UTILIZING SELECTIVE WITHDRAWAL IN THE VENTILATION OF LARGE ROOMS "SELECT-VENT"

AIVC 12050

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ABSTRACT

This paper presents a way of ventilating a large room so that the room can be divided into different zones by temporary vertical walls (canvas, plastic sheets etc) and with no physical ceiling. Different activities, like welding, painting or mechanical assembly, can go on inside each of these zones, unaffected by each other, as long as pollutants are extracted through designated extract openings in the outer walls.

These inner, temporary walls need only reach from say 3 - 4 metres above the floor and up to some metres above the pollutants' height of equilibrium. Thus, transport at floor level can go on between the different zones, and traverse cranes can pass freely above the zones.

This principle has been developed by for practical industrial ventilation, and we designate it "Select-vent".

KEY WORDS

Air flow pattern,
Displacement ventilation,
Full-scale experiments,
Large premises,
Selective withdrawal.

INTRODUCTION

Inside a large enclosure, the flow picture is dominated by convection currents and by thermal stratification. The stratification effect confines the pollutants inside a limited height range in the room. We can observe how layers in different heights move back and forth horizontally, appearently independent of each other, and with lille or no vertical mixing between the layers.

These observations have led us to the idea of utilizing the principle of selective withdrawal in large room ventilation. In 1994, Techno Consult carried out a research project with the aim of developing the principle of selective withdrawal for vetilation purposes. In 1995 these principles were applied in practice at the Kværner Kimek shipyard in a hall of 40 metres height, 40 metres width and 80 metres length. The ideas were proven to be successful in practice.

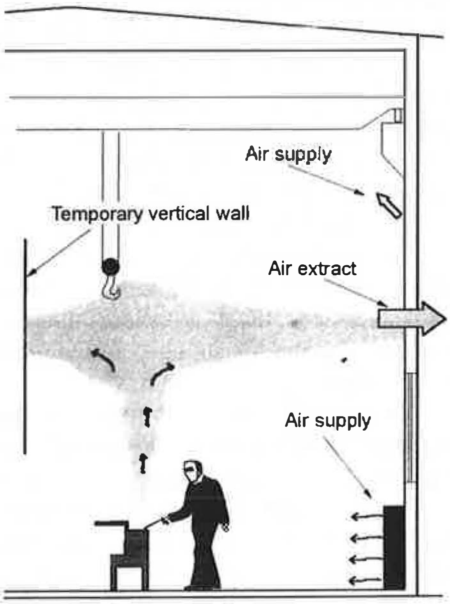

Figure 1 Selective withdrawal of a polluted layer of air - "Select-vent".

THE QUESTIONS

When we developed these ideas, the main questions we asked ourselves were:

IN WHAT CASES CAN SELECTIVE WITHDRAWAL BE APPLIED?

In a case where selective withdrawal shall be applied, the following conditions must be satisfied:

- the pollutants must find their height of equilibrium at a level below the ceiling. Preferably the equilibrium height should be near the height of the extract, but this is not necessary. See Figure 4.
- the walls of the enclosure must extend above the equilibrium layer or the withdrawal layer (whichever is the higher), and below the equilibrium height or the withdrawal height (whichever is the lower).

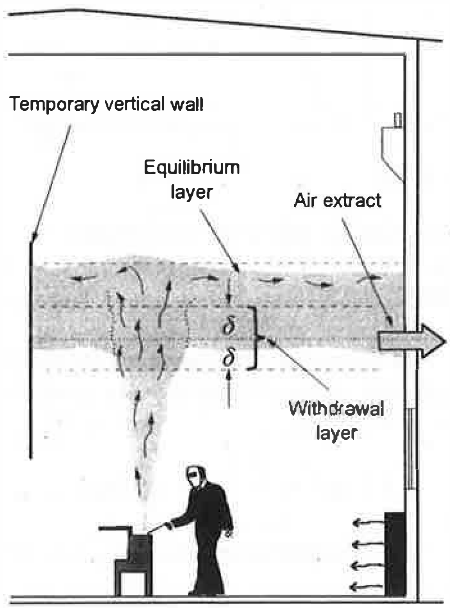

Figure 4 The withdrawal layer may be below or above the equilibrium layer.

