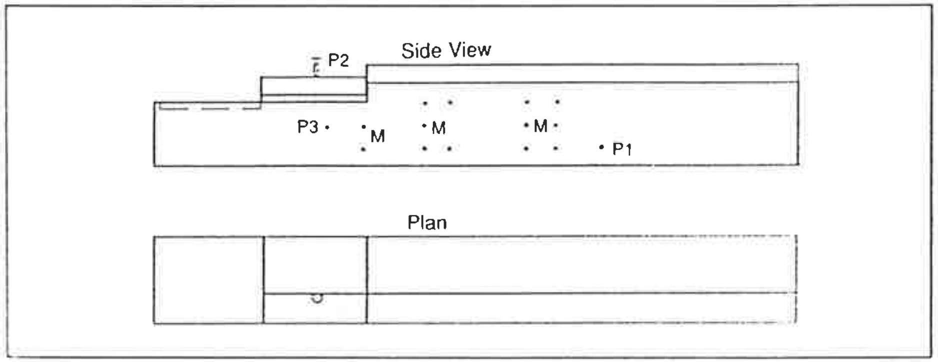

Fig. 2. A schematic view of the building investigated. The positions of the exhausts (P) and the measuring points (M) are marked.

The measurement conditions are given in Table 1.

Table 1. Measurement conditions.

Exhaust location	Wind speed at roof height m/s	Wind direction	Outside temperature °C
P1, wall	1 - 3	northwest	0.5
P1, wall	1 - 3	northwest	0.5
P2, roof	2 - 5	west	3.3
P3, wall	3	west	1.7
P3, wall	3 - 6	south	0.3

The sampling time was 2 minutes for each measurement point, including 17 concentration values. From these values a time-averaged concentration was calculated. The measurements were generally repeated five times at 18 minute intervals.

The dilution between the exhaust and intake vent is defined as

$$D = C_e/C \tag{1}$$

where D is the dilution, C_e is the exhaust concentration and C is the surface concentration at the wall. According to the ASHRAE Handbook (4), for buildings with exhaust of zero stack height on a flat roof, the minimum dilution at a roof or wall intake with a 10-minute averaging time is defined as

$$D_{min} = (D_0^{0.5} + D_s^{0.5})^2 \quad (2)$$

where

$$D_0 = 1 + 7.0\beta(V_e/U_H)^2 \quad (3)$$

and

$$D_s = B_1(U_H/V_e)(S^2/A_e) \quad (4)$$

where D_{min} is the minimum dilution, D_0 is the apparent initial dilution caused by internal turbulence in the exhaust jet, D_s is the distance dilution caused by the combined action of the building and the atmospheric turbulence, U_H is the mean wind speed at wall height, V_e is the exhaust face velocity, S is the "stretched string" distance between the exhaust and intake, A_e is the exhaust face area, and ß and B_1 are constants.

Equations 2 - 4 show that the minimum dilution is proportional to the velocity ratio $M=V_e/U_H$ and the dimensionless distance $S/\sqrt{A_e}$. The ASHRAE Handbook (4) also describes the formula for adjusting the 10-minute values to 2-minute values.

RESULTS

An example of the test results is presented in Figure 3.

