Ventilation design practices in Nordic hospitals

Jukka Vasara 2.7.2026

Granlund

Jukka Vasara

Vice President in Granlund Group
Director of Granlund Group Hospital business
Chairman of the Integrated Hospital Design Alliance IHDA
Chairman of the Alliance for Sustainable Cleanrooms ASC

Hospital HVAC design

- 35 years of project management experience in dozens of hospitals
- Finland's representative in the European CEN/TC156WG18 standard working group developing hospital ventilation ”Ventilation in Hospitals”

Clean room design

- Dozens of cleanroom design projects in Finland, the UK, China, India and Russia
- Finland's representative in the ISO/TC 209 working group on clean room standards
- Board member of R3 Nordic (Nordic cleanroom association)

Granlund was established in

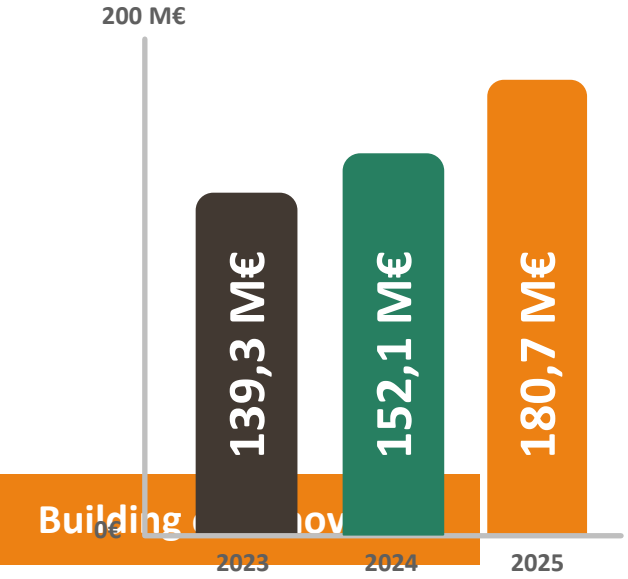
1960

Majority owned by employees, global asset manager ICG as partner

Personnel at the end of the year

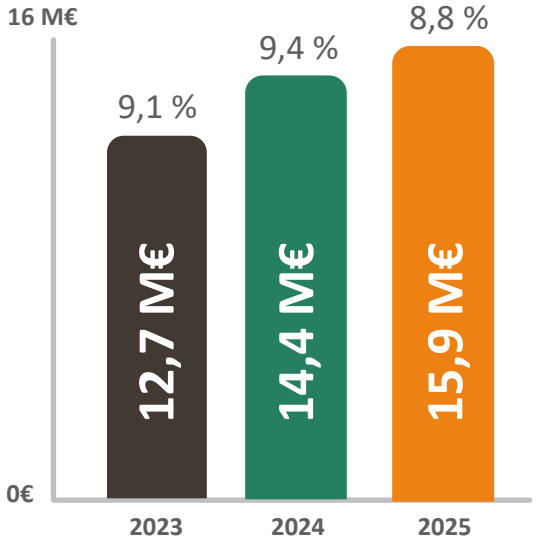
2023	2024	2025
1423	1545	1730

Net sales



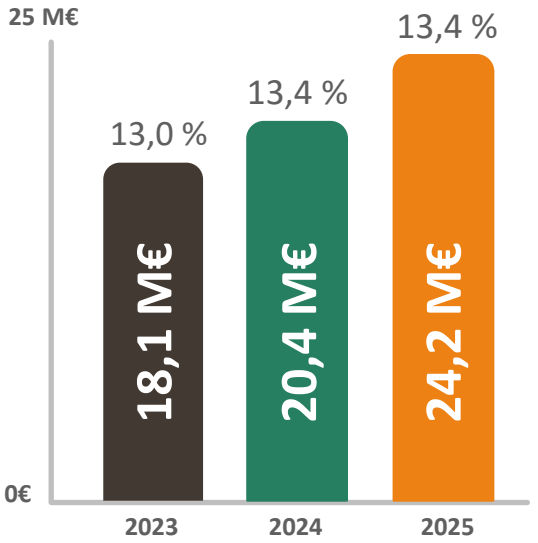
Operating profit

from net sales



EBITDA

from net sales



6%

of net sales in innovation

Our business areas

MEP DESIGN

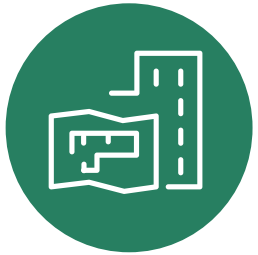
Market leader in Finland in MEP design

ARCHITECTURAL DESIGN

User-oriented, functional and high-quality architecture

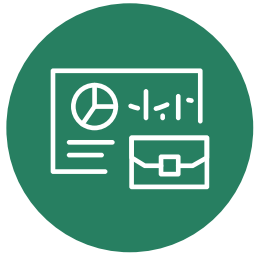
STRUCTURAL DESIGN

Adaptable and lifecycle-proof structural design



CONSTRUCTION MANAGEMENT

Versatile project management services, cost control and monitoring



CONSULTING

Strong expertise in property, energy and sustainability consulting

SOFTWARE

Granlund Manager brings property management to a new level

Our strengths

ENERGY

SUSTAINABILITY

DATA AND DIGITALISATION

PRODUCTIVITY

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”

> 4 million square metres of designed hospital space

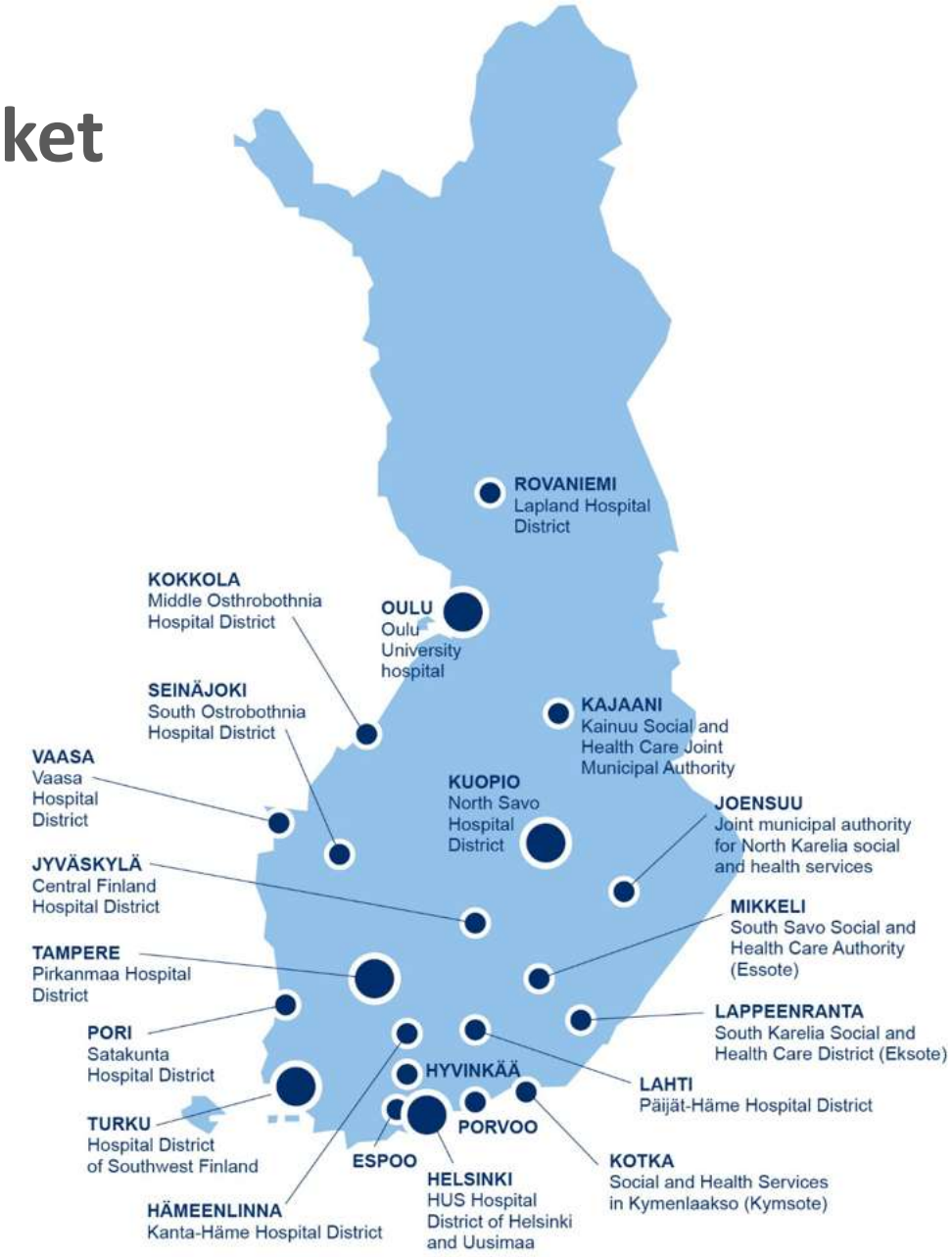
Our Projects

- Bridge Hospital, Helsinki (75.000m2)
- Oulu University Hospital (+200.000m2)
- Hospital Nova, Jyväskylä (106.000m2)
- Turku University Hospital (55.000m2)
- Kuopio University Hospital (56.000m2)
- Laakso Psyciatric Hospital (180.000m2)

- And most importantly:
  - ✓ Numerous small and medium-sized Key Account Projects

Some history and the Finnish hospital market

- We have a long history with many clients from almost all of the hospital districts (from 1960s)
- All the major central hospitals in Finland were built in 1960-70
- During the last decade (2010s) the hospital districts started building completely new university and central hospitals
  - ✓ Building cost altogether about 10 billion €
  - ✓ Granlund have participated in most of the projects in some role



Cleanroom classifications

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Different cleanroom classifications

- EN-ISO 14644-1 Cleanroom standard
- Good manufacturing practices (GMP)
  - EU guidelines on good manufacturing practices for medicinal products
- Ventilation for Hospitals (TC156WG18)
  - Draft European level standard proposal for hospital ventilation
- R^3 Nordic Guideline for Hospital Ventilation
  - Based on TC156WG18
  - Bublished 9/2023 by the Nordic Cleanroom Association

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Areas of application

- Hospital pharmacies
- Operating rooms
- Pharmaceutical industry
- Other GMP facilities
- Cleanrooms for the food industry

- Electronics industry
- Cleanroom industry
- Research laboratories

Building on Innovation

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Cleanrooms and regulations concerning them

- According to the cleanroom standard EN-ISO 14644: “A cleanroom is a room in which the particulate content of the air is controlled and which is constructed and operated in such a way that the entry, accumulation and retention of particles within the room is minimised. In addition, other relevant parameters such as temperature, humidity and pressure are controlled as necessary.”

