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Ventilation Effectiveness
REHVA Guidebook no 2

AUTHORS

- Elisabeth Mundt, Professor, KTH-Royal Institute of Technology, Stockholm, Sweden (editor)
- Hans Martin Mathisen, Ph.D., Sintef, Trondheim, Norway
- Peter V. Nielsen, Professor, Aalborg University, Denmark
- Alfred Moser, Ph.D., ETH, Zürich, Switzerland
## CONTENTS

1. VENTILATION EFFECTIVENESS IN A NUTSHELL (3 p)
2. SYMBOLS AND TERMINOLOGY (4 p)
3. WHY VENTILATION EFFECTIVENESS (5 p)
4. TYPICAL CONTAMINANTS AND CONTAMINANTS DISTRIBUTION IN VENTILATED ROOMS (6 p)
5. THEORY AND DEFINITIONS (8 p)
6. MEASUREMENTS (12 p)
7. PREDICTION OF AIR QUALITY BY COMPUTATIONAL FLUID DYNAMICS (4 p)
8. CASE STUDIES (21 p)
9. DEFINITIONS OF VENTILATION EFFECTIVENESS IN DIFFERENT COUNTRIES (1 p)
10. APPENDIX 1 (1 p)
11. REFERENCES (4 p)
VENTILATION EFFECTIVENESS includes

A
Indices representing the ability of a system to exchange the air in the room

- air change efficiency, $\varepsilon^a$
- local air change index, $\varepsilon_p^a$

B
Indices representing the ability of a system to remove air-borne contaminants

- contaminant removal effectiveness (CRE), $\varepsilon^c$
- local air quality index, $\varepsilon_p^c$
INTRODUCTORY CHAPTERS

1. VENTILATION EFFECTIVENESS IN A NUTSHELL
2. SYMBOLS AND TERMINOLOGY
3. WHY VENTILATION EFFECTIVENESS
4 TYPICAL CONTAMINANTS AND CONTAMINANTS DISTRIBUTION IN VENTILATED ROOMS

Return opening

The location of a return opening may have a very large influence on the concentration distribution, although it only has a small influence on the velocity distribution.
Displacement ventilation and vertical concentration gradient

The idea behind displacement ventilation is to accept a variation in the concentration distribution with a high value below the ceiling and a low value in the occupied zone.
5 THEORY AND DEFINITIONS

Air Change Efficiency $\varepsilon^a$

$$\varepsilon^a = \frac{\text{Mean age of air in the exhaust}}{2 \times \text{Room mean age of air}} = \frac{\tau_n}{2 \cdot \langle \tau \rangle}$$

The mean age of air in the exhaust is always equal to the nominal time constant $\tau_n$.

What is the mean age of the air in the room?

The room mean age of air can not be less than half the nominal time constant!

Thus the air change efficiency $< 100\%$
5 THEORY AND DEFINITIONS

Air Change Efficiency

- **Piston flow**
  - $\langle \tau \rangle = \frac{\tau_n}{2}$
  - $\varepsilon^a = 100\%$

- **Fully mixed flow**
  - $\langle \tau \rangle = \tau_n$
  - $\varepsilon^a = 50\%$

- **Displacement flow**
  - $\frac{\tau_n}{2} < \langle \tau \rangle < \tau_n$
  - $50\% \leq \varepsilon^a \leq 100\%$

- **Short-circuit flow**
  - $\langle \tau \rangle > \tau_n$
  - $\varepsilon^a \leq 50\%$
5 THEORY AND DEFINITIONS

Contaminant Removal effectiveness, CRE

\[
CRE = \frac{\text{Concentration in the exhaust}}{\text{Mean concentration in the room}} = \frac{c_e}{\langle c \rangle}
\]
5 THEORY AND DEFINITIONS

Contaminant Removal effectiveness, CRE

Contamination source close to exhaust

Contamination source in a stagnant zone

Contamination source close to exhaust

Contamination source in a stagnant zone

\[ \langle c \rangle < c_e \]

\[ \langle c \rangle > c_e \]
6 MEASUREMENTS

Injection of tracer gas

Pressure control valve
Closing valve
Flowmeter (Rotameter) or mass flow controller
Injection point
Routines for how to measure and calculate the ventilation effectiveness

This part of the curve could be used to calculate the decay $\lambda$.

For calculation of the tail the calculated decay is used.

$C_0$, $C_i$, $C_{i-1}$, $C_n$, $t_i$, $t_{i-1}$.
Commissioning

1. Develop team
2. Incorporate commissioning specifications
3. Review project design
4. Develop commissioning plan
5. Develop prefitional checklist
6. Execute prefitional checklist
7. Are expected results realised?
   - Yes
   - 8. Approve prefitional checklist
7A. Correct deficiencies
   - No
   - 11. Is equipment in compliance?
     - No
     - 11A. Correct deficiencies
     - Yes
11A. Correct deficiencies
   - No
8. Approve prefitional checklist
9. Develop functional tests and diagnostic monitoring plan
10. Execute monitoring and functional plans
11. Is equipment in compliance?
12. Accept equipment performance
13. Develop final commissioning report

Planning

Design

Installation

Acceptance

Post-acceptance

Federation of European Heating, Ventilation and Air-conditioning Associations
Contaminant distribution around a sedentary person, contaminant source at the floor
7 PREDICTION OF AIR QUALITY BY COMPUTATIONAL FLUID DYNAMICS

The exposure of a standing person from different surfaces with the same emission
8 CASE STUDIES
Description and Design Values, Measured Results, Discussion of Results

Auditorium

- Measurement column
- 320 seats
- 3.8 kW ceiling light
8 CASE STUDIES

Auditorium

Temperature, °C

22,4 °C
23,8 °C
24,8 °C
20,7 °C

Room width: 21.5 m

Temperature, °C

20 25

Local air quality index

0,85-0,97
0,56-0,82

890 ppm CO₂
420 ppm CO₂

Room width: 21.5 m
8 CASE STUDIES

Office in town hall

Office in town hall

Full scale experiments
Office in town hall

Winter case
- Warm supply air jet
- Cold down-draught from windows

Summer case
- Draught from the subcooled supply air jet

Flow pattern before reconstruction of the ventilation system
Office in town hall

Carpet as contaminant source

Concentration profiles

New system
Old System
Industrial building

Section A-A

Measuring position

Mixing ventilation

Displacement ventilation

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8 CASE STUDIES

Homogeneous emission techniques

Laboratory hall

Subdivision of the room
8 CASE STUDIES

Homogeneous emission techniques

Local mean age of air

| 0.35 | 0.42 | 0.50 | 0.54 |
| 0.28 | 0.35 | 0.45 | 0.60 |
| 0.27 | 0.28 | 0.43 | 0.63 |
| 0.33 | 0.33 | 0.48 | 0.57 |

Computed local mean age of air in the sub-volumes between the two layers

1,33 m above the floor

Floor level

The shadowed ellipses show the positions of the two 750 W air convectors at the floor level

Local concentrations with point sources
Thank you for your attention

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