OR ventilation systems, a view from different perspectives

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Introduction

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Review

Operating room ventilation systems: recovery degree, cleanliness recovery rate and air change effectiveness in an ultra-clean area

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A R T I C L E I N F O

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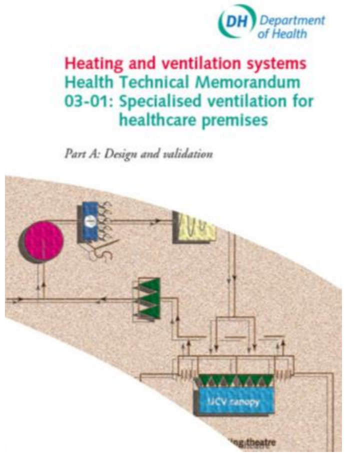
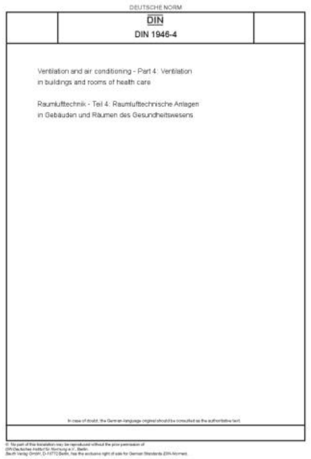
S U M M A R Y

Background: Entrainment test methods are described in most European standards and guidelines to determine the protected area for ultra-clean ventilation (UCV) systems. New UCV systems, such as temperature-controlled airflow (TcAF) and controlled dilution ventilation (cDV) systems, claim the whole operating room (OR) to be ultra-clean. However, current test standards were not developed to assess ventilation effectiveness outside the standard protected area.
Aim: To assess and compare the ventilation effectiveness of four types of OR ventilation systems in the ultra-clean area using a uniform test grid.
Methods: Ventilation effectiveness of four ventilation systems was evaluated for three

Background

- Operating room (OR) ventilation systems are important to prevent surgical site infections[17] through airborne contamination[1-8].
- The wound area, the area of the surgical staff and the instrument tables are defined as ultra-clean areas.
- To date, entrainment test methods are described in most European standards to determine the protected area for traditional Ultra Clean Ventilation (UCV) systems[9-15,18].
- New OR UCV ventilation systems are introduced in the market which claim to use less energy and the whole OR to be ultra-clean[15,16]. They can not be tested according to current standards and guidelines.
- The study gives insights of the functioning of different OR ventilation systems on the market.


DH Department of Health
Heating and ventilation systems
Health Technical Memorandum 03-01: Specialised ventilation for healthcare premises
Part A: Design and validation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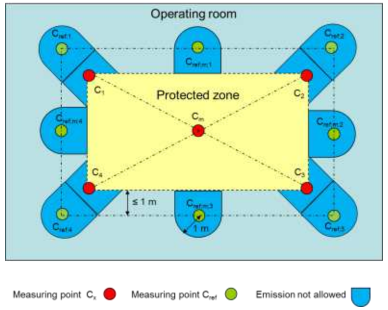
Ventilation and air conditioning - Part 4: Ventilation in buildings and rooms of health care
Raumlufttechnik - Teil 4: Raumlufttechnische Anlagen in Gebäuden und Räumen des Gesundheitswesens


Teknisk specifikation
SIS-TS 39:2012
Mikrobiologisk renhet i operationsrum – Förebyggande av luftburen smitta – Vägledning och grundläggande krav
Microbiological cleanliness in the operating room – Preventing airborne contamination – Guidance and fundamental requirements

OK /Opdek classificatie Prestatieniveau	Classificatie beschermd gebied volgens ISO 14644-1 at rest op ≥ 0,5µm	Classificatie periferie volgens ISO 14644-1at rest op ≥ 0,5µm	Beschermingsgraad	Hersteltijd ISO 14644-3 (factor 100) in midden beschermde gebied*) op ≥ 0,5µm	Hersteltijd ISO 14644-3 (factor 100) op ≥ 0,5µm
1	ISO 5	7	Rand ≥ 2 Midden ≥ 2	≤ 3 min	-
2	ISO 7	N.v.t.	-	-	≤ 20 min