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EN ISO 14644 consists of

Part 1: Air Purity Classification (2015)
Part 2: Minimum requirements for monitoring and supervision (2015)
Part 3: Testing Methods (2019)
Part 4: Design, Construction and Implementation (2001) – new version to be published in 2022
Part 5: Cleanroom Operating Principles (2004) – update in progress
Part 7: Separating devices (laminar cabinets , glove boxes, isolators , etc.) (2004)
Part 8: Classification of airborne contamination (2013) – update in progress
Part 9: Classification of particles on surfaces (2012) – update in progress
Part 10: Monitoring of chemical compound concentrations on surfaces (2013) – update in progress
Part 12: Methods for monitoring air purity for nanoscale particulate matter (2018)
Part 13: Cleaning of cleanroom surfaces (2017)
Part 14: Assessment of the suitability for use of equipment based on particle content (2016)
Part 15: Assessment of the suitability of equipment and materials through chemical concentration (2017)
Part 16: Energy efficiency in cleanrooms (2019)
Part 17: Application of Particle Deposition Rate (2021)

In preparation,

- Part 18 (assessment of suitability of consumer goods)
- Part 19 (modular air-insulated rooms for first aid rooms)

EN-ISO 14644-1

(particles / m^3 air)

ISO classifi-cation	FED 209E	0,1 µm	0,2 µm	0,3 µm	0,5 µm	1 µm	5 µm
1		10	2				
2		100	24	10	4		
3	1	1000	237	102	35	8	
4	10	10000	2370	1020	352	83	
5	100	100000	23700	10200	3520	832	29
6	1000	1000000	237000	102000	35200	8320	293
7	10000				352000	83200	2930
8	100000				3520000	832000	29300
9					35200000	8320000	293000

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GMP classification

Good manufacturing practices (GMP)

- EU guidelines on good manufacturing practices for medicinal products
- Categories A, B, C and D

Typical uses of categories:

A: Filling of pharmaceutical products (usually in a laminar flow cabinet)

B: The space surrounding the Class A space

C: Preparation of sterile filterable solutions, filling of terminally sterilized preparations

D: Preparation of materials

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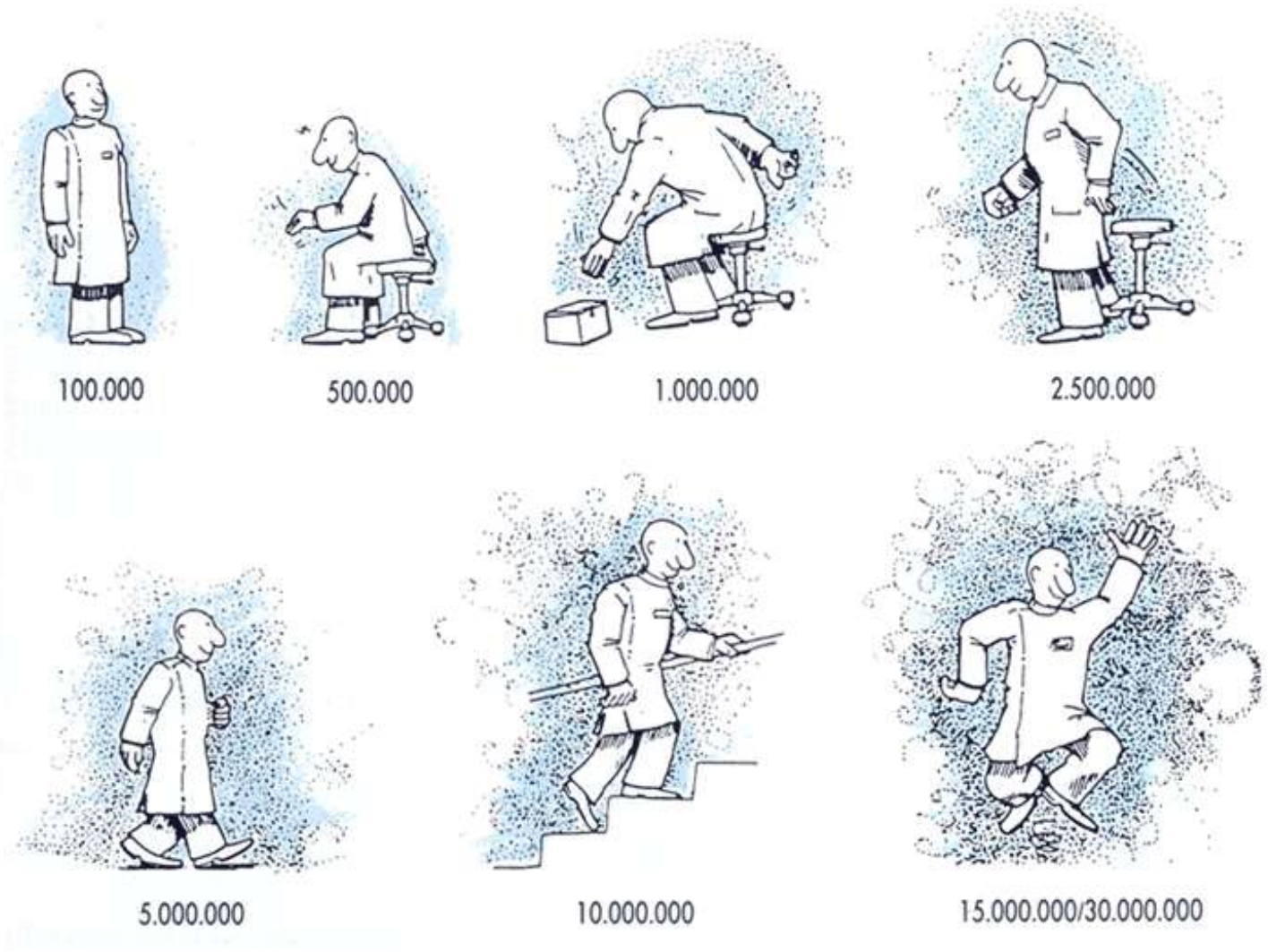
	Maximum permitted number of particles per m^3 equal to or greater than the tabulated size			
	At rest		**In operation**	
Grade	**0.5 µm**	**5.0µm**	**0.5 µm**	**5.0µm**
A	3 520	20	3 520	20
B	3 520	29	352 000	2 900
C	352 000	2 900	3 520 000	29 000
D	3 520 000	29 000	Not defined	Not defined

19. Recommended limits for microbiological monitoring of clean areas during operation:

	Recommended limits for microbial contamination (a)			
Grade	air sample cfu/m^3	settle plates (diameter 90 mm) cfu/4 hours (b)	contact plates (diameter 55 mm) cfu/plate	glove print 5 fingers cfu/glove
A	< 1	< 1	< 1	< 1
B	10	5	5	5
C	100	50	25	-
D	200	100	50	-

Examples of particle output



Number of particles per minute (< 0.5µm)

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Particle counts

To illustrate the point, we can say that the number of particles in one liter of air (0.5 μm) is:

- 1 billion on the highway
- 100 million in the city
- 1 million in rural areas
- On the polar ice cap 10000
- In a cleanroom 3500 (ISO class 8/GMP class D)
- In cleanroom 2900 (ISO class 7)
- In cleanroom 20 (ISO class 5)

Examples of particles

Particle	Diameter (µm)
Sand	80 to 2,000
Hair	100
Pollen	10
Flour	1 to 10
Bacterial	0.3 …2
Blood cell	7.5
Tobacco smoke	0.01 … 1
Virus	0.003 …. 0.05

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Ventilation in clean rooms

- Air distribution method, product/person protection, odors
- Indoor climate control and sizing
- Pressure ratios
- Particulate control with filtration
- Sufficient ventilation coefficients
- The right choice of materials and equipment

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R³ Nordic Guideline for Hospital Ventilation

Kim Hagström, Lars Jansson, Berit Reinmüller,
Flemming Malcho, Jan Mottlau, Kari Solem Aune, Jukka Vasara

R^3 nordic and the guideline section

Population: 28 million people
Geographical area > 1150 000 km^2

Guideline section:

- Kim Hagström, chair (FI)
- Berit Reinmüller (SW)
- Bengt Ljungqvist (SW)
- Lars Jansson (SW)
- Jan Mottlau (DK)
- Flemming Malcho (DK)
- Jukka Vasara (FI)
- Kari Solem Aune (NO)

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R³ Nordic Guideline – an overview

- **Project process and verification**

- **General medical locations**
  - Design basis for general patient and staff areas
  - Functional performance requirements and their verification
  - Systems and components requirements

- **Additional requirements for specific areas**
  - Operating rooms
  - Isolation rooms

Main goal: protection of patients, staff and visitors against harmful agents

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Sustainability

- **There is continuous / increasing need for saving energy in Hospitals**

- **The early stage in the design process is also the time for setting the project goals related to sustainability.** Ventilation systems in medical areas may be very energy consuming, so every project needs to take a close look to the possibilities for:
  a) reducing the amount of air
  b) reducing the energy needed to climatize and circulate the air
  c) re-use of materials and components
  d) other project-specific elements

This document provide guidance on best practise, including reduced operation and set-back operation modes, to be applied in this respect.

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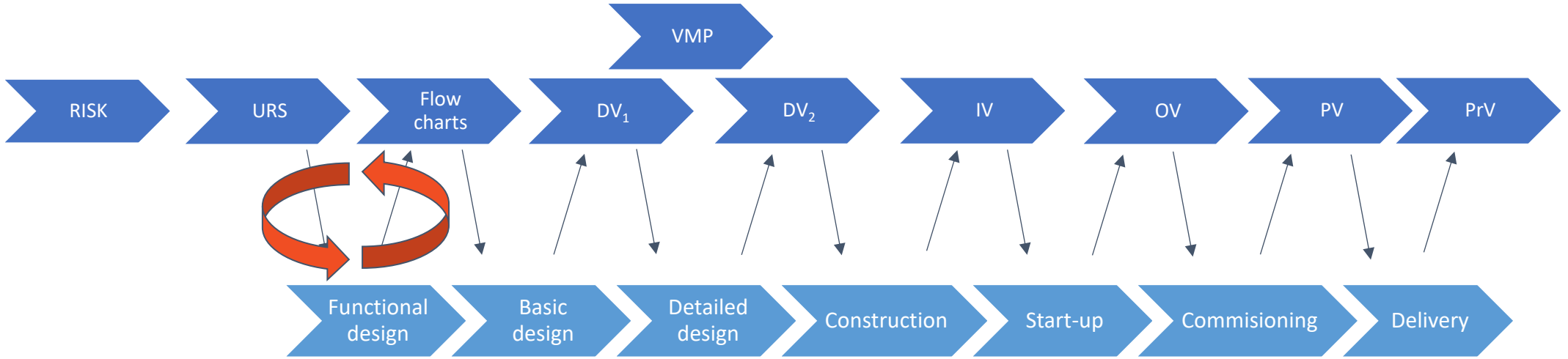
Project process and verification



Defining the needs/risks for medical areas

Area A

- Functional requirements
- Quantities

→ Risk assessment Area A

Area B

- Functional requirements
- Quantities

→ Risk assessment Area B

Area C

- Functional requirements
- Quantities

→ Risk assessment Area C

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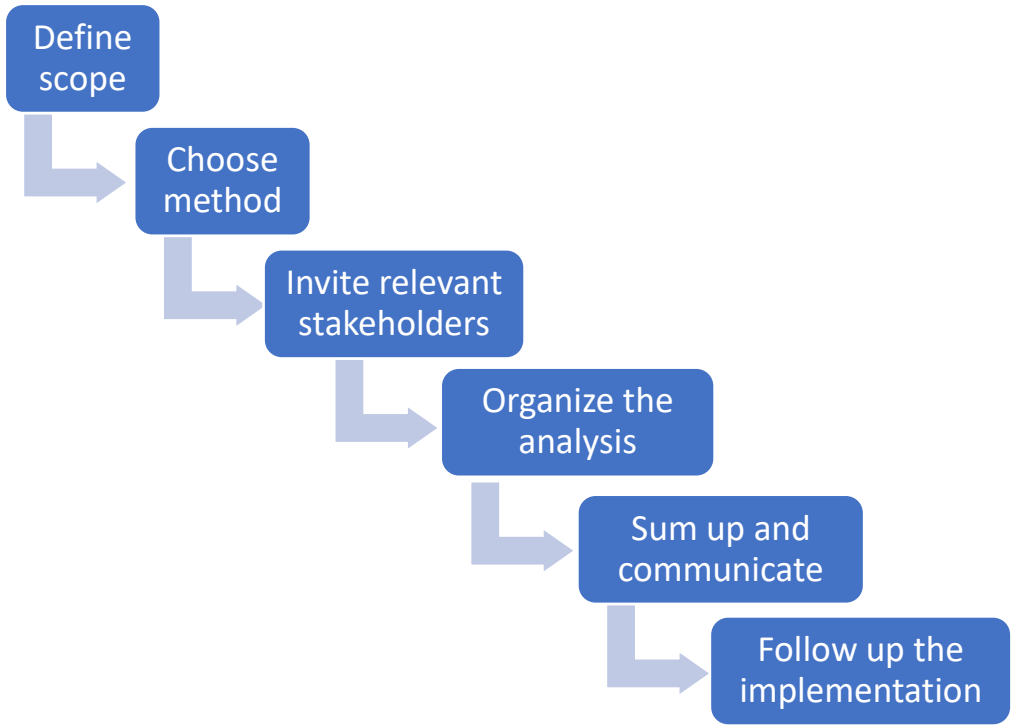
Risk assessment

To be done when the scope and preliminary layout is decided – but BEFORE the detailed layout, the budget and other major decisions!



URS – **U**ser **R**equirement **S**pecification

Should be owned by the hospital

A document with the following key elements:

- Short background for the project
- Medical areas covered
- Relevant regulations /standards /guidelines agreed upon
- Main functional requirements and quantities
- Actions from the risk assessment
- Detailed specifications

Detailed specifications:

- Area and volume of the rooms
- Hygienic level
- Comfort level (temperature and humidity)
- Number of people
- Thermal load from equipment
- Air quality
- Normal functionality
- Functionality in failure situations (e.g. fire alarm, fan failure)

Design

2.2 Requerments for indoor Environment quality

Supply air quality in a hospital should meet at least SUP 1 according to EN 16798-3.

