

Recent Research on Operating Room Ventilation & Implications

Swedish survey and a summary of investigations in operating rooms

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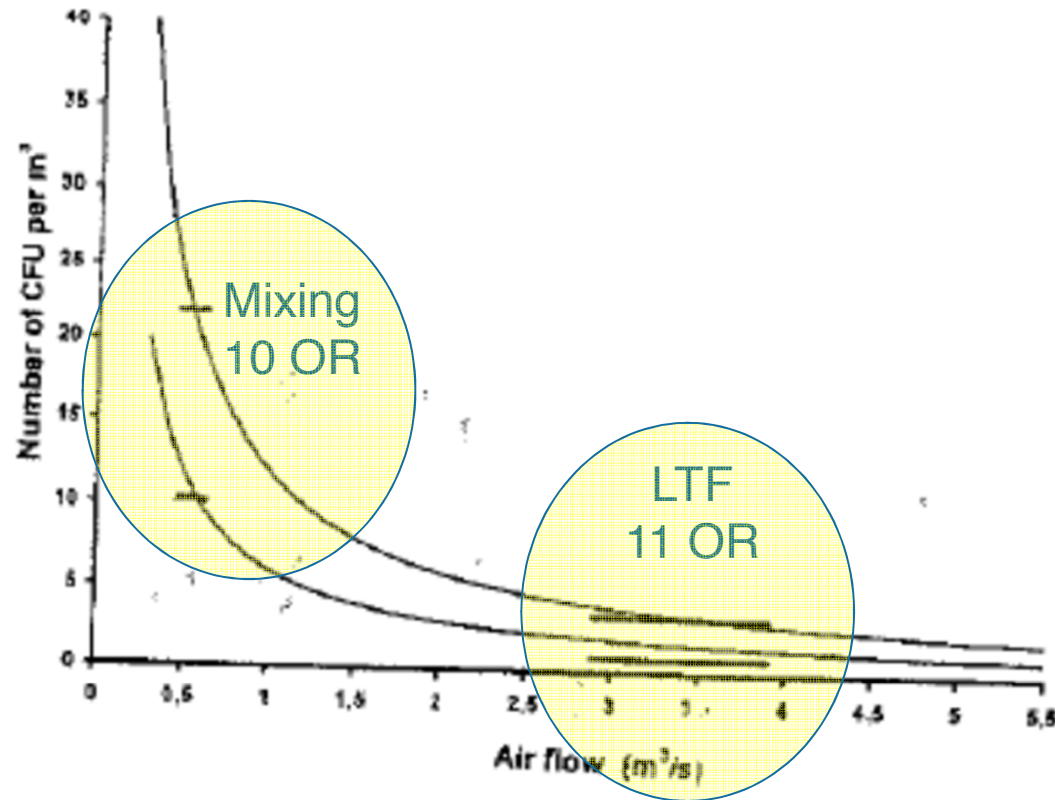
A survey is presented with data from 27 operating rooms in four county councils, where information from 111 ongoing surgical operations was given regarding air volume flows, measured concentration of airborne viable particles and used clothing systems. With results from the survey the mathematical expression describing the dilution principle was established to predict the concentration of airborne viable particles present in the operating room during ongoing surgery. As well supply air system as surgical clothing system used play here an important role.

The results from Figure 2 show that there is a good agreement between the values off confidence intervals that are received from the air flow intervals of $0.5 - 0.56 \text{ m}^3/\text{s}$ (turbulent mixing systems) and $2.9 - 3.9 \text{ m}^3/\text{s}$ (UDF systems), respectively and theoretical relations given by Equation (1). The explanation seems to be that in these cases the dilution principle is valid during ongoing surgery.

When the air flows exceed $4.6 \text{ m}^3/\text{s}$ ($16\,600 \text{ m}^3/\text{h}$) the measured values mostly are lower than the values given by Equation (1). This might depend on that the air velocities in these UDF-units often exceed 0.4 m/s , which can give steady velocities over the operating table creating a sweeping action of air. Similar results have been described by Whyte (1973). However, if the air velocity in the UDF-unit is less than 0.3 m/s the air movements over the operating table during ongoing surgery tend to become turbulent mixing.

It should be noted that the values in Table 2 and Figure 2 indicate that the mean value of the source strength for tightly woven clothing systems is about 1.5 CFU/s .

A study of tightly woven clothing systems and common clothing systems of mixed material (cotton/polyester) is described by Tammelin et al (2000). The results show that during ongoing operations the concentration of bacteria-carrying particles were reduced by 64% by tightly woven clothing systems compared to common surgical clothing systems. This gives that the source strength for common surgical clothing systems of mixed material is about 4.2 CFU/s , which is in agreement with results described by Ljungqvist et al (2011, 2012).



- Comparison between calculated upper and lower confidence intervals shown in Table 2 and the CFU concentrations given by Equation (1) when $n=6$ and $q_s=1\text{CFU/s}$ and $q_s=2\text{CFU/s}$, respectively (lower and upper curve).