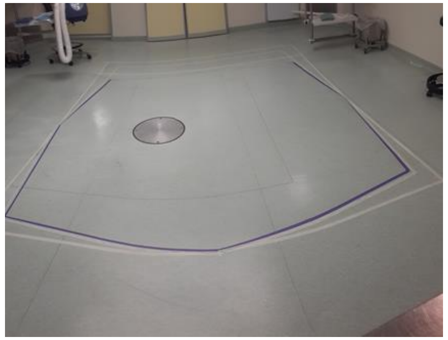
*) Niet van toepassing voor opdekruimtes

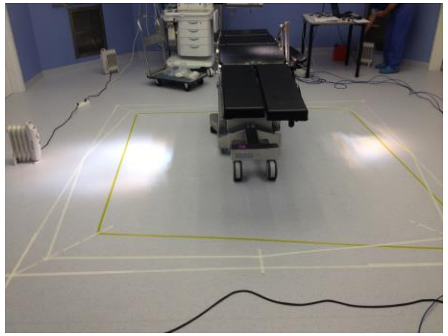


Problem definition

Problem 1a.

The protected area of a traditional UCV system, a uni-directional airflow (UDAF)[21,23], is for some surgical procedures not large enough to position and protect all instrument tables underneath the UDAF and to allow enough space between sterile staff and instrument tables[29,30].





Problem definition

Problem 1b.

New UCV systems, such as temperature-controlled airflow (TcAF) and controlled-dilution ventilation (cDV) claim the whole OR to be ultra-clean[24-26].

However, current standards are not developed to test ventilation systems that claim the whole OR to be ultra-clean.

Halton Vita OR Space is an airflow solution which provides the highest required air cleanliness for the ultraclean operations in the entire operating space. This

Source HALTON

- Flexible use of the space in operating room allows full use of floor area

Source HALTON

Journal of Hospital Infection (Oct 2017). The Opragon operating room ventilation system is actively sweeping away the bacteria carrying particles before they can whirl around the room and contaminate the wound or the sterile instruments. The whole OR is kept at ISO 5 or better. This leads to less than 5 cfu/m³ in the surgical working area and less than 10 cfu/m³ in the whole room (provided that hygiene requirements are met). This means a 3-5x larger sterile work zone

Source Avidicare

Problem definition

Problem 2.

When building or renovating an OR complex, the hospital faces many choices. One of these choices is to select the type of UCV[22,27,28,32] in the OR.

Besides problem 1, the final choice of the UCV system determines, in addition to the necessary ventilation (HVAC) installation, the final amount of the investment (CAPEX) and the resulting maintenance and operating costs (OPEX).

Ultra-clean ORs with less energy

The Opragon achieves ultra-clean conditions using 30% less energy than standard laminar airflow systems according to an article in the Journal of Hospital Infection (Oct 2017). The Opragon operating room

Source Avidicare

- Flexible use of the space in operating room allows full use of floor area
- Comfortable conditions in the operating room increase wellbeing and comfort of the patient and the medical team
- Energy efficiency brings savings in operational costs
- The offering is compliant with various national and international standards

Source HALTON

Objectives 4 OR ventilation systems compared

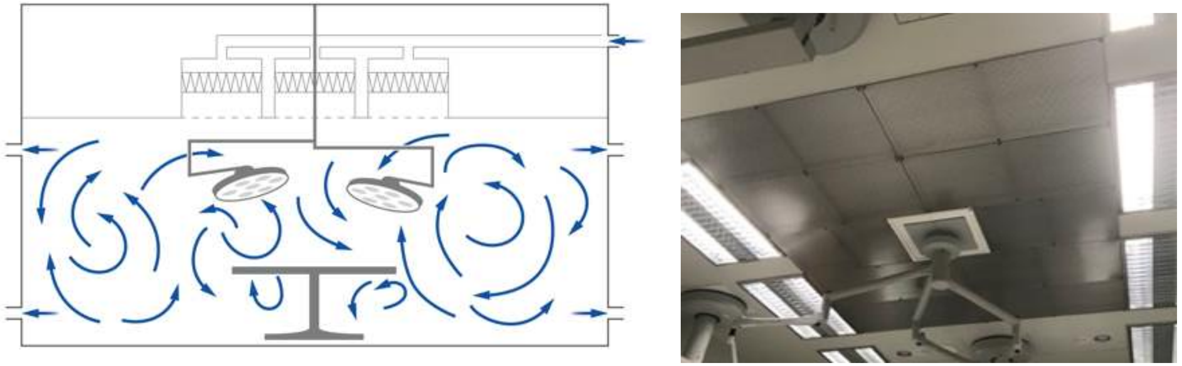


Figure 1. Working principle (1a) and photo CV LUMC, Leiden (1b).