SELECTIVE WITHDRAWAL IN A SHIP YARD

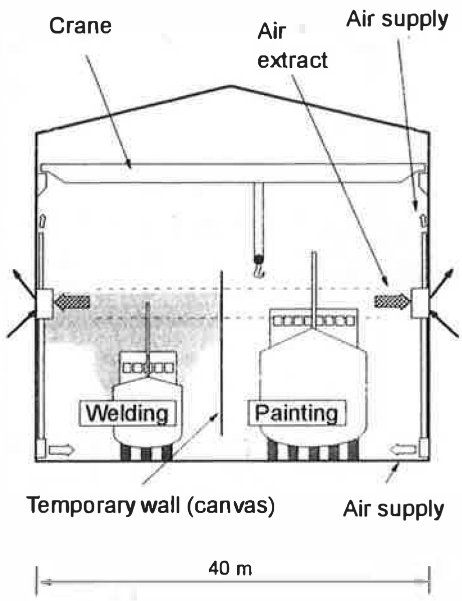

Figure 5 Cross section of Figure 6.

In 1995, we applied the theory of selective withdrawal to the ventilation of the ship repair shop of Kværner Kimek in Kirkenes, Norway. The room is 40 metres high, 80 metres long and 40 metres wide. There are different activities like welding, painting, mechanical assembly and shot blasting going on in the room. The shot blasting requires complete enclosure of the process, while activities like spray painting, welding and mechanical assembly may go on unaffected by each other in different parts of the hall. The different parts need only be separated by vertical walls that extends some 2 - 4 metres above the extract height, and that reach down to say 3 - 4 metres above the floor.

When arranging such systems, one has to consider the direction of the horizontal leak flow between the zones, so that the supply air at floor level moved from the less polluted zones and into the more polluted zones. See Figure 6.

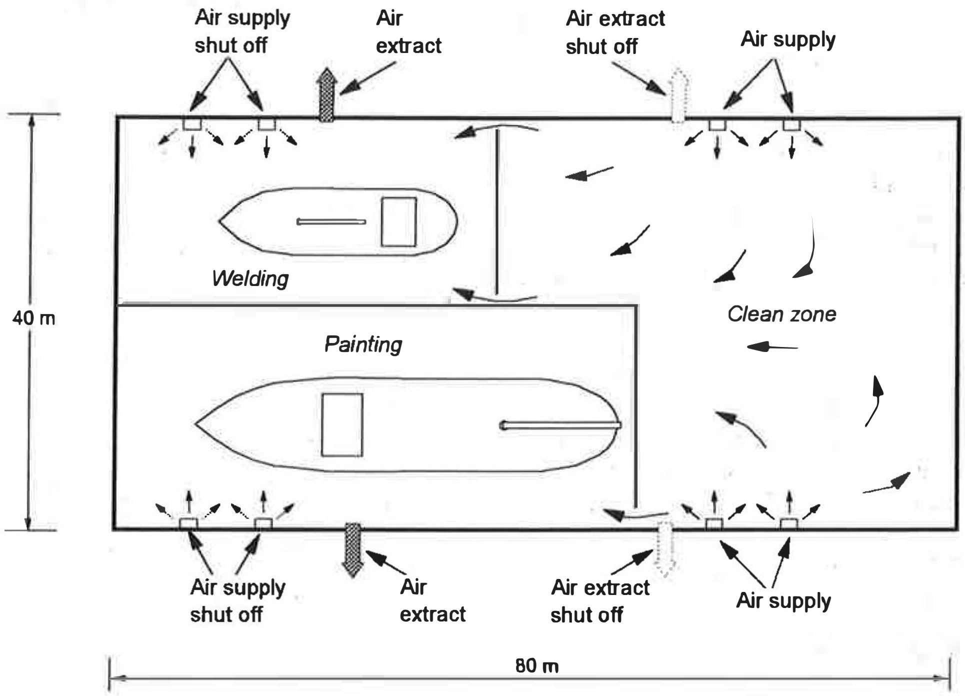

Figure 6 Different polluting activities in various zones in a hall for ship repair.