Recirculation of air between rooms or different zones is not allowed. Use of additional secondary air (SEC, EN 16798-3) of equal air quality may be used within a room.

Overflow of air may be used within a unit with functionally associated rooms, such as air lock serving patient room.

Extract air (ETA, EN 16798-3) from healthcare premises is defined as ETA 2: Extract air with moderate pollution level, or a higher pollution level. SUP, SEC and extract (ETA) air in ventilation systems shall be designed, controlled, operated and maintained such that unacceptable contamination e.g., by inorganic or organic substances, harmful gases within the system, are controlled.

The **room types** are divided to ventilation classes and should meet the requirements given in Table 1. Additional requirements for rooms with special treatments or processes should be identified in **URS.**

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Design

2.2 Requirements for indoor Environment quality

Table 1 Ventilation classes

Ventilation Class	Flow direction	Sound level of the ventilation system** dB(A)	Room type
CL1	Outward flow from clean to less clean	≤45	Operating rooms, additional terminal filtration of ISO 35H or better is required*
CL2		≤45	
CL3		≤40	Other rooms in OR department
CL4	N.A.	≤ 40	Treatment/consultation room, staff meeting room etc.
CL5	N.A.	≤30**)	Patient ward
CL6	Outward or inward flow**)	≤30	Isolation Room ***)

* Detailed performance specifications in Part 2.
** With minimum airflow rate, when patient only is present.
*** Detailed performance specifications in Part 3.

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Design criteria
2.3 General performance requirements

The ventilation system for the general room types should be designed to meet comfort conditions in accordance with the URS having Table 2 as baseline.

CEN IAQ standard used as basis

Table 2 Requirements for indoor environment for general room types

Room Type	Ventilation class	Amount of outdoor air (ODA)*	Relative Humidity***	Temperature
			%	°C
Patient room with occupancy of permanent nature **	CL5	0,010 m^3/s,patient and 0,001 $m^3/s,m^2$ ****	Air humidification is not required	Heating season: **20-24** Cooling season: **23-26**
Rooms for Staff, and other general areas**	CL4	0,007 m^3/s,person and 0,000,7 $m^3/s,m^2$ *****	Air humidification is not required	Heating season: **20-22** Cooling season: **23-26**

* Additional ventilation may be required by local regulations or for microbiological and chemical dilution and heat gains and losses etc.
** Visitors and staff should be taken into account separately based on variable usages. There may be elevated airborne exposure risk in close contact with the patient, Kalliomäki et al (2020)
***Condensation of moisture on components or surfaces is not allowed. If humidification is needed for specific purpose, it should be defined in URS.
**** Category I and low polluting building according to EN16798-1
***** Category II and Low polluting building according to EN16798-1
Note 1: Bold indicates the range over which the parameter may float.

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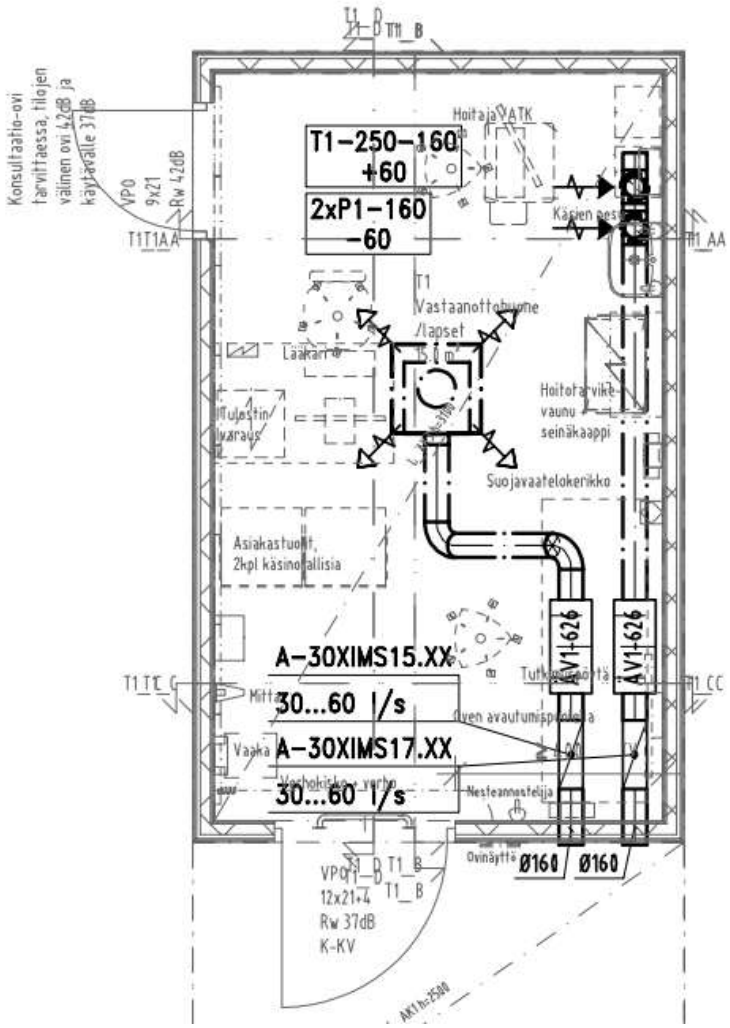
Design criteria

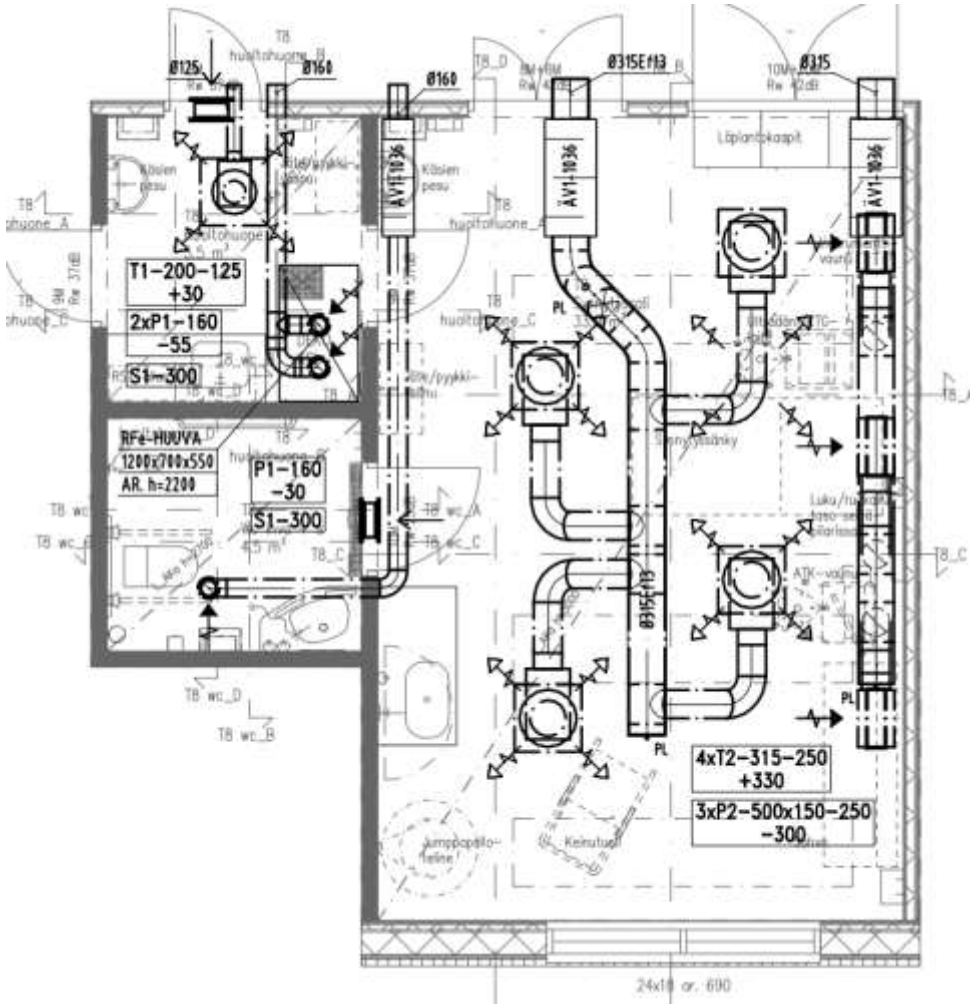
2,4 General system and component requirements

- The ventilation system should be designed and built safe and easy to maintain and clean in such a way that need to access patient areas for inspection or maintenance (e.g., filter change, fan maintenance) is reduced, while they are in medical use.
- While considering the location of components with the need of maintenance they should be easily accessible and maintainable without causing occupational health risk to maintenance personnel, for example in such a way that maintenance and cleaning can be easily performed from outside.
- Wet surfaces in ventilation system are not allowed in patient or medical sensitive areas and only dry cooling should be used.
- Sustainable design practices should be applied to minimize energy usage.
- Demand based operation of the ventilation system enables energy saving opportunities also in hospitals. However, when implementing such operation user activity and medical process and its variation needs to be understood and taken in into account in design and implementation of the control system.
- This should be considered in URS.