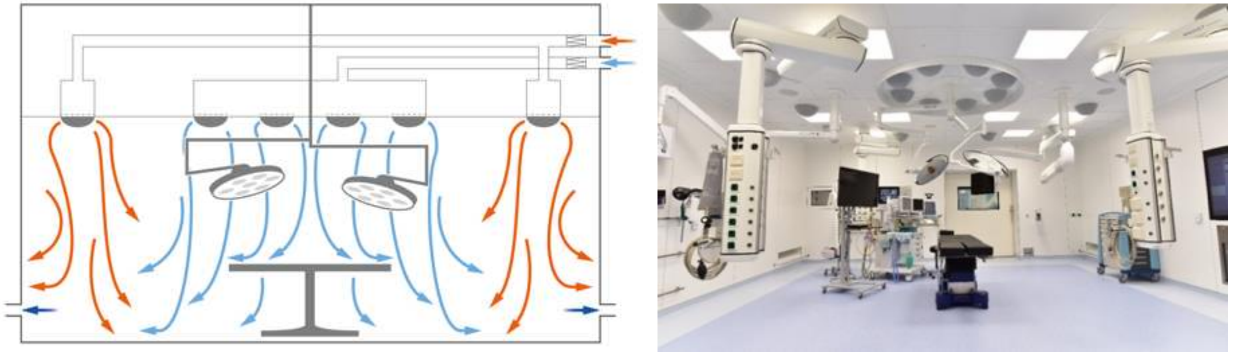


Figure 2. Working principle (2a) and photo TcAF Rijnstate Hospital Arnhem(2b).

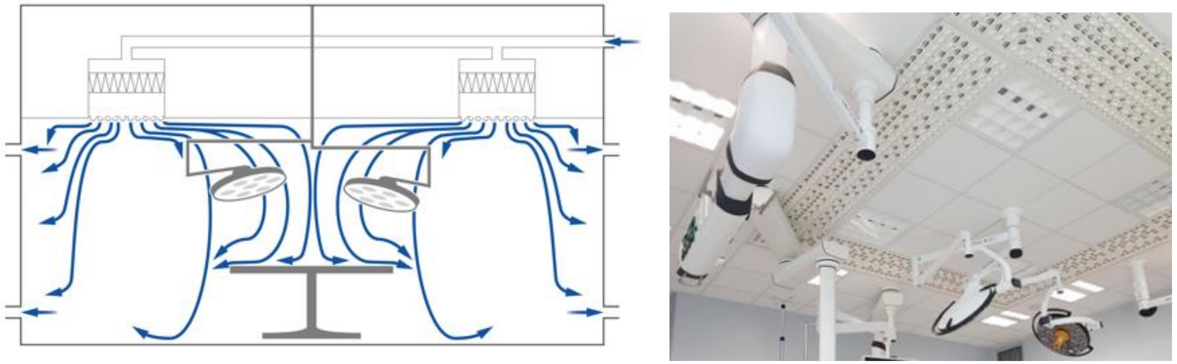


Figure 3. Working principle (3a) and Photo cDV Nij Smellinghe Hospital, Drachten (3b).