Why Clean Mixing Solution – Safety of operation

- **Results of the recent Scandinavian research (Nordenadler J et al)**
 - Operation personnel is the main source of pollution; # of personnel, clothing quality and personnel activity & movement through doors.
 - Necessary fully mixed dilution air flow rate to reach the targeted cleanliness can be dimensioned based on the source strength.
 - Motivation: Low turbulence downflow system is vulnerable to disturbances, which may impair the performance in use - > Infection risk
- **Designing the dilution airflow based on the source strength is a low risk alternative**

**New Clean Dilution solution
for Operating Rooms**

Nya Karolinska Sjukhuset, Stockholm, Sweden

- 1500 milj.€ Project Under construction, in operation by 2017
- All 40 ultraclean operating rooms supplied with a new type dilution solution by Halton
- The prevalidation tests were conducted by Halton laboratory
- Simulated Operations made to Verify in Operation conditipns



CEN TEC 156 WG 18

Ongoing work for

Standardization of Hospital Ventilation

Part 3: Operating Rooms - Content

- Targets for in Operation conditions
- Requirements for At Rest conditions
- Test procedures
- High Risk Surgery / Normal Risk Surgery
- For High Risk Surgery both Protected Zone & Dilution Mixing Systems Acknowledged

Target Levels In Operation - Draft

Table 1: **Operational** Performance criteria for OR room **High Risk surgery**

High Risk			Operational	
	Standard	Specification	Critical zone	Periphery area
Microbiological test Air	ISO 14698	Cfu/m3	<10	<10
Microbiological test Sedimentation	ISO 14698	Cfu/Agar Ø90mm 1 hr	≤1	≤1

Note: For Operational status No performance criteria are required for particles, recovery, segregation

Table 2: **Operational** Performance criteria for OR room **Normal Risk Surgery**

Normal Risk			Operational	
	Standard	Specification	Critical zone	Periphery area
Microbiological test Air	ISO 14698	Cfu/m3	<100	<100
Microbiological test Sedimentation	ISO 14698	Cfu/Agar Ø90mm 1 hr	≤12	≤12

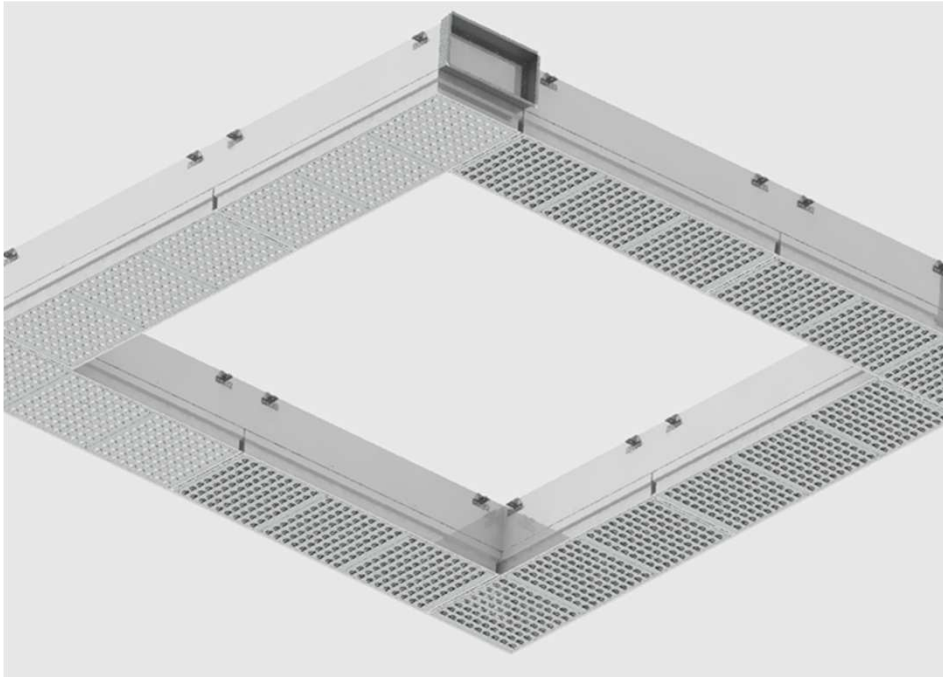
Note: For Operational status No performance criteria are required for particles, recovery, segregation

At Rest Dilution Mixing – Draft, example

Table 4: **Dilution mixing system: At Rest** Performance criteria for OR room **High Risk Surgery**

High Risk			At rest	
	Standard	Specification	Critical zone	Periphery area
Particle concentration	ISO-14644-1	$\geq 0,5\mu\text{m}$	ISO 5	ISO 6
Recovery test	ISO 14644-3	1:100	<15min	<15min

**Nya Karolinska
Sjukhuset
Prevalidation of
Halton Vita Space**



Ventilation solution for the operating theatre

- Circulation unit, airflow 2200 l/s, of which 500 l/s fresh air
- Unit has heating and cooling coils
- VOS 4200x4200 with HEPA-H14 filters
- Adjustable throw pattern with nozzles
- 4 exhaust grilles on the wall: 2 near ground level, 2 at ceiling level
- One exhaust valve inside false ceiling
- Room at 24 Pa overpressure – overpressure vents

Measurements for the Prevalidation mock-up

- Cleanroom airtightness
- Adjust airflows and overpressure
- HEPA-filter leakage test
- Cleanliness classification
- Recovery time
- Temperature & humidity
- Velocity
- Soundpressure levels
- Airflow visualization
- Simulated tests



New Halton Vita OR Space Solution

In the light of validation results the new dilution mixing solution is a good alternative for High risk operations combining:

- **Clean Operating Environment**
- **Good thermal comfort and adjustability of airflow pattern**
- **Energy Savings possibilities by demand based operation**
- **Low Sound levels**



Thank You!