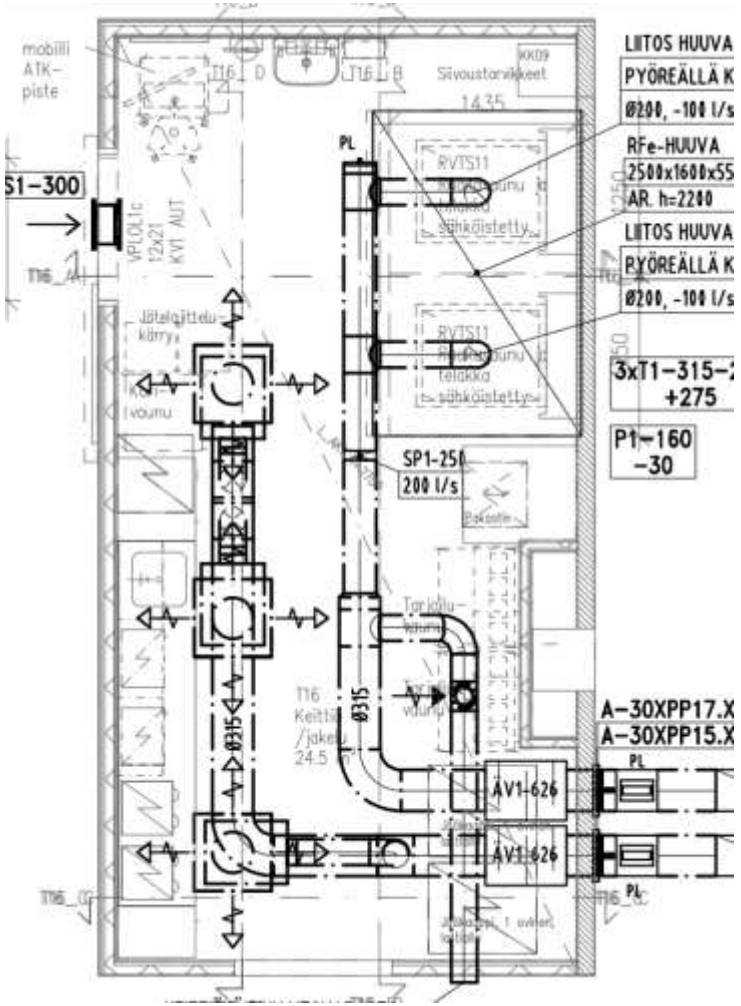
Standardization of the type rooms



Treatment room

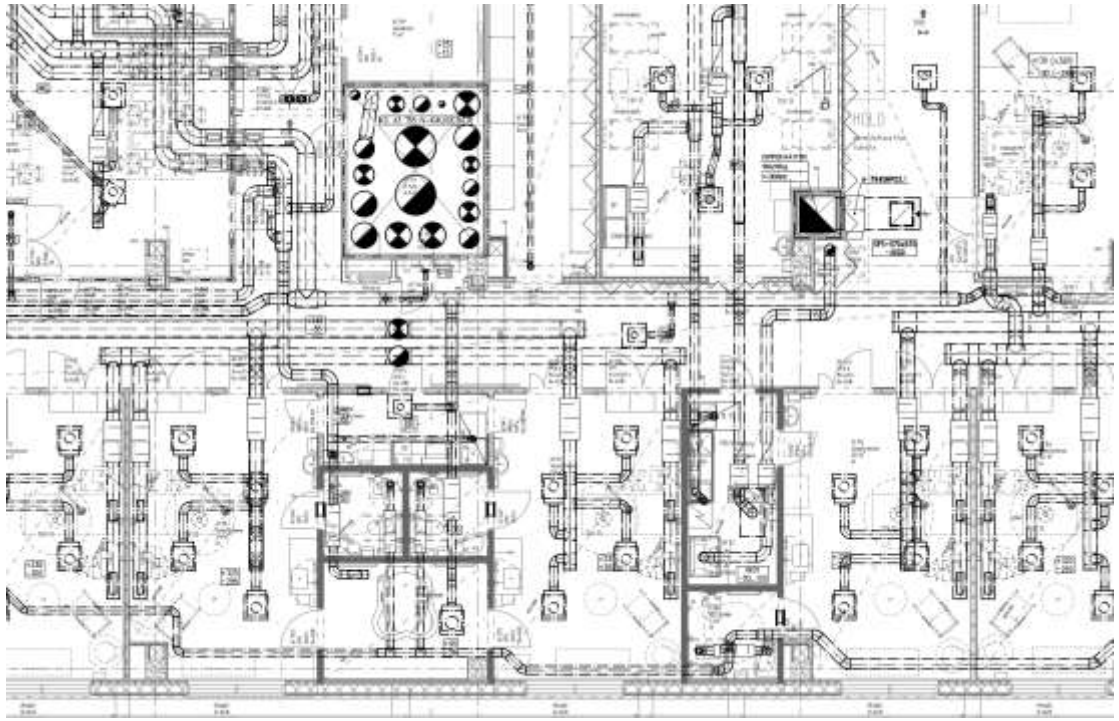


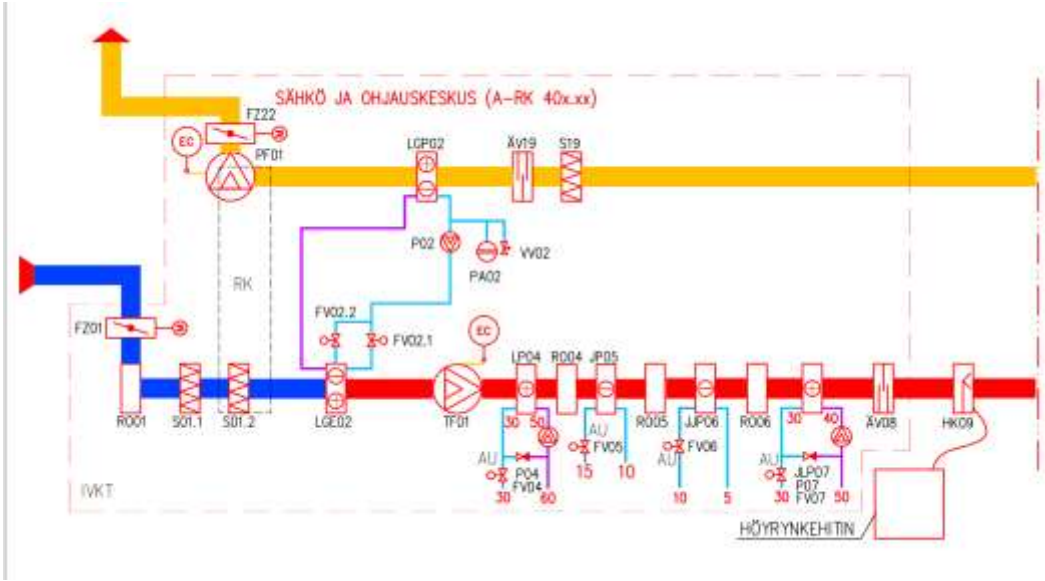
Childbirth room

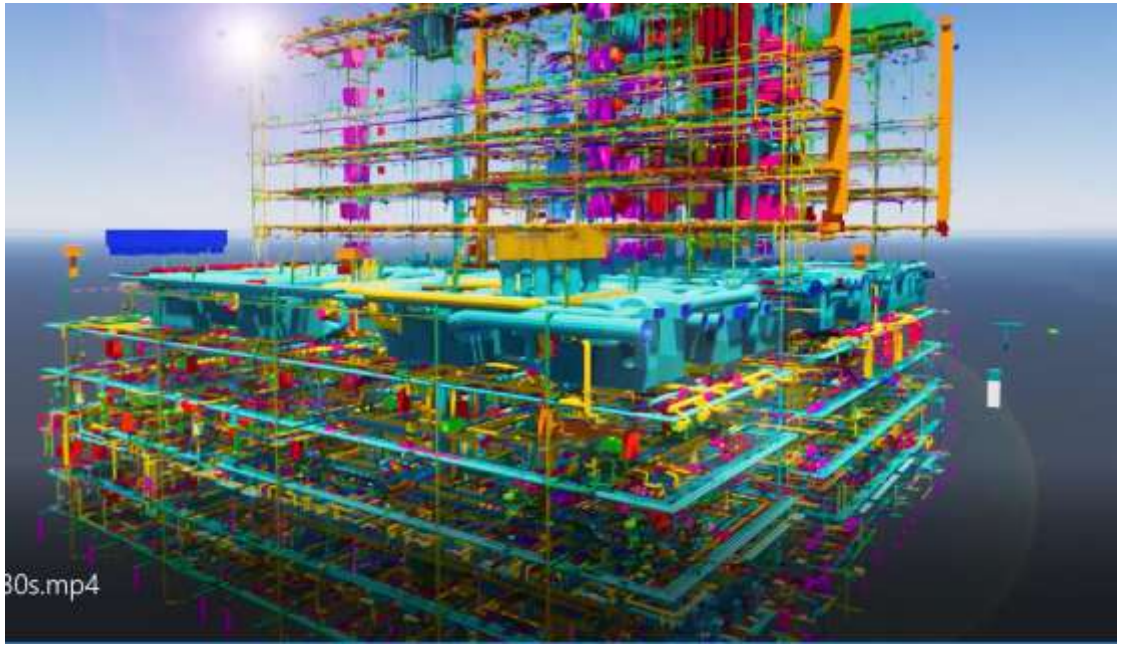


Ward kitchen

Air condicioning systems







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2.4.3 General performance requirements

Draft, Humidity and condensation

Wet surfaces and water (condensate) in the system should be avoided because they cause corrosion and growth of microorganisms.

The humidity in the system is an important indicator of the risk for condensation in the system. Humidity at the air filters of more than 90% often cause problems even if they are of a short duration.

If wet surfaces are to be expected, such units should be in the technical room where they can periodically be checked, cleaned and maintained. It should be ensured as early as the design stage (of AHUs) that temperatures below the dewpoint are avoided within the area of the air filters, especially during standstill of the system.

It should be ensured that no uncontrolled condensation in the system can occur during all normal operating conditions, or during failure, if that can be simply prevented by a safety function.

a) If a humidifier is installed, the control system should keep the humidity in the ducting after the humidifier to a maximum of 70%

b) If the humidity exceeds this limit (70%) or there is no air flow, the humidification should be stopped.

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2.4.5 General performance requirements

Surfaces and materials within the air flow

- Only devices and system components should be used which do not release any harmful substances, fibers, and odors into the air flow or the rooms, respectively, and do not stimulate the growth of microorganisms. Surfaces which are in contact with the transported air should be designed and manufactured smooth and cleanable, so that a deposit of dirt is not promoted.
- Glass and mineral fiber mats used for insulation or sound attenuation should not be in direct contact with the air e.g., unsealed attenuators and internal insulation. Any porous linings within the air flow should be covered with suitable abrasion-proof material (e.g., glass silk cover).
- Seals and sealants should be smooth, have closed pores, should not absorb any moisture nor form a nutrient substrate for micro-organisms.
- The use of injectable joint sealants on site should be avoided and expanding foams should not be used.
- Local conditions should be considered when choosing construction and materials for plant and external ductwork and components e.g., coastal areas.

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2.6 General requirements for components

Component type	Requierments ultra brief
Outdoor air intake	Recommendation –wet, -snow, -blocked by freezing nor referment to standard, (Thus Denmark DS447 is requiered)
Outdoor air shut-off dampers	Least EN1751: Class 3 airtightness
AHU	EN 13053, least class D2, EN 1886 and Table 4 least class L2, comply with Table 7, east ISO EPm1 (>=80%) filtration, least class T3,t least TB4, weatherproof TB3, Hygenic design
Heat recovery	EN 308 and EN 13053 for hygienic purpose
Ductwork	EN 1506, EN 1507 and EN 12097. Comply with ATC-2 as EN 16798-3
Filters	EN ISO 16890 ePM1 >80% , EN16798-3 SUP1 (prev. 13779)
HEPA filters	ISO 29463 least 35H class, test ISO14644-3
Air terminals	Comfort, cleanability
Shut off dampers	EN 1751: class 4
Cooling coils and dehumidifiers	Wet surfaces and water (condensate) in the system should be avoided, face velocity < 2 m/s
Humidifiers	EN 13053, humidifier class E, should be used.
Droplet eliminators	EN 13053 hygenic effect. , (> 2 m/s for demister effect)
Drainage systems	Wet surfaces and water (condensate) in the system can cause corrosion and growth of microorganisms and should be avoided.

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2.6 General requirements for components
Air Handling Unit (AHU) 2/2

- In addition, the AHU should meet the following requirements:
- a) the internal surfaces of the AHU should be smooth, easy and safe to be cleaned,
- b) the seals used should not absorb any moisture and should not form a nutrient substrate for
- micro-organisms
- c) the internal components of the AHU should be accessible or extractable for cleaning,
- sanitation and maintenance
- d) for humidifiers, coils, upstream and downstream should be accessible or extractable for
- cleaning, sanitation and maintenance
- The AHU should have indicators to assess the status of the internal components. The components to
- be assessed are at least: filters, humidifiers and fans. Filter, cooling coil and humidifier sections should
- be equipped with windows and lighting for inspection and maintenance.

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2.6 General requirements for components

HEPA filters

- HEPA final filters should meet at least class ISO 35H (H13: EN 1822) according to ISO 29463. For proof
- of s HEPA, the filter efficiency an individual test certificate should be provided with the filter.
- HEPA filters should be placed in the air supply/exhaust device or as close to the room air terminal as
- possible. Disregard to location of the HEPA filter it should be possible to integrity test by scan testing
- (according to EN ISO 14644-3) To facilitate testing
- - a tightly closable test aerosol supply connection must be arranged before each HEPA filter
- - a representative concentration measurement point should be provided upstream of the
- filter accessible from the room side
- Filter integrity test according to ISO-14644-3 should be performed at the first and every new filter
- installation, or as per reverification program (typically every 2. Year), to demonstrate the integrity of
- the installation.