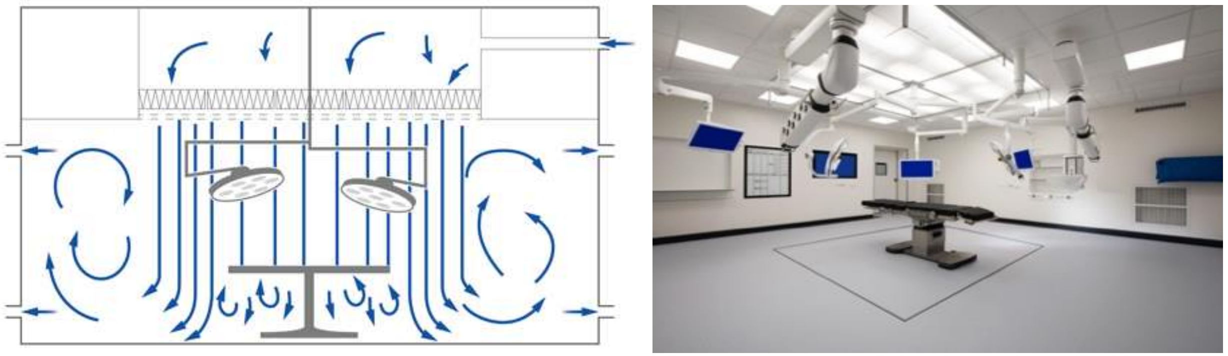


Figure 4. Working principle UDAF (4a) and photo UDAF IJsselland Hospital (4b).

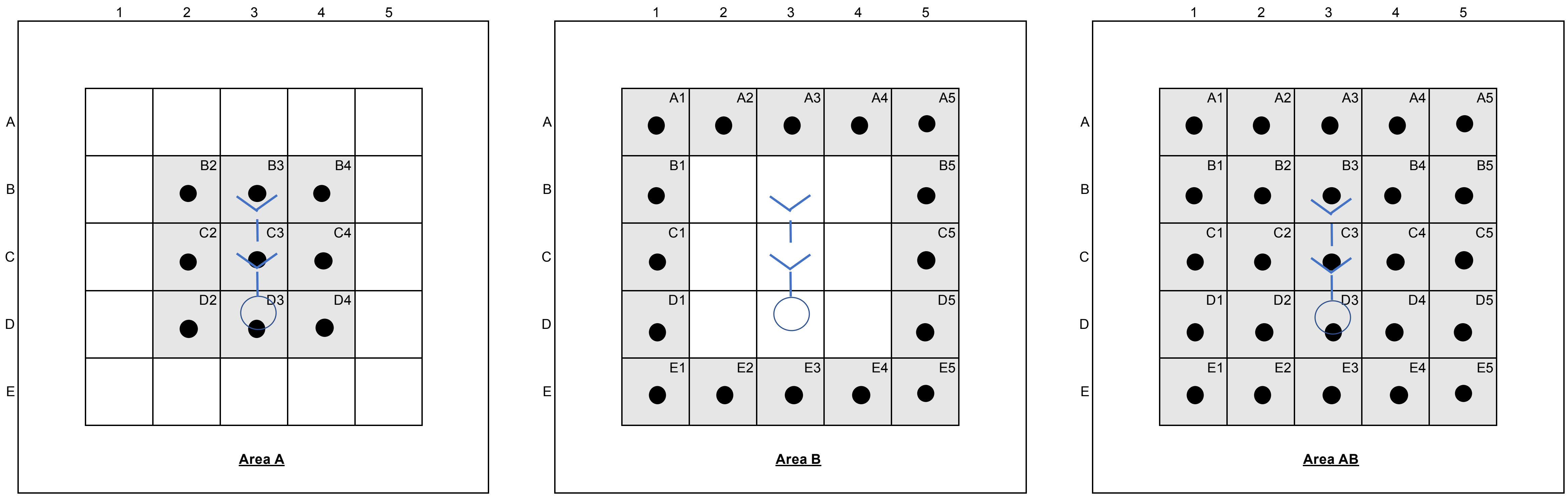
Research questions

1. How do the different OR ventilation systems ventilation effectiveness compare?
2. Which OR ventilation system performs the best in terms ventilation effectiveness[20,31] measured in the whole OR?

