Recirculated air ceiling for operating rooms made by Krantz Components

Reference project

Krantz OR ceilings in the hospital 'Dreifaltigkeits-Krankenhaus' in Wesseling, Germany

- Expansion by two operating rooms, class Ia, 40 m² each

- Building owner: Maria Hilf NRW gGmbH
- Architect: GLSW Architekten Ingenieure
- Consulting engineers: Ingenieurbüro Klinkhamels Haustechnik
- Mechanical contractor: Bilfinger Wolfferts Gebäudetechnik GmbH

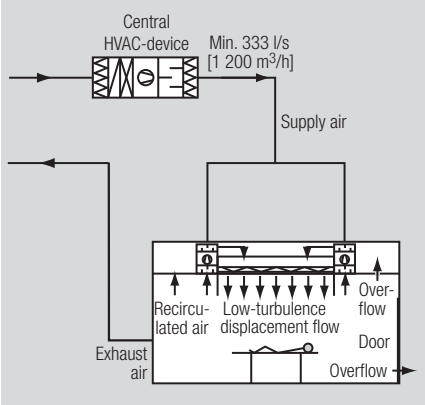
For more than 20 years Krantz Components has been developing and delivering high-quality HVAC products for hospitals. Here, particular attention is paid to thermal comfort and hygiene and with that to the protection of patients and staff.

The hospital 'Dreifaltigkeits-Krankenhaus Wesseling' is an academic teaching hospital of the University of Bonn and is part of the Maria Hilf NRW gGmbH, a Christian responsible body for several hospitals and nursing homes. In the course of extensive modernisation and new constructions of the entire hospital, the wing with the operating rooms was expanded by two further ultra-modern ORs of class Ia, 40 m² each.

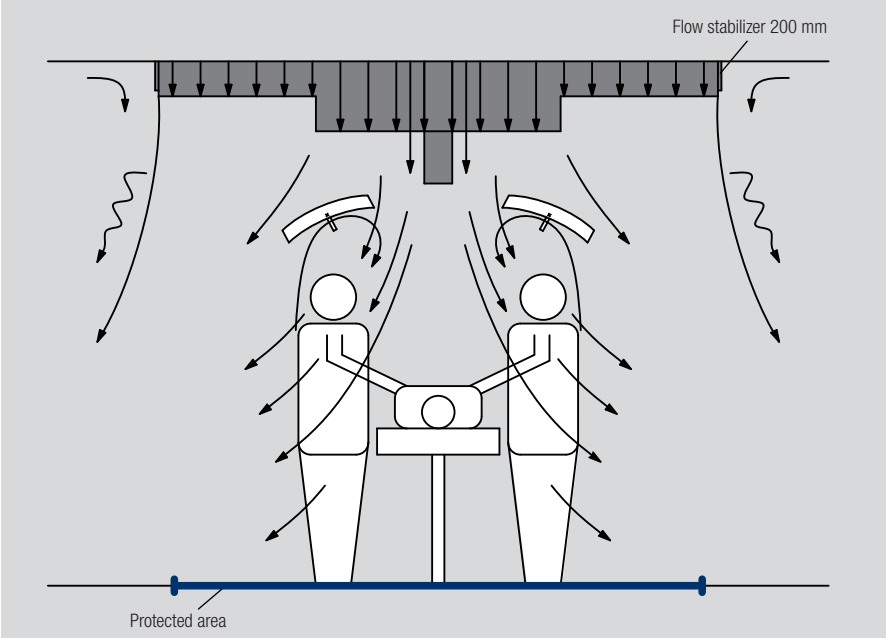
Krantz Components delivered and mounted a complete ceiling system, consisting of two recirculated air ceilings for operating rooms with perimeