IEA-EBC ANNEX 78: Supplementing Ventilation with Gas-phase Air Cleaning, Implementation and Energy Implications.

Bjarne W. Olesen
Center for Indeklima og Energi
Department of Civil Engineering
Technical University of Denmark

ANNEX STRUCTURE
Operation Agents

- Dr. Bjarne W. Olesen, Technical University of Denmark.
- Dr. Pawel Wargocki, Technical University of Denmark.

- PREPARATION PHASE 01-07-2018 TO 30-06-2019
- WORKING PHASE 01-07-2019 TO 30-06-2023
- REPORTING PHASE 01-07-2012 TO 30-06-2024

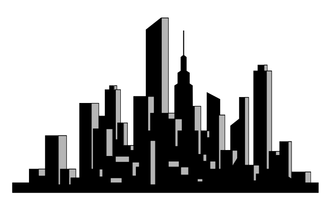
ANNEX STRUCTURE

- Subtask A: Energy benefits using gas phase air cleaning
  - Subtask leader: Alireza Afshari, Denmark
  - Co-leader: *Sasan Sadrizadeh* , Sweden
- Subtask B: How to partly substitute ventilation by air cleaning
  - Subtask leader: Pawel Wargocki, Denmark
  - Co-leader: Shin-Ichi Tanabe , Japan
- Subtask C: Selection and testing standards for air cleaners
  - Subtask leader: Paolo Tronville, Italy
  - Co-leader: Jinhan Mo, China
- Subtask D: Performance modelling and long-term field validation of gas phase air cleaning technologies
  - Subtask leader: Karel Kabele, Czech
  - Co-leader: Jensen Chang , US

Concept for calculation of design ventilation rate
ISO CEN ASHRAE

People Component

Building Component

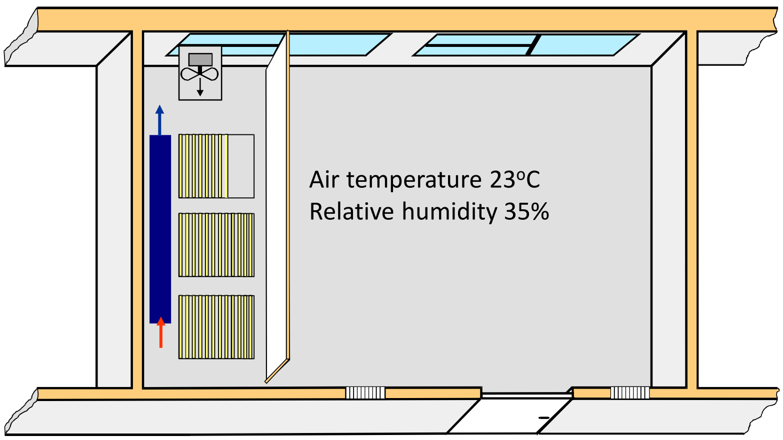


Breathing Zone Outdoor Airflow

$$V_{bz} = R_p P_z + R_a A_z$$

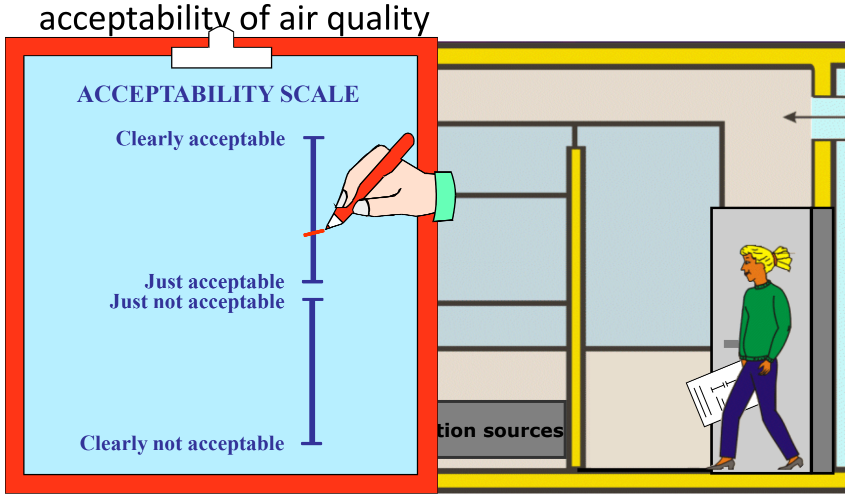
- R_p: Minimum l/s/Person
- P_z: Number of People
- A_z: Building Area
- R_a: Minimum l/s/m²

Experimental setup

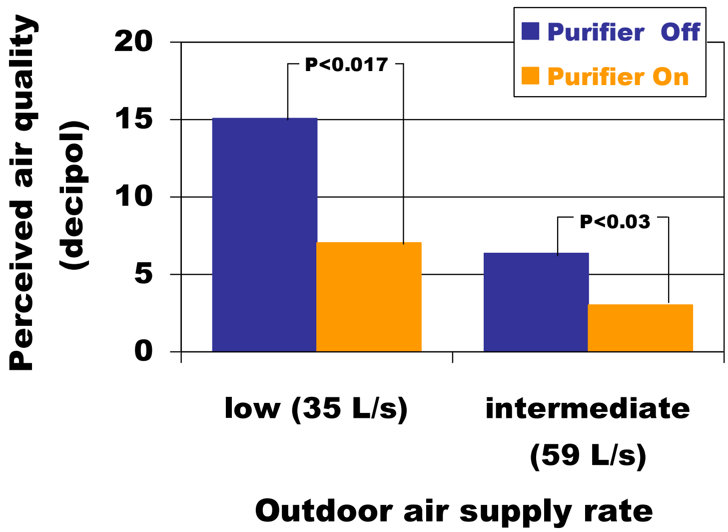


Sensory measurements

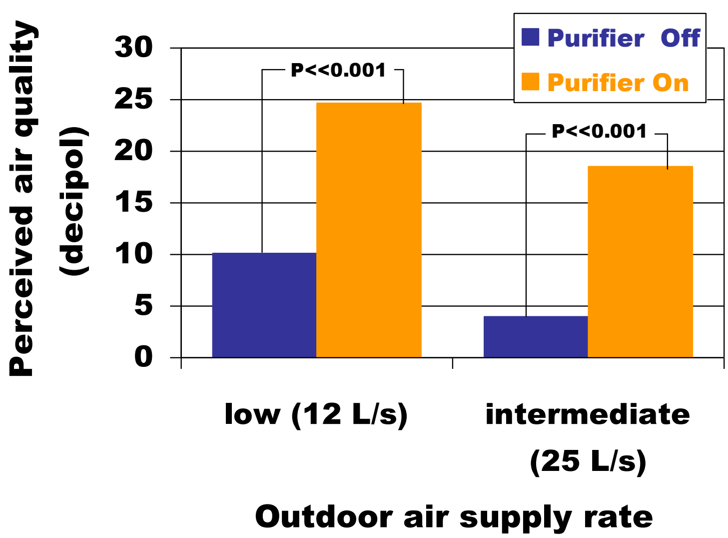
- Panel of 50 untrained subjects assessed acceptability of air quality



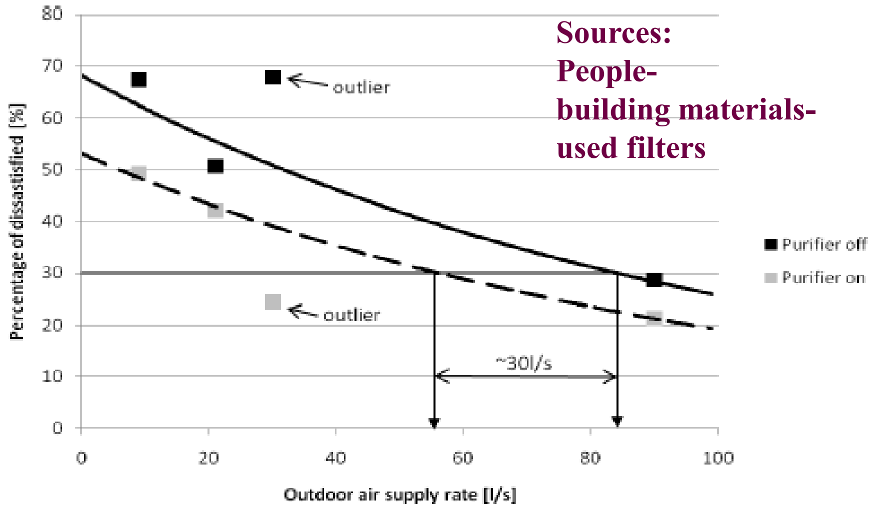
Results: Bldg mat, PCs, filters



Results: Human bioeffluents



Effect of air cleaning on perceived Air Quality



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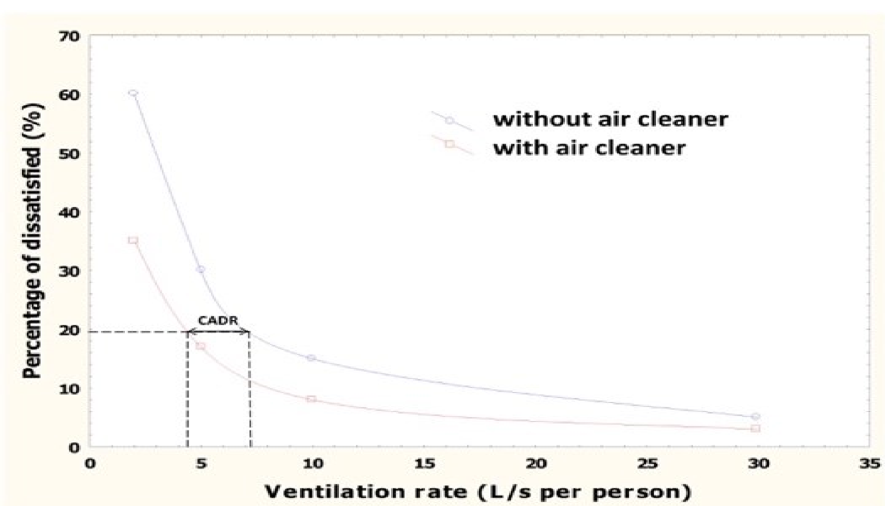
Clean Air Delivery rate per person



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• ISO 10121:2014 "Test method for assessing the performance of gas-phase air cleaning media and devices for general ventilation

INTERNATIONAL STANDARD **ISO 10121-1**

First edition
2014-04-15

Test method for assessing the performance of gas-phase air cleaning media and devices for general ventilation —

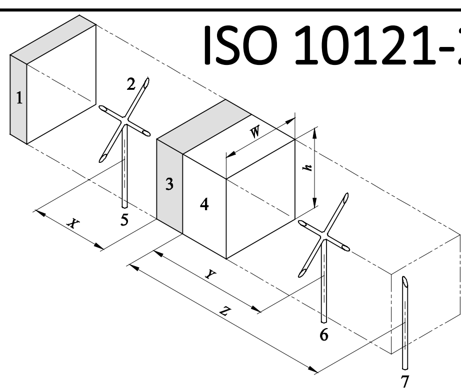
Part 1:
Gas-phase air cleaning media

INTERNATIONAL STANDARD **ISO/FDIS 10121-2**

Test methods for assessing the performance of gas-phase air cleaning media and devices for general ventilation —

Part 2:
Gas-phase air cleaning devices (GPACD)

ISO 10121-2:2014



Key

1 diffusor and Δp device
2 sampling points – should be of “fork” type or similar with multiple inlet points to make a compounded sample over the whole cross section
3 GPACD under test
4 GPACD section of test duct
5 upstream sampling point for T_U, RH_U, p_U and C_U at X mm before the GPACD
6 Downstream sampling point for T_D, RH_D, p_D and C_D at Y mm after the GPACD
7 Q, air flow rate sampling point at Z mm after the GPACD
W internal width of the test duct along the GPACD section, 3+4
h internal height of the test duct along the GPACD section, 3+4

Figure 1 — Normative section of test stand showing ducting, measurement parameters and sampling points

This part of ISO 10121 aims to provide an objective test method to estimate the performance of any full size gas filtration device (GPACD) for general filtration regardless of media or technique used in the device.
To ensure objectivity for test equipment suppliers, no specific design of the test apparatus is specified
This part of ISO 10121 can also be used with technologies such as scrubbers, absorbers, non-sorptive devices or packed columns as long as they fit into the test apparatus, can be meaningfully judged by the test method and are intended for general ventilation applications, both residential and non residential.

Table 2 — Challenge gases and concentrations for the simplified benchmark test

Challenge gas and concentration for the initial efficiency determination (6.3)								
Parameter	**Selected gas**	**Challenge level**	**Unit**	**Reference analysis technique**	**Face velocity [m/s]**	**T_U [°C]**	**RH_U [%]**	**Maximum permissible efficiency decay during test[b]**
Acid	SO_2[a]	450	ppb(v)	UV fluorescence[d]	2,5	23	50	5 %
Base	NH_3	450	ppb(v)	chemiluminescence[d]	2,5	23	50	5 %
VOC	toluene	5	ppm(v)	PID[d] or FID[d]	2,5	23	50	5 %
Challenge gas and concentration for the capacity determination (6.4)								
Parameter	**Selected gas**	**Challenge level**	**Unit**	**Reference analysis technique**	**Face velocity [m/s]**	**T_U [°C]**	**RH_U [%]**	**Minimum permissible efficiency decay after 12 h[c]**
Acid	SO_2[a]	9/90[c]	ppm(v)	UV fluorescence[d]	2,5	23	50	>10 %
Base	NH_3	9/90 [c]	ppm(v)	chemiluminescence[d]	2,5	23	50	>10 %
VOC	toluene	9/(90)[c]	ppm(v)	PID[d] or FID[d]	2,5	23	50	>10 %

[a] For other acid gases SO_2 may not be representative. In applications for H_2S, NO, NO_2, etc. it may be better to test with the gas in question.

[b] A test for initial efficiency should not decay during the test but this may be the case if the selected low concentration is well beyond challenge capacity of the filter. Therefore, a maximum permissible efficiency decay during the initial efficiecy test is given. A GPACD not filling this demand may still be tested according to 5.4.

[c] The lower or higher concentration is selected depending on filter type/ weight/ purpose/ data sheet. The lower concentration is preferred for toluene while the higher concentration may be needed for all gases to reach the minimum permissible efficiency decay after 12 h.

[d] The reference techniques are the ones preferred in this part of ISO 10121. However, other techniques may be used provided that the test supplier can show doccumented correlation versus the reference technique.

EXPRESSION OF PERFORMANCE

- Clean Air Delivery Rate (CADR)

$$\mathbf{CADR = \varepsilon_{PAQ} \cdot Q_{AP} \cdot (3{,}6/V)}$$

where:
Q_{AP}· is the air flow through the air cleaner, l/s;
V is the volume of the room, m^3.

Air Cleaning Efficiency

$$\boldsymbol{\varepsilon_{clean} = 100(C_U - C_D)/C_D}$$

where:
E_{clean} is the air cleaning efficiency;
C_U is the gas concentration before air cleaner;
C_D is the gas concentration after air cleaner.

$$\varepsilon_{PAQ} = Q_o / Q_{AP} \cdot (PAQ / PAQ_{AP} - 1) \cdot 100$$

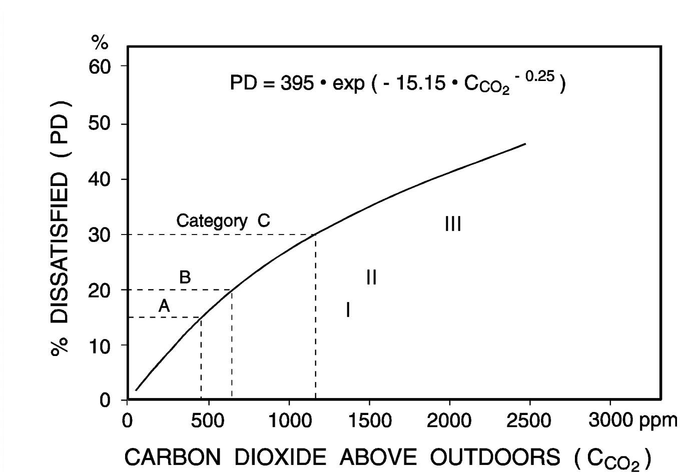
where:
ε_{PAQ} is the air cleaning efficiency for perceived air quality;
Q_o is the ventilation rate without air cleaner, l/s;
Q_{AP} is the ventilation rate with air cleaner, l/s;
PAQ is the perceived air quality without the air cleaner, decipol;
PAQ_{AP} is the perceived air quality without the air cleaner, decipol

- Higher Air Quality Category

EXPRESSION OF PERFORMANCE

- Reduced Energy Use
  - Heating/Cooling of Supply Air
  - Reduced energy for humidification and/or De-humidification
  - Fan Energy
  - Energy Use of Air Cleaner
  - Heat Recovery or not
- Noise level
  - Reduced air flow in AHU
  - Noise from air cleaner
- Draught level
  - Reduced air flow in occupied space
  - Draught from portable air cleaner

CO_2 as reference



$$Q_h = \frac{G_h}{C_{h,i} - C_{h,o}} \cdot \frac{1}{\varepsilon v}$$

where

Q_h is the ventilation rate required for dilution, in m^3 per second;
G_h is the generation rate of the substance, in micrograms per second;
$C_{h,i}$ is the guideline value of the substance, in micrograms per m^3;
$C_{h,o}$ is the concentration of the substance of the supply air, in micrograms per m^3;
ε_v is the ventilation effectiveness.

Issues

- International Standards for Ventilation (Indoor Air Quality) like EN16798-1, ISO17772-1 and ASHRAE 62.1 are mainly based on criteria for the Perceived Air Quality (PAQ), sometimes expressed as levels of CO_2 as a tracer for emission from occupants.
- If air cleaning is used, an equivalent level of air quality will be reached at higher CO_2 concentrations.
- It is also assumed that when ventilation is used for PAQ, the required ventilation will also dilute other substances like Radon, VOCs.
- The decreased ventilation rate when using gas phase air cleaning may not be sufficient.

ΔCO_2 levels considering a 30 % reduced ventilation rate due to air cleaners

Space type Single office	*Occupancy [m^2 per person]*	*Category*	*Derived from qtot*	
			Very low-polluting building	*Low-polluting building*
			Indoor CO_2 level above outdoor level ΔCO_2 *[ppm]*	
Without air cleaner	10	IEQ_{I}	370	278
		IEQ_{II}	**529**	**397**
		IEQ_{III}	926	694
		IEQ_{IV}	**1389** (1010)	**1010** (794)
With air cleaner	10	IEQ_{I}	529	397
		IEQ_{II}	**756**	**567**
		IEQ_{III}	**1323** (1029)	**992** (817)
		IEQ_{IV}	**1984** (1100)	**1443** (911)

Issues

- Today, gas phase air cleaners are tested based on a chemical measurement, which do not account for the influence on PAQ and human bio effluents as a source of pollution.
- Studies have shown that some gas phase air cleaning technologies will not work when humans are the source, and the evaluation is done by PAQ.
- There is a need for new test standards
- Testing with PAQ requires a measurement of subjective reactions
- Testing with human bio effluents as a source requires the use of humans as a source

Testing Issues

- If only a test with chemical measurements is done, should it be allowed to reduce the building component?
- How to standardise the building source?
- How to standardise the human bio effluent source?
- It is a relative measurement, which makes some of the issues less important
- A test method using PAQ is voluntary; but will give the industry a possibility to show that their air cleaner can improve the IAQ and the ventilation rate can be decreased.