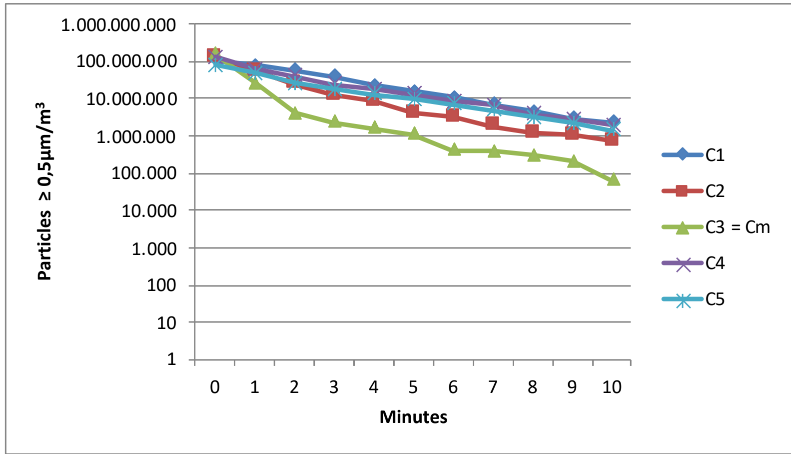
Methodology

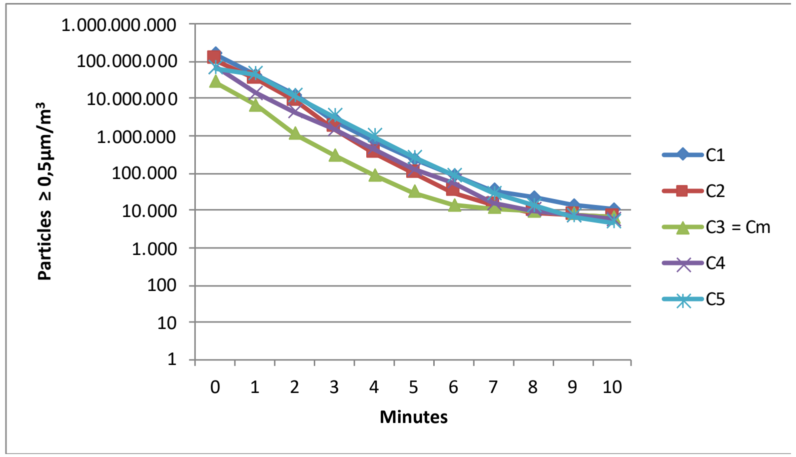
Methodology	Description
Literature	Literature research – current guidelines and standards
Measurements	Uniform test grid with measuring points
Prospective	Measurements