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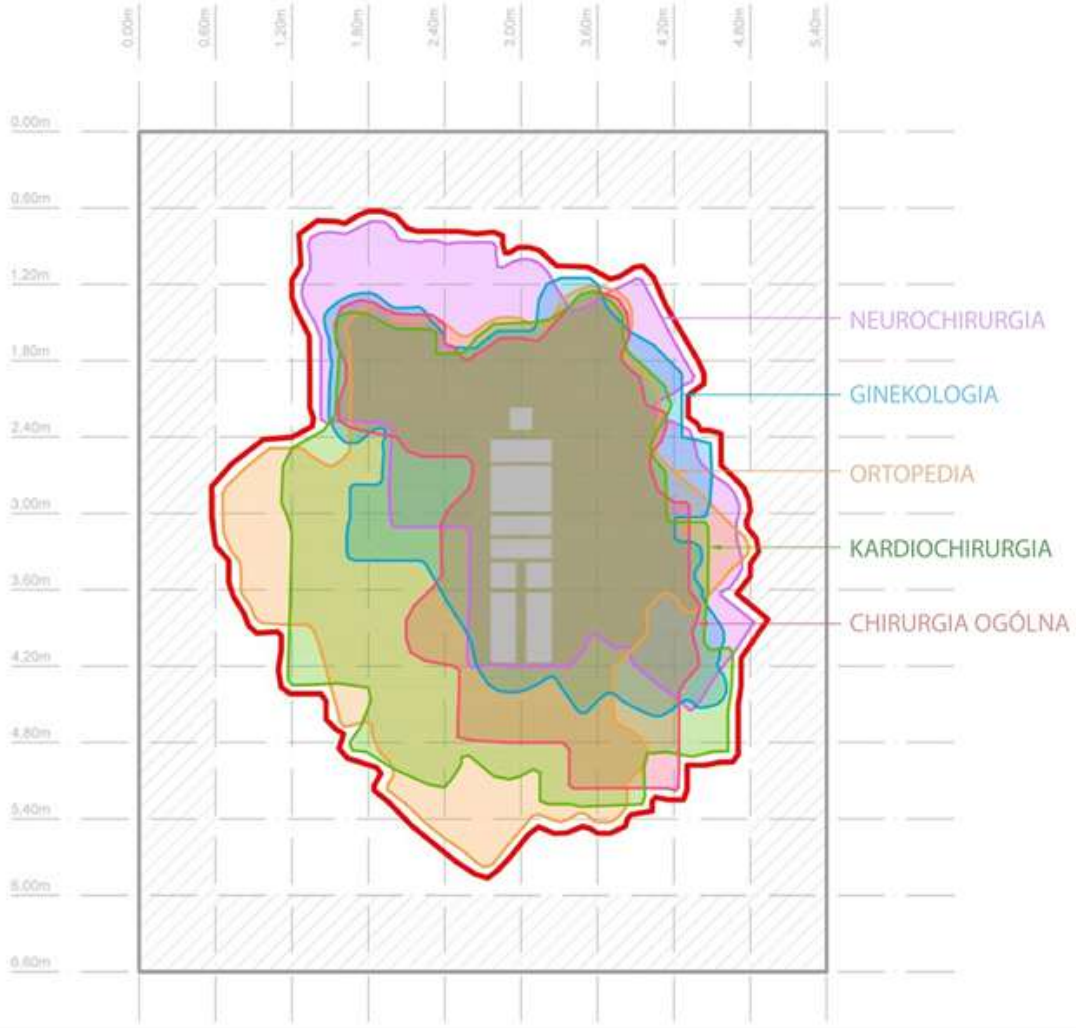
Part 2: Operating rooms

Operating rooms

- **How to design, set up the requirements**
  - Type of operation – cleanliness level
  - Identification of Critical Area (Type of operation)

- **2 Different Ventilation concepts**
  - Dilution / Zoning
  - Dimensioning principles
  - Verification requirements and processes
  - At Rest, In operation and Reverification (Set Back)

- **Requirements for room**
  - Flow direction, room tightness and pressure cascade



Picture courtecy of dr n. med. Maciej Matłok, Industria Project, Poland

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Operating rooms

What to consider, be aware of contamination from:

- Number of people
- Clothing
- Behavior
- Door openings
- Cleanliness outside
- Logistics – for example of sterile goods
- Pollution sources (anesthesia gases, surgical smoke, etc.)
- System operating parameters (dT, v)

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Air cleanliness levels and ventilation principles

- **Two levels for operational air microbial cleanliness, CL1 and CL2 are defined.**

- Both cleanliness levels can be achieved by applying two different ventilation principles:
  - The protected zone principle
  - Dilution mixing principle.

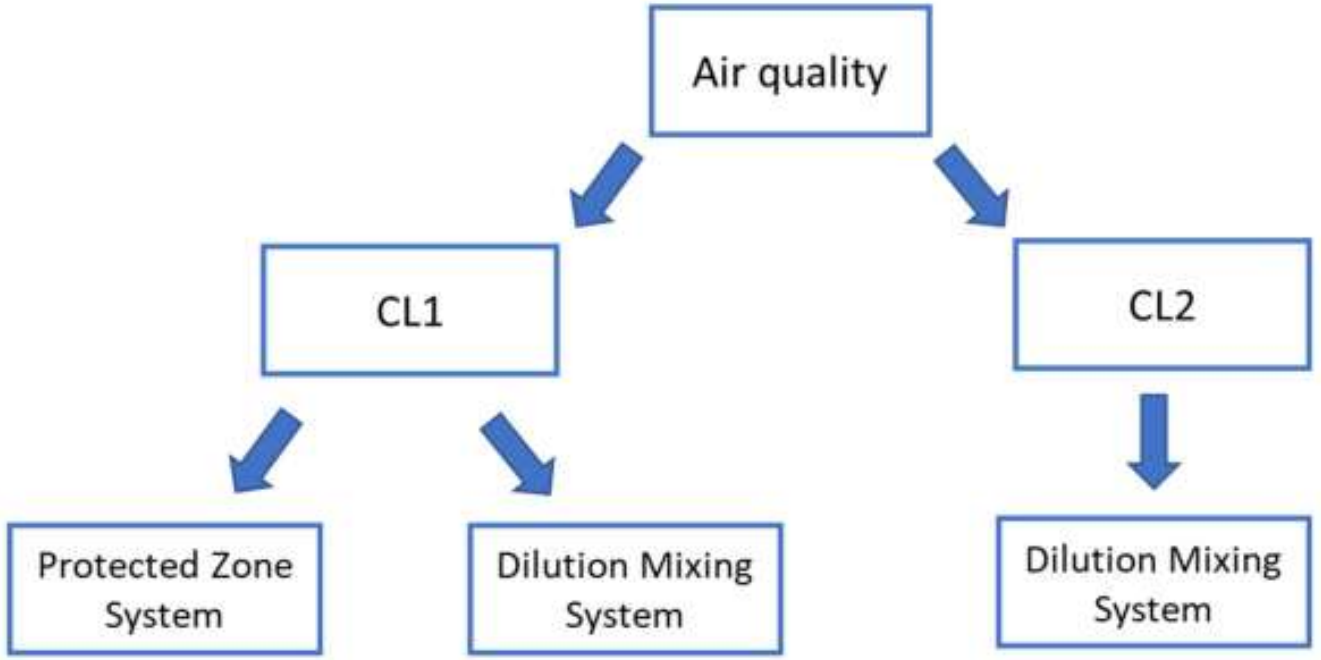
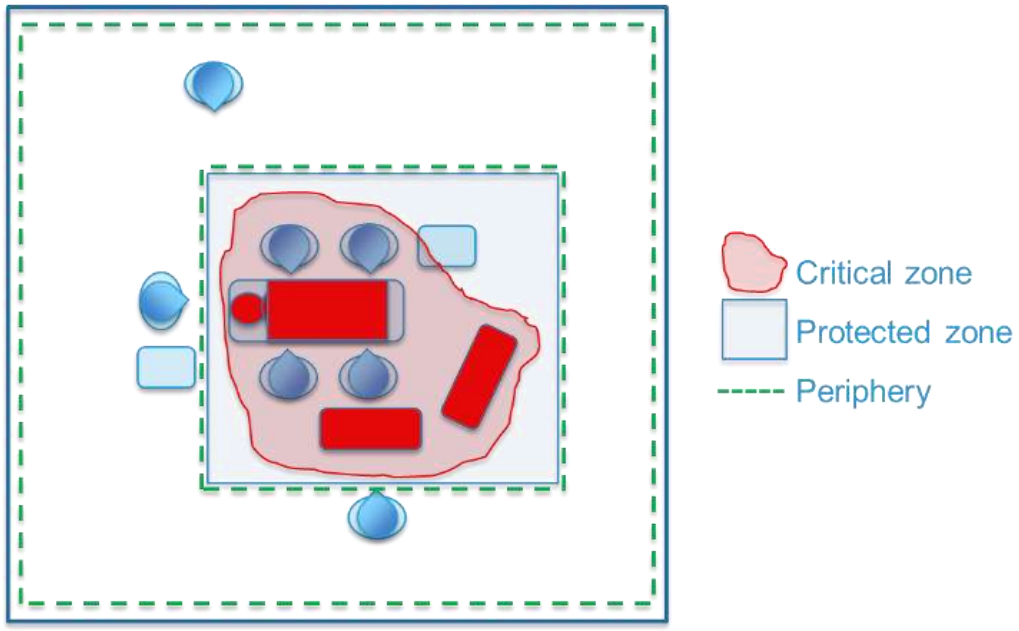


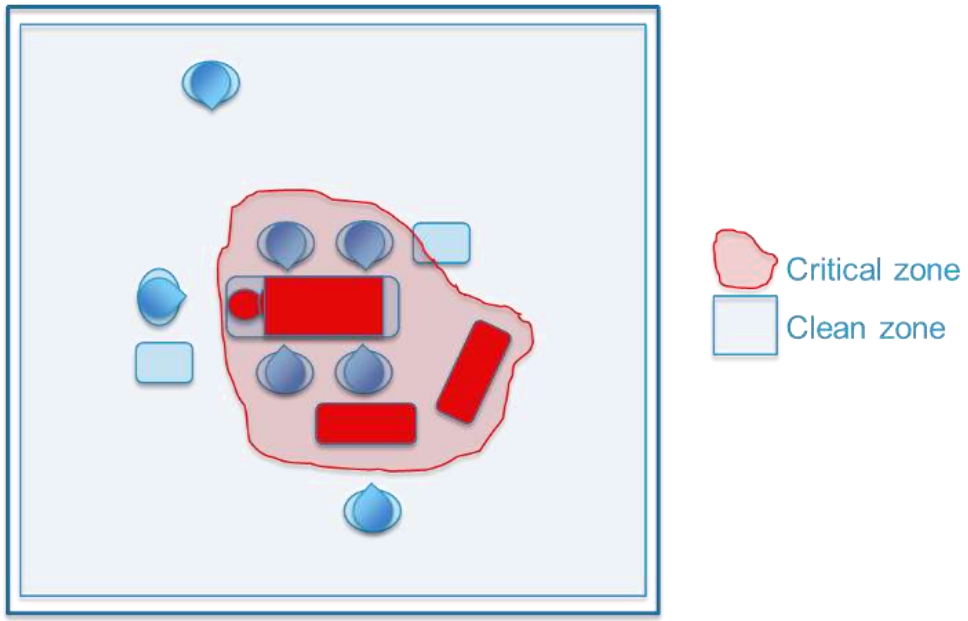
Figure 5. Flowchart: guidance for performance level, risk class and, system principle

OR Ventilation Concepts, Requirements

ZONING



DILUTION



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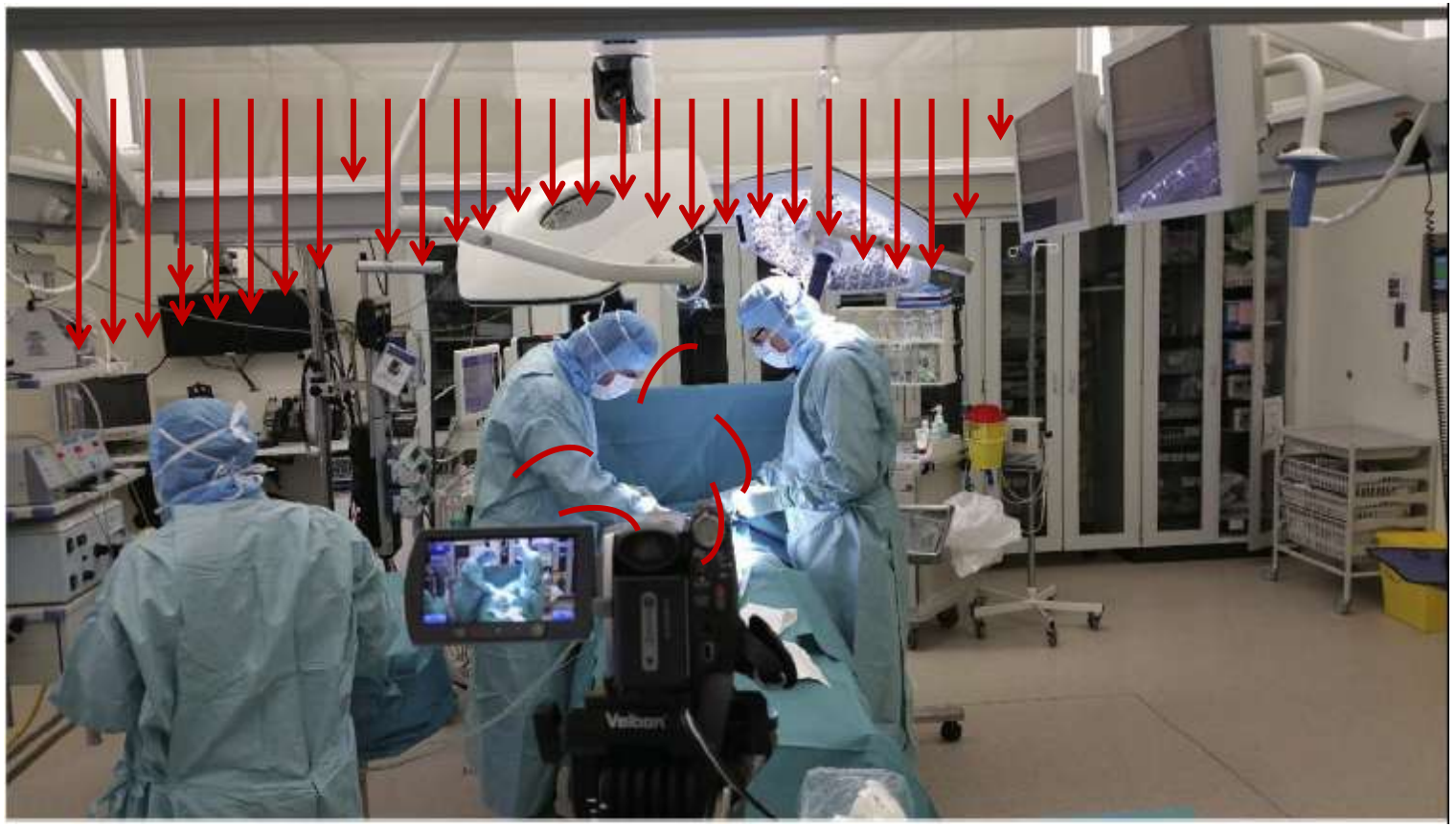
OR Ventilation performance, "At Rest" vs. "In Operation"