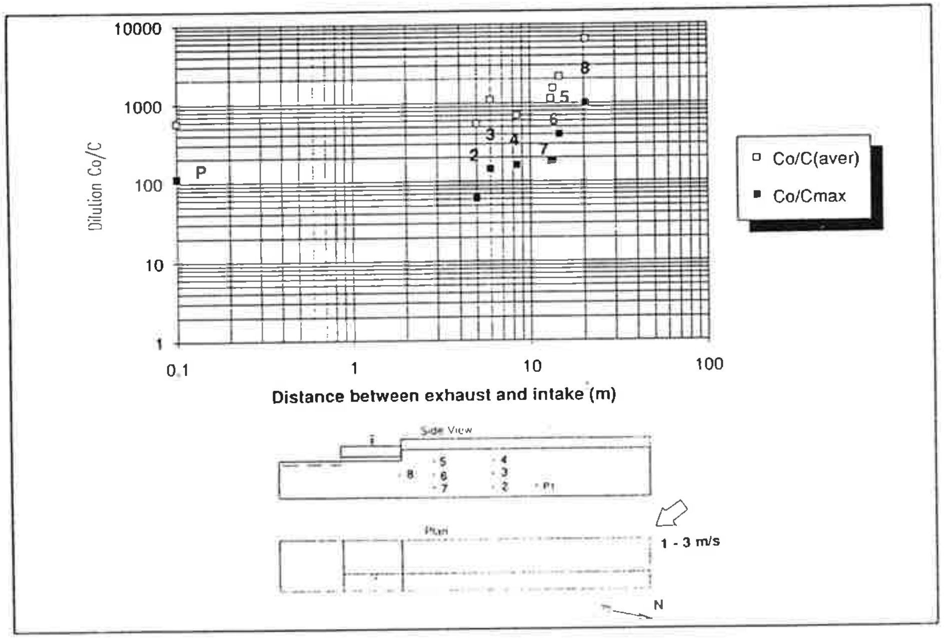

Fig. 3. The minimum dilutions in different locations by the wall. C_0 is the exhaust concentration, C(aver) is the time-averaged (2-minute) surface concentration by the wall and C_{max} is the maximum instantaneous concentration at the same point.

The maximum instantaneous concentrations (i.e. minimum instantaneous dilutions) are also shown in Figure 3. The difference between the instantaneous and time-averaged (2-minute) dilutions can be a decade. According to the measurements, the local concentration fluctuated rapidly and over a wide range caused by the nature of the wind. Thus the extreme values are short-lived and cannot be considered to have a dimensioning impact on the quality of the supply air.

Perhaps it is questionable to compare full-scale results with the theory because in field measurements the velocity ratio M and wind direction are not constant. Furthermore, due to the limited amount of points, the intrinsic minimum dilution may remain unnoticed. However, in order for the formula according the theory to be useful, the measurement values should be higher than the minimum values that represent the most disadvantageous velocity ratio according to the theory. In Figure 4 it is marked as a dotted line. Measurement values in Figure 4 are from two different wind cases.

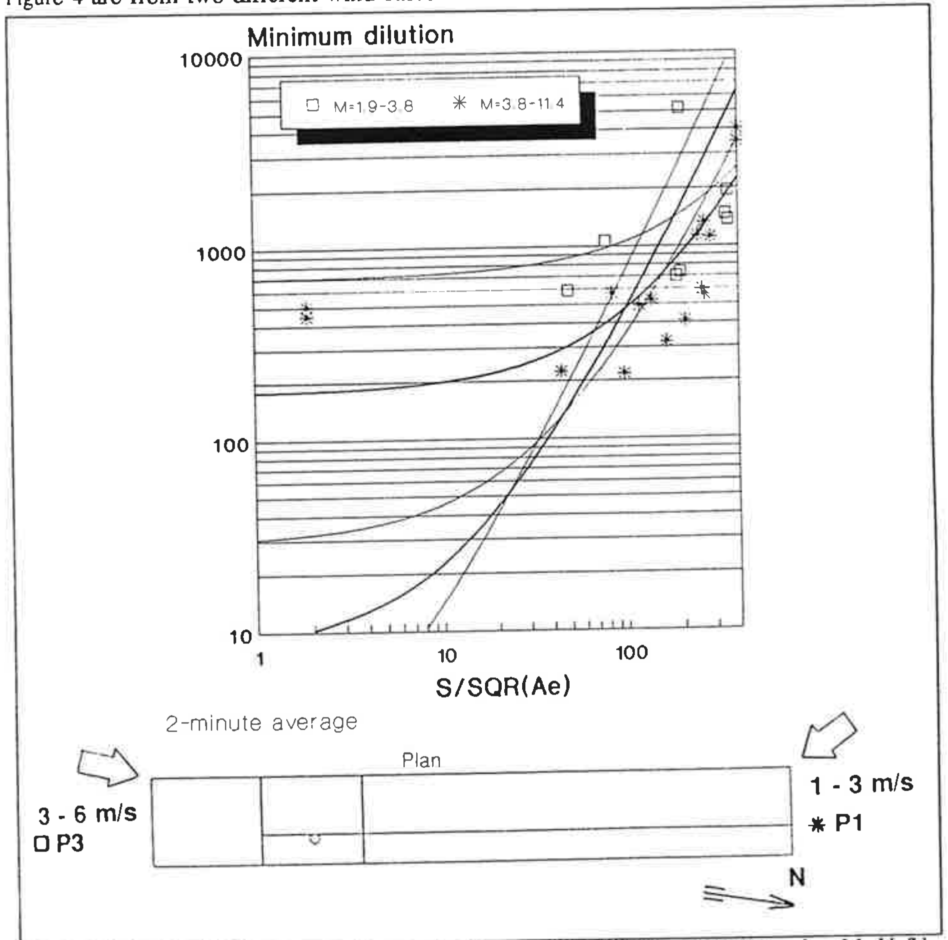

Fig. 4. Minimum dilutions according to the theory with different velocity ratios $M=V_e/U_H$ (lines). V_e is the exhaust face velocity, U_H is the mean wind speed at wall height, S is the "stretched string" distance between exhaust and intake, and A_e is the exhaust face area. The dotted line DMIN corresponds to the most disadvantageous velocity ratio.

The results were in agreement with the formula for roof exhaust near the exhaust but at greater distances (5 - 10 m; $S/\sqrt{A_e} > 150$) the formula gave minimum dilutions that were too high. One explanation for this might be the wind condition: the formula assumes wind blowing along the wall, whereas in the measurements the wind direction was partly around the corner of the building. This caused an alteration of the flow-field near the wall.

On the basis of cooking tests performed (3), up to 0.6 % of exhaust air can be permitted in the supply air. In accordance with the definition of this odour threshold, 50 % of the occupants do not observe any odour. The corresponding minimum dilution is 168. The value was determined in test conditions where herring were fried. Here it has been assumed that the exhaust air of the apartment does not contain any odour other than that caused by cooking. In this study 2-minute mean values obtained for the intake air were lower than the highest permitted value of 0.6 % (the highest 2-minute mean was 0.5 %).

The results concerned only one exhaust. However, it is possible that a number of families are eating herring on the same day. Accordingly, the summarizing effect of numerous exhausts should be studied.

CONCLUSIONS

The formula for minimum dilution in the ASHRAE Handbook (4) can be used for wall exhaust over short distances. For longer distances (5 - 10 m) the formula gave minimum dilutions that were too high.

The highest 2-minute mean intake air concentration was 0.5 % of the exhaust air concentration. This relative concentration was slightly smaller than the odour threshold value of 0.6 %.

The effect of the sampling time was found to have a considerable effect on the results.

On the basis of the tests performed so far, the wall exhaust system seems to be acceptable in residential buildings. The summarizing effect of numerous exhausts should be studied.

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ASSESSMENT OF HOOD STACK RE-ENTRAINMENT AS DETERMINED BY REAL-TIME TRACER GAS MEASUREMENTS

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ABSTRACT

A tracer dispersion study was performed to evaluate the dilution of exhaust stack emissions from chemical fume hood stacks on the rooftop of a laboratory building complex located on a United States midwestern university campus. Tests were designed to (1) experimentally verify dilution ratios at outdoor air intakes for emissions from existing chemical fume hood stacks on the building complex; (2) evaluate potential exposures to rooftop service personnel; (3) further characterize the airflow on the rooftop and the effect that turbulence might have on the dispersion of stack pollutants both instantaneously and averaged over time; and (4) evaluate the effects of increased stack heights as they relate to minimum and time weighted median stack dilution. Study results indicate that under normal operating conditions, vapors generated in the laboratories and emitted from the stacks were not expected to reach the outside air intakes in concentrations high enough to detrimentally impact the health of building occupants. However, odors of certain chemicals could be detected in some instances at the outside air intake and therefore could be sensed by occupants of the building and cause complaints about air quality.

INTRODUCTION

Environmental Health & Engineering (EH&E) performed a series of tracer gas tests to determine if the heights of currently-installed exhaust stacks provide acceptable exhaust dilution at a United States midwestern university building complex (hereafter, "the Building"). Since many of these stacks exhaust potentially hazardous substances, the dispersion of exhaust streams at the air intakes of the Building was of vital importance for the health and comfort of Building occupants. This study also provided the basis of evaluating the safety precautions that should be used by personnel who may be on the rooftop (i.e., to service equipment).

The study directly measured the amount of dilution that occurred on the rooftop from stacks of various heights, under varying wind conditions, and at various distances downwind of the source. This was accomplished by injecting tracer gas directly into an exhaust stack and monitoring the concentration of the tracer gas downwind on a real time basis using a computerized data acquisition system (DAS). These measurements were then assembled into frequency distributions to evaluate the percentage of time that the tracer dilution at the receptor was above a certain level. These measurements also serve as a check on calculated stack height requirements and outdoor air intake locations as based on a dispersion model study previously performed for these stacks and the Building's outdoor air intakes. Calculations were performed using a Gaussian Plume model for continuous sources to determine dilution ratios for planned and current stack locations, heights, and discharge velocities. The model used assumed steady-state flow conditions, and the results can best be related to the time-weighted median concentration of tracer (and dilution ratios) observed during the study. The effects of local turbulence were not included in these calculations.

METHODS

A tracer gas, sulfur hexaflouride (SF_6), was used to mark the air discharged from current and prototype stacks on the Building's rooftop. The tracer gas was delivered into the stack on the inlet side of the exhaust fan using an injection system designed to monitor and maintain a steady flowrate of tracer gas. Tracer flow was controlled by maintaining a constant delivery pressure