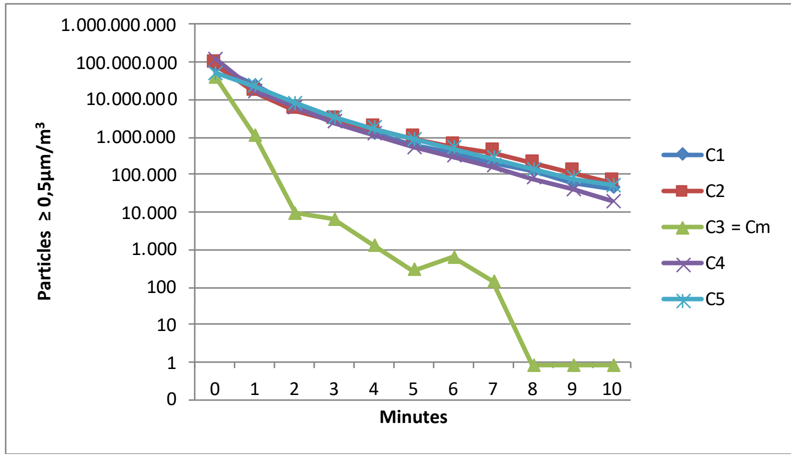
Methodology - Measurement grid -

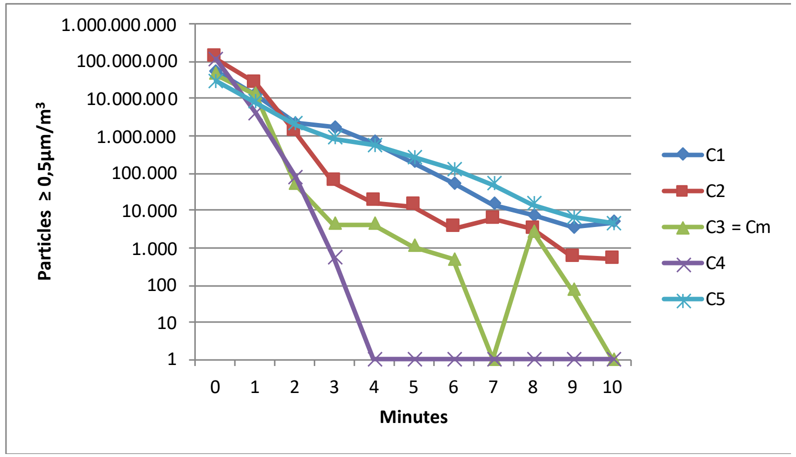


Methodology - CRR -

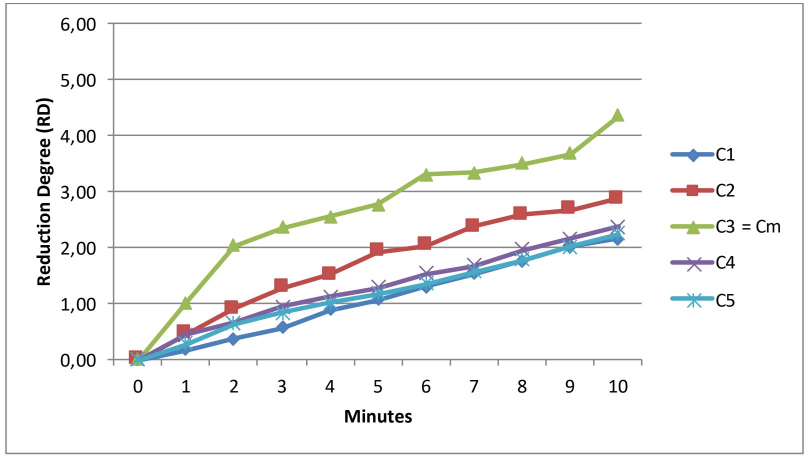


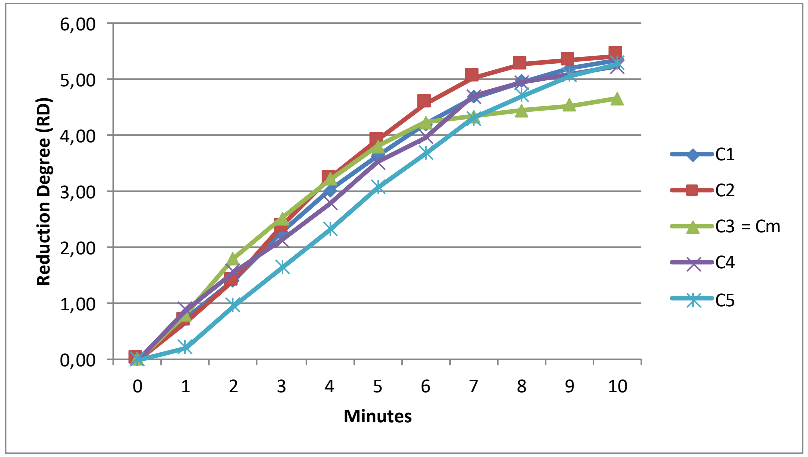


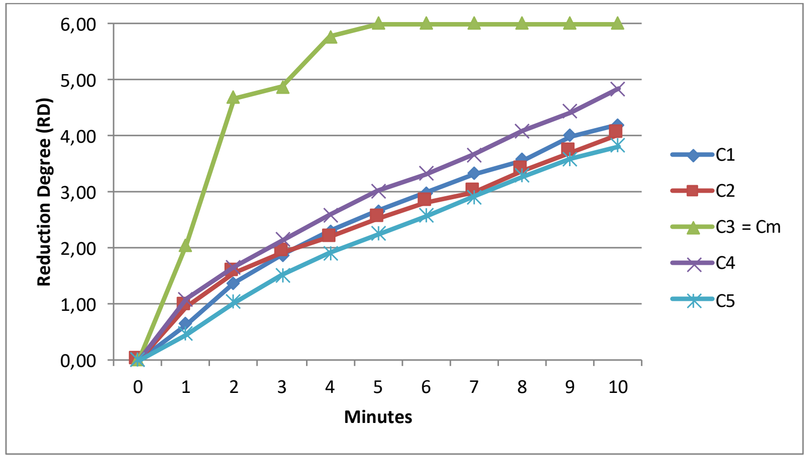


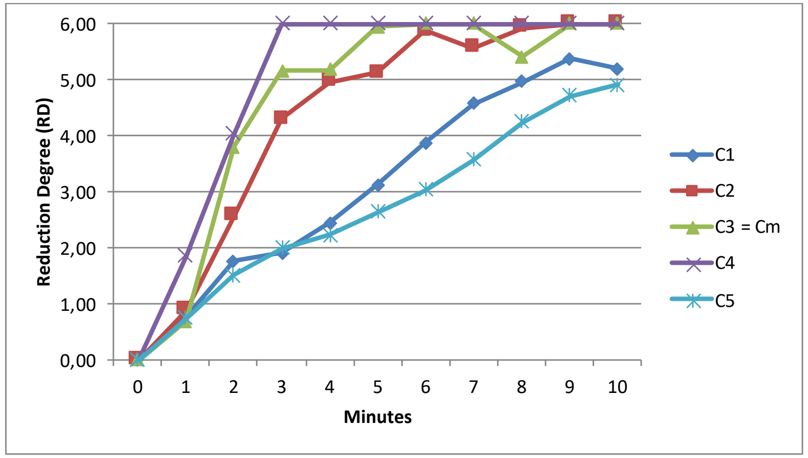


Methodology - RD -







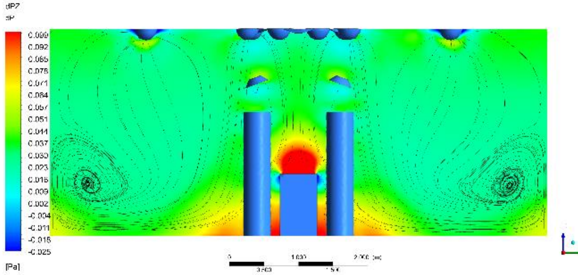


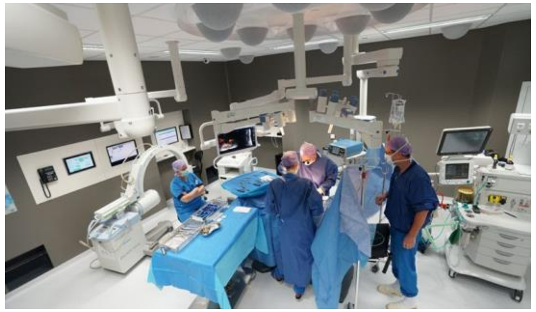
Results

Ultra-clean Area	CV	cDV	TcAF	UDAF
Area A				
n	45	54	45	54
RD *p*-value **TcAF** *p*-value **TcAF**	2.22 (1.23) *p*=0.05	4.17 (0.94) *p*=0.06	2.96 (0.73)	6.00 (<0.001)
CRR *p*-value TcAF	0.50 (0.39) *p*=0.42	1.22 (0.26)	0.73 (0.28)	5.42 (2.49)
ACE *p*-value **cDV** *p*-value **cDV**	1.20 (0.90) *p*=0.75	1.08 (0.23)	0.97 (0.36) *p*=0.51	4.64 (1.93)
Area B				
n	80	96	80	96
RD *p*-value **cDV**	1.86 (0.78)	4.63 (1.49)	2.90 (1.52)	4.33 (2.40) *p*=0.05
CRR *p*-value **cDV**	0.39 (0.08)	1.23 (0.18)	0.67 (0.18)	1.12 (0.33) *p*=0.15
ACE *p*-value **cDV**	0.93 (0.19)	1.08 (0.16)	0.81 (0.22)	0.96 (0.32) *p*=1.00
Area AB				
n	125	150	125	150
RD *p*-value **UDAF**	1.94 (0.87)	4.48 (0.99) *p*=0.31	2.92 (1.28)	5.35 (1.85)
CRR *p*-value **UDAF**	0.40 (0.18)	1.23 (0.20) *p*=1.00	0.70 (0.21)	1.29 (2.50)
ACE *p*-value **UDAF**	0.98 (0.41)	1.08 (0.18) *p*=1.00	0.86 (0.26)	1.14 (2.26)

Table 2. Descriptives examined OR ventilation systems, Area A, B and AB. Results are presented as median (interquartile range).

Scientific and societal Relevance PhD





Scientific Relevance

Ventilation effectiveness different OR ventilation systems compared.

Ventilation effectiveness of different OR ventilation systems compared with levels of CFU.

Air quality in ultra clean area in relation to quantity of CFUs, different OR ventilation systems.

CFD compared with an as built Hybrid OR ventilation system.

Societal Relevance

Environmental impact OR ventilation systems, energy consumption.

Investment (CAPEX) costs different OR ventilation systems.

Operational costs (OPEX) different OR ventilation systems.

Measurements according to current standards and guidelines are time consuming.

Contribution to cost/benefit balance of infection prevention.

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Questions