Illustrasjon: Windsor

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Requirements for Operating Room
Environment

Table 3 Thermal, ventilation and air quality requirements for operating suites

Room Type	Ventilation Class (See Table 2)	Amount of outdoor air (ODA)	Relative Humidity	Temperature
			%	*°C*
Operating room	CL1, CL2	≥0,275 m^3/s *) **)	**<60** (at 21 °C) Air humidification is not required	**18-26**
Instrument lay-up room	As associated operating room	0,007m^3/s,person and 0,0007 $m^3/s,m^2$	**<60** (at 21 °C) Air humidification is not required	
Other rooms	CL3			

*Additional ventilation may be required by local regulations or for microbiological and chemical dilution and heat gains and losses etc. The maximum number of people in the OR should be decided by the client.
** Minimum total value per room
Note 1: The presented minimum ventilation airflow rate is based on a situation where operating rooms are equipped with local exhaust systems for anesthetic gases and surgical smoke. If this is not the case, it is recommended to use higher airflow rate.
Note 2: Bold indicates the range over which the parameter may float.
Note 3: Patient temperature control is taken care of by medical thermal devices.

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Requirements At-Rest

Table 4.Performance requirements for operating room ventilation *At-Rest*

	Specification	CL 1*		CL2
		UDF	DMF	DMF
Particle concentration	ISO 14644-1 0.5 micron	ISO 5 Periphery ISO 6	ISO 5	ISO 7
Segregation test	Annex C	10^{-4} or better		
Recovery test	Annex D	100:1	≤ 10 min	≤ 20 min
Microbiological test (active air sampling) CFU/m³ **	Annex B EN 17141	<1 No fungi	<1 No fungi	<1 No fungi

*This measurement is to ensure that initial cleanliness is reached prior the room is taken in use.
** CL1 also applicable for the separate instrument lay-up room

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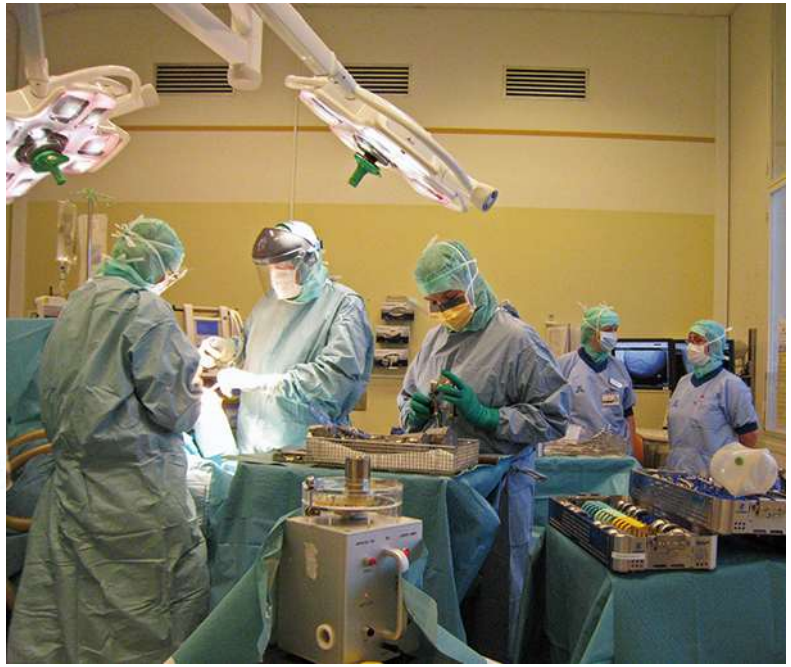
Requirements During surgery

Table 5 Requirements for *Operational* air cleanliness for Operating room ventilation

Test	Specification	CL 1**		CL2
		UDF	DMF	DMF
Microbiological test (active air sampling) CFU/m³	Annex B EN 17141	Protected zone ≤10 Periphery ≤30	≤10	≤50
Fungi's			< 1 CFU/m3 (no growth)	

*Mean value during one operation: max value for single measurement 3 times the mean value. The results of this measurement are not only dependent of the ventilation system but is also depending on the (medical)process e.g., number of staff, clothing systems

** CL1 also applicable for the separate instrument lay-up room



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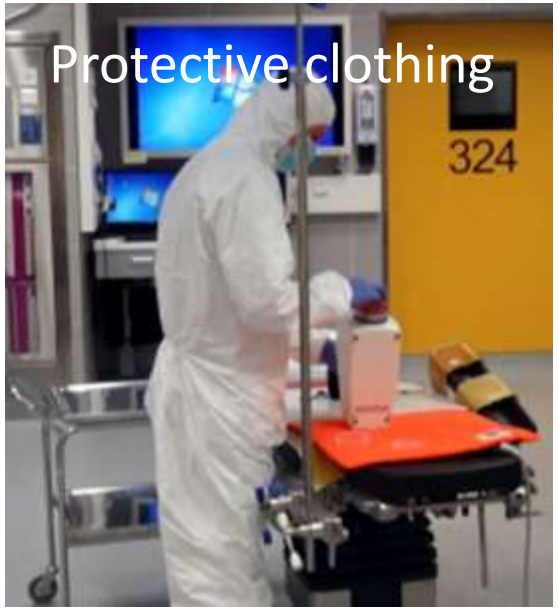
Sampling of air At Rest



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Annex B: Sampling during ongoing operation

- Measurement at a representative location
- As close to critical areas as possible
- Must not disturb the operation
- Protective clothing worn by the measuring person

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Operating rooms, Design for microbial cleanliness 10 CFU/m^3

Dilution Principle

$$Q_{DMF} = \frac{n * q_s}{C * Cr}$$

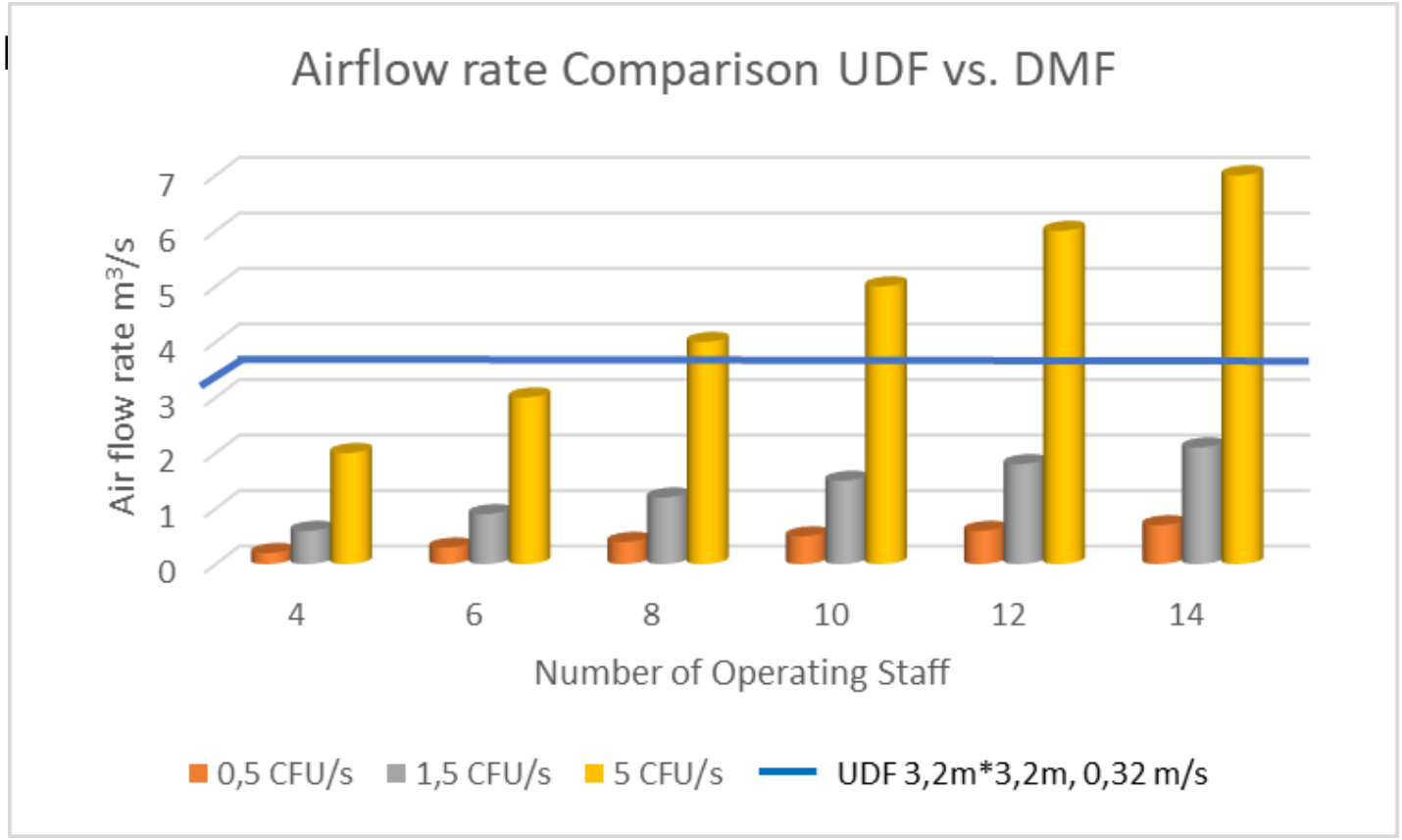
where
Q = minimum total air flow rate for dilution mixing ventilation (m^3/s)
n = number of people (number)
q_s = source strength per person (CFU/s)
C = concentration (CFU/m^3)
Cr = contamination removal efficiency

Zoning Principle

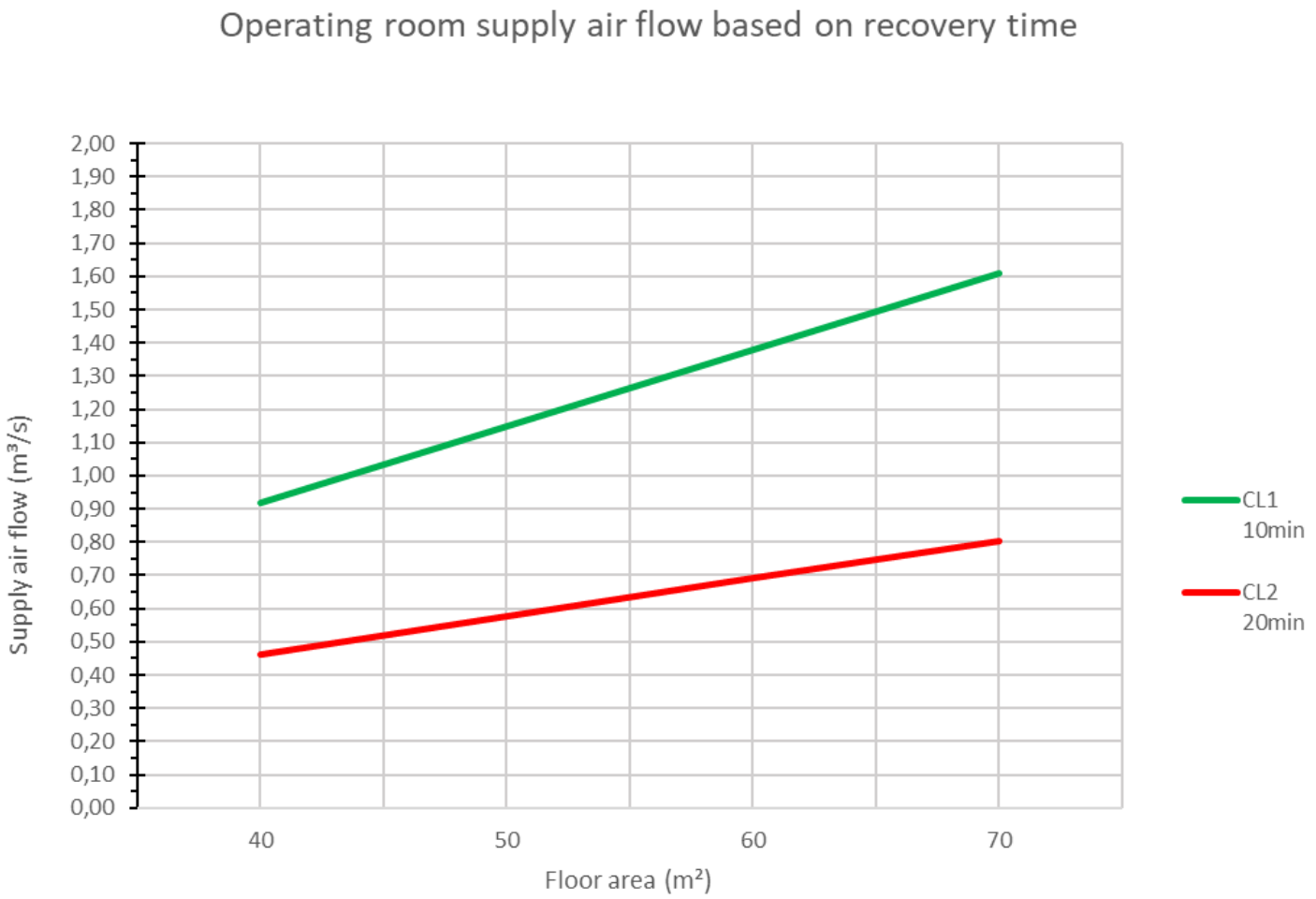
$$Q_{UDF} = A * v \qquad \text{(E.2)}$$

where

Q_{UDF} = total air flow (m^3/s) for uni directional flow
A_i = the area of supply surface (m^2)
v_i = the supply velocity (m^3/s) at surface



Recovery time and airflow



Recovery is important to ensure that the room is clean for next operation – after previous operation and cleaning

Note: The calculations have been made with a ceiling height of 3.0 meters. For illustrative purposes, the x-axis of the table has been chosen as the floor area instead or room volume.

Operating of infectious patients

Target to minimize the exposure for operating staff

- Operation of infectious patients:
  - Ultra clean operation conditions (CL 1)
  - Maximum airflow rate
  - Cleaning and decontamination after surgery

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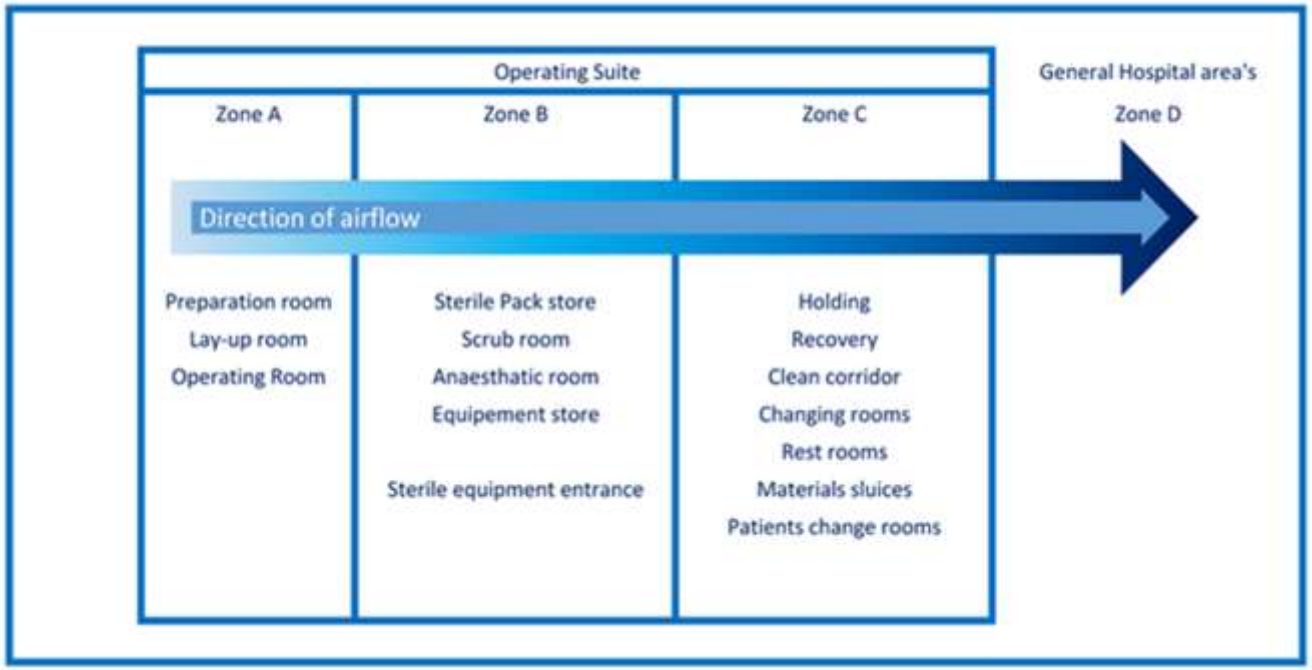
Room pressure / Flow direction

The operating room should be kept in overpressure

- flow direction at the boundaries of the operating department should be directed towards the general hospital areas to prevent intrusion of infectious particles by airflow.
- The operating room construction should be tight to ensure controlled flow from cleaner areas to less clean.
- The construction tightness should be defined in the design documents
- Recommended tightness of the structures is 0,4 l/s,m2 at 50 Pa.
- The doors should be sealed and not impair the general room tightness – for example class C – air leakage < 9 m3/h m2 100Pa (EN 12207:2016).



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R3 Nordic Guideline vs TS39:2025

- TS39 is giving requirements and some guidance, too (Mainly What is required?)
- R3 as a guideline gives both requirements and implementation guidance (What is required, Why requirement is set and How to implement?)

- The ventilation requirements are essentially the same, with exception of minimum outside airflow rate:
  - TS39: 0,56 m^3/s
  - R3: 0,275 m^3/s *

* Separate exhaust system for surgical smoke and anaesthetic gases required

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Motivation for lower outside airflow

- Outside airflow is a principal in energy usage (Sustainability)
  - Fan, Heating, Cooling, Dehumidification

- During standardization work international benchmarking was made
  - In German speaking areas (GER, SWI, AUT) standards requirement is 222-333 m^3/s

- The main reason for outside airflow is hygienic airflow for OR staff
  - 275 l/s means 25 l/s, person (10 staff + 1 patient) which is well beyond highest CEN IAQ Criterion (CEN: 10 l/s, person + 1 l/s, m^2 -> 170 l/s)
  - Airflow is also sufficient to provide overpressure in reasonably tight room

- Lower outside airflow in summertime could also help with humidity challenges in existing hospitals

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Part 3: ISOLATION ROOMS

Airborne Isolation

Guideline covers only isolation units for <u>airborne</u> isolation.

- Contact isolation is covered by normal single patient rooms and gives no additional requirements for ventilation systems.

The different types of airborne isolation covered by this guide are:

- Source isolation (of single/multiple infected patients)
- Isolation level S_A - Normal/Typical risk
- Isolation level S_B - High/unknown/hidden risk
- Protective isolation (of patients with elevated infection risk)
- Combined isolation (for infected patients having simultaneously elevated infection risk)

- Some specific types of isolation may have additional requirements for indoor environment (e.g., burn patients). Also, in every country there may be few rooms for patients with exceptional risks that may have special design.

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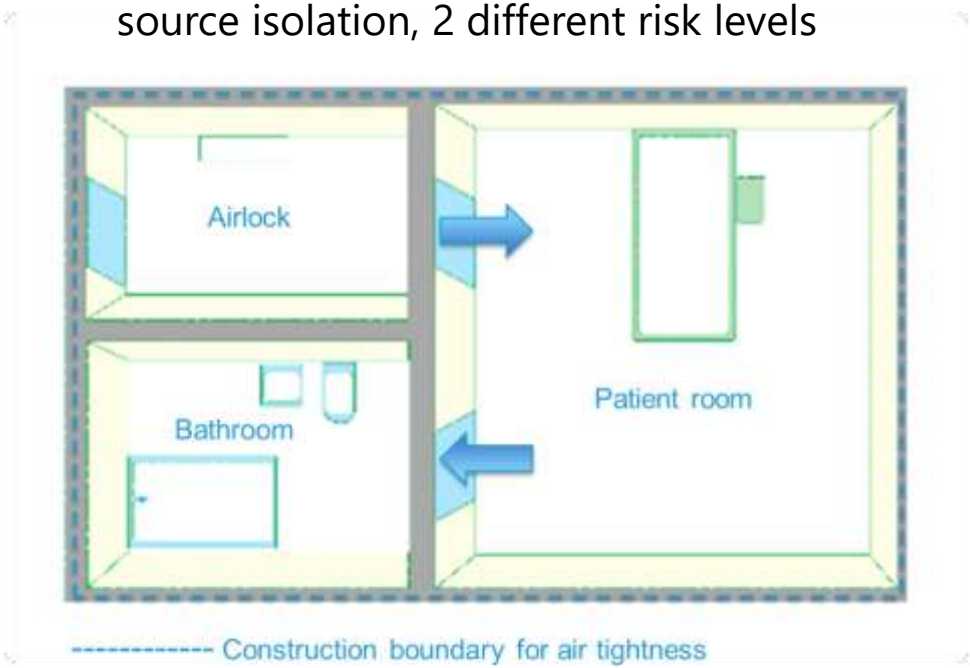
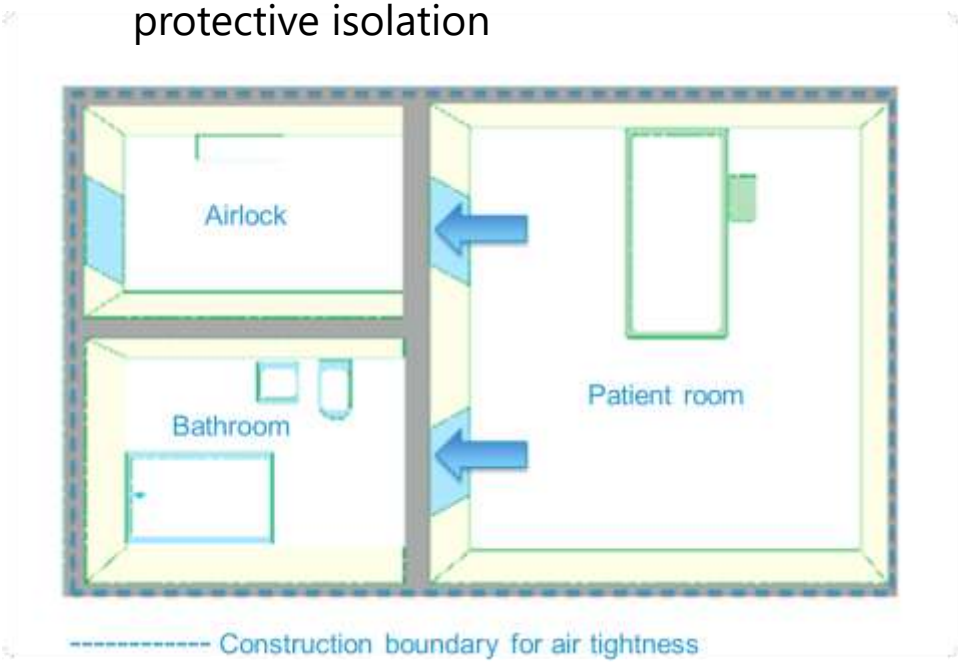
Isolation rooms - airflow principles

source isolation, 2 different risk levels



protective isolation



Leakage rate through the construction boundary should be minimized – tightness requirement given in guideline.

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Isolation Rooms - Design Principles

- **Isolation unit; patient room, airlock, bathroom/toilet etc.**
- **Air leakage of whole isolation unit minimized – By tight construction barrier**
- **Based on targeted protection degree, ventilation efficiency, and nursing process.**
- **Design based on influence from the nursing process:**
  - Patient room, steady state source (patient's breathing) - Room size has no effect on airflow rate
  - Increased exposure risk of HCW close to patient - "worst case" situation addressed
  - Airlock used only few minutes - dynamic dilution
  - Design of multi-patient isolation room covered

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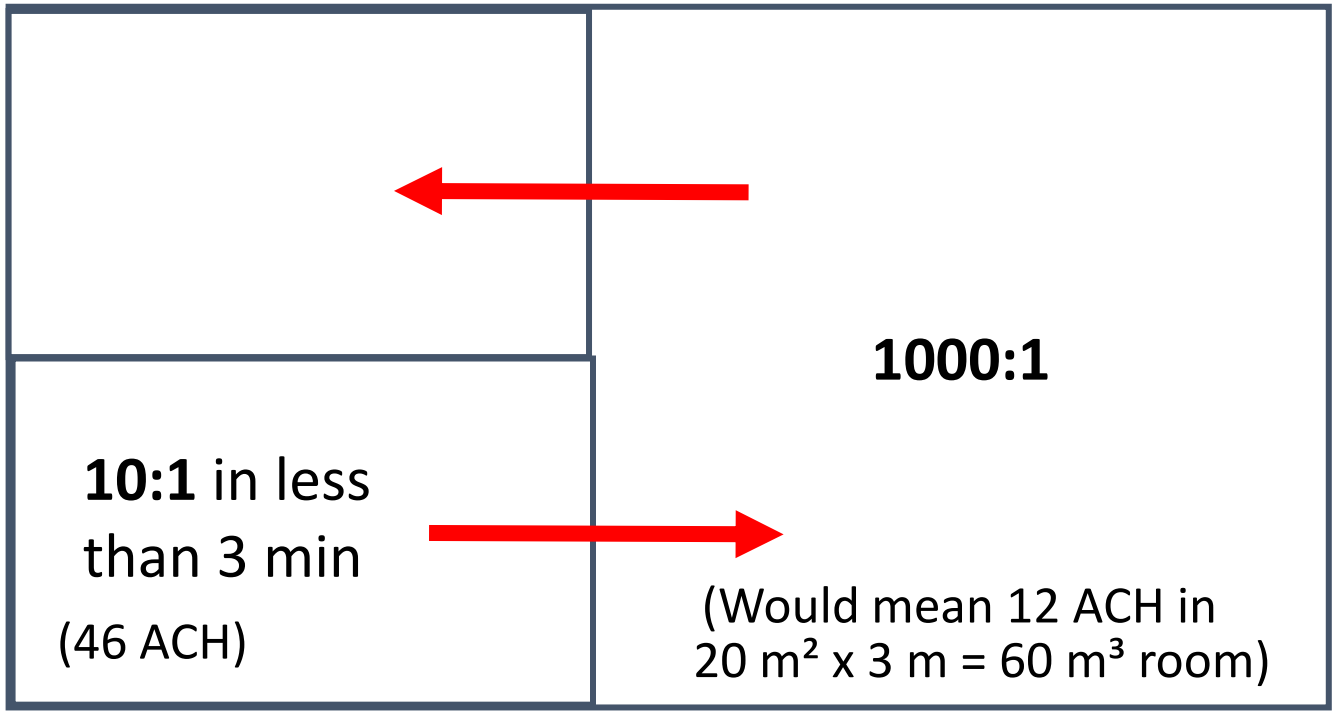
Technical requirements, level S_A

Dilution factor target:

10 000:1 in total

(Isolation room to public area)

- Patient Room Steady state
- Airlock dynamic situation



Insert l/s per person and not ACH as it will vary depending of room size and no of persons

Contamination in the patient room

Breathing frequency at rest: 12-15 pr min

Breathing volume: 450-600 ml pr breath

Breathing volume pr hour: 0,54 m^3/h (0,15 l/s)

→ Person breathing volume is used as contaminant source strength to be diluted

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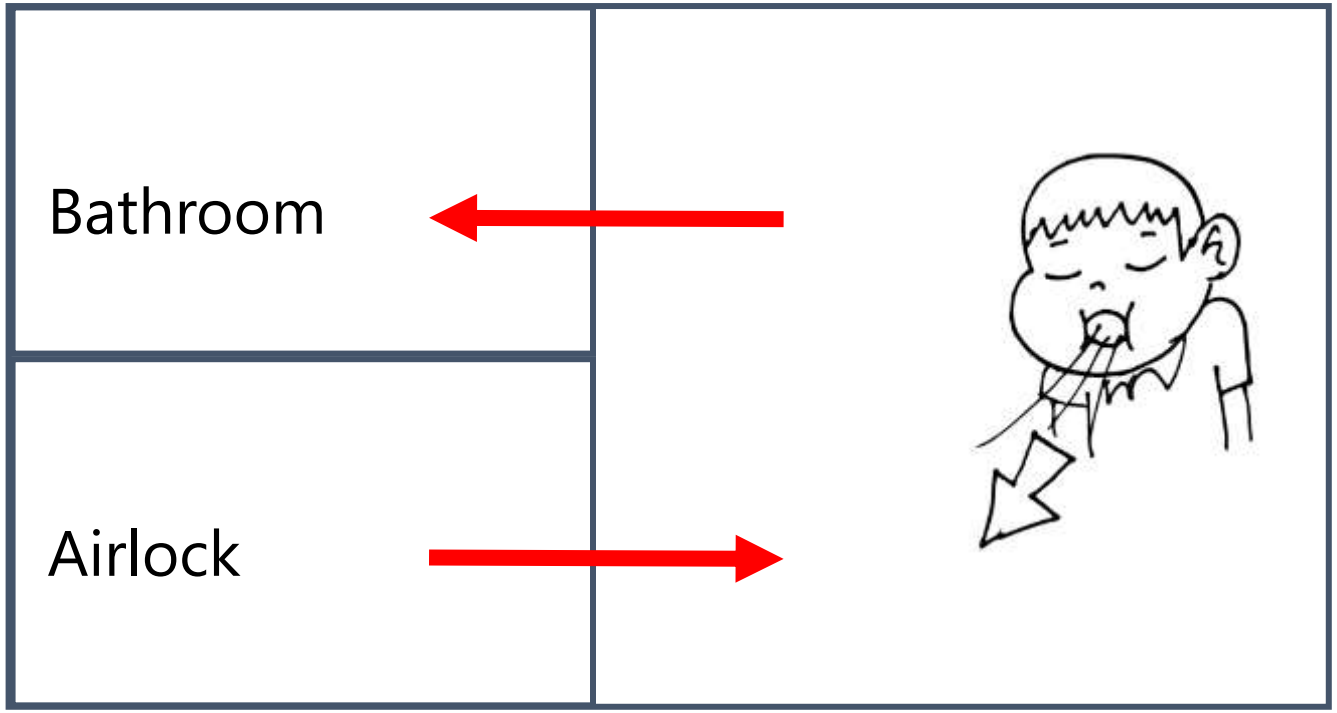
Room Concentration vs Breathing air

Air flow rate [dm^3/s]	Relative Concentration $C_{room}/C_{breathing\ air}$
4	0,02
14	0,01
100	0,0015
150	0,001
300	0,0005

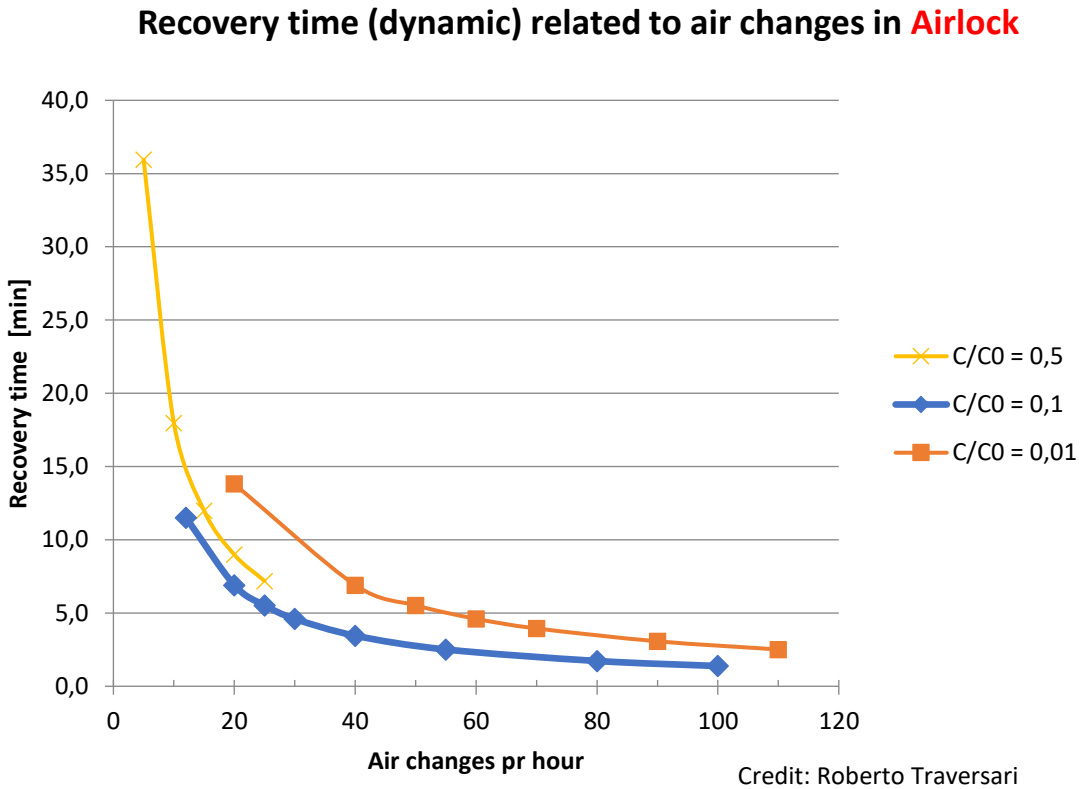
dm^3/s = l/s



Note! Above table with 100% ventilation efficiency, in guideline ventilation efficiency 75% is used for table value 200 dm^3/s

Airlock Design - Recovery time

- Airlock used for
  - Buffer room between patient room and environment
  - Dilute the contamination levels before entering to cleaner area
  - Dress/undress protective clothing
  - Dimensioning based on
    - Needed dilution rate
    - Time spent in airlock
    - Interlock to ensure needed recovery time



Credit: Roberto Traversari

Airflow, Design requirements

Type of isolation unit	**Source isolation Level S_A**	**Source isolation Level S_B**	**Protective isolation**	**Combined isolation**
Air flow rate				
Patient room (/bed)*	200 l/s	400 l/s	200 l/s	200 l/s
Airlock	Upon recovery time	Upon recovery time	Upon recovery time	Upon recovery time
Recovery time (100:1)				
Patient room, 60m^3	< 24 min	< 12, min	< 24 min	< 24 min
Airlock	< 6 min	< 6 min	< 6 min	< 6 min
Waiting time in the airlock**	>3 min	>5 min	>3 min	>3 min
Typical ACH**				
Patient room, 60m^3	12 ACH	24 ACH	12 ACH	12 ACH
Airlock	46 ACH	46 ACH	46 ACH	46 ACH
WC	-	-	-	-

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Design Aspects, requirements

- System risk assessment
- Construction tightness
- Decontamination, e.g. Vaporization
- Alternating usage
- Set-back /Patient room mode
- Operating mode selection
- Exhaust arrangements
- Heat recovery
- Filters
- Ductwork
- Air terminals/airflow pattern
- Dampers
- Indicators and alarms

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Summary

- A new guideline based on Pan-Nordic teamwork
- Free Guideline download from: https://r3nordic.org/guidelines/
- Trainings to be organized upon expressed need
- Aim to be a dynamic document, revised annually, based on received comments, experience and new research
  - Comments to (hagstrom.kim@gmail.com)

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https://www.granlundgroup.com/industries/hospitals-and-healthcare/