In practice, the smoke from the welding arcs rise only up into the withdrawal layer, whereas the convection flow from acetylene cutting may rise all the way up to the ceiling, and thus penetrate the thermal lid on top of the withdrawal layer.

The dust and vapours from spray painting are confined inside the painting zone.

PAINTING AN AIRCRAFT INSIDE A PARTLY ENCLOSED SPACE

In 1986, the fuselage of an aircraft was painted inside an enclosure in an aircraft maintenance hangar as shown in Figure 8 (SAS Fornebu). Although this experiment does not have the extract at some height in the room, it shows how stable stratification can be used to stop vertical spreading of contaminants.

For this experiment, the ventilation air was supplied below the ceiling, with 1- 2°C higher temperature than the room air. The air was extracted at floor level, in front of the airplane's nose.

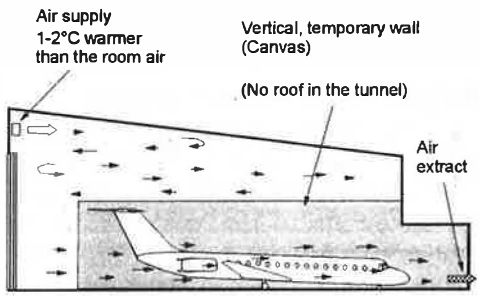

Figure 7 Cross section of Figure 8.

We observed an air flow pattern as shown in the figures. Measurements of solvent vapours and dust showed that no dust occured outside the enclosure, and the concentration of solvent vapours were well below 1/10 of the hygienic limits.

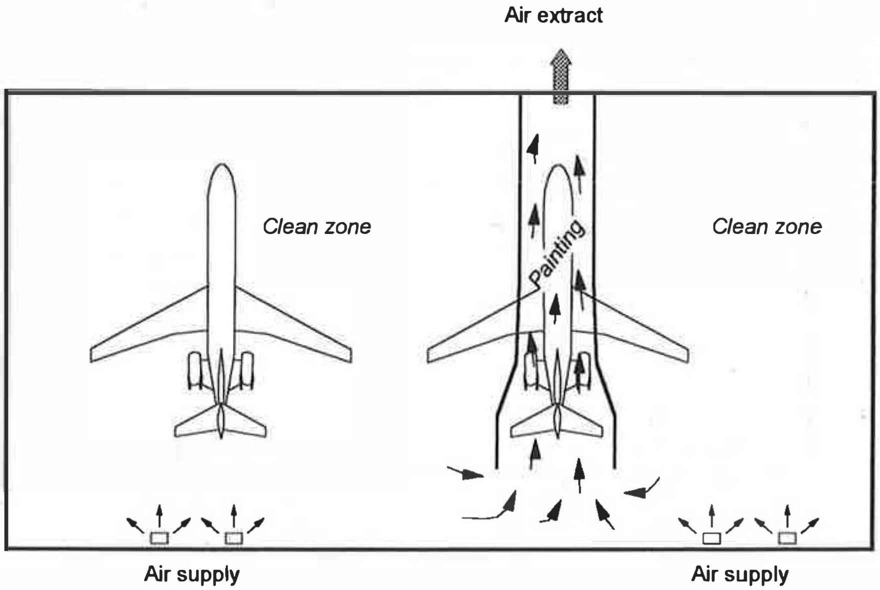

Figure 8 Arrangement for spray-painting av aircraft fuselage without contaminating the rest of the room.

DISCUSSION

Thickness of the withdrawal layer

Until equation (1) has been verified by practical experiments it should be used with care. Particularly the width dimension, B, is hard to establish. The thickness of the withdrawal layer calculated for the Kimek case compares, however, well with the autor's practical experience. So, until better knowlege is obtained, we take equation (1) to yield the order of magnitude for the thickness of the withdrawal layer.

Disturbing air flows

The principle of selective withdrawal can only be used for extracting pollutants that layers at some height inside the room. Several factors disturb the use of this principle:

Strong convection currents rise all the way up to the ceiling and carry the pollutants up through all the layers of air in the room. The convection current from acetylene cutting is an example of that. See Figure 9.

Also, cold draughts may carry pollutants down to floor level, or down to their level of equilibrium. See Figure 10.

The presence of a temperature gradient

The utilization of selective withdrawal requires the presence of a vertical temperature gradient. I.e., there have to be heat sources present inside the room. If this is not so, the temperature gradient may be artificially created, like the example shown in Figure 8. Otherwise, in the case of a multi-use hall (see Figure 6), the temperature gradients created by the welding and cutting activities in one zone, also provides temperature gradients for the painting zone.

The selective withdrawal effect has been demonstrated to work for a temperature gradient as low as 0,125 °C/m, but higher temperature gradients will be more resistant to disturbances, and will decrease the thickness of the withdrawal layer.

ACKNOWLEDGEMENTS

A major part of the study of selective withdrawal in room ventilation has been carried out in a research project sponsored by the Norwegian Research Council. Dr. Bent Børresen of Techno Consult AS has made valuable contributions to the development process through model tests and development of the theories.

In the completion of this paper, dr. Per Olaf Tjelflaat of NTNU and dr. Thomas Mc. Climans of SINTEF have been valuable discussion partners.

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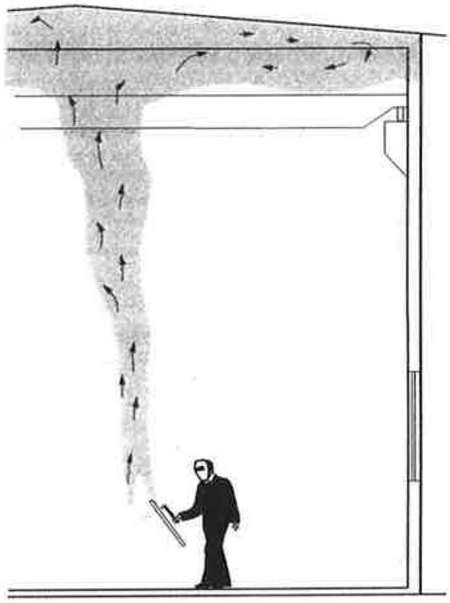

Figure 9 Strong convection currents penetrates all layers up to the ceiling.

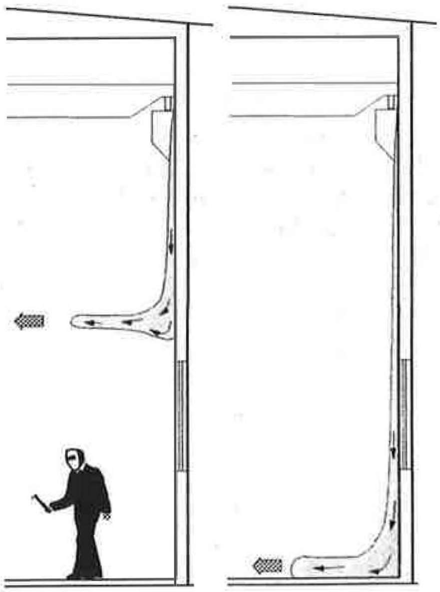

Figure 10 Cold draughts descend down to their level of equilibrium, or down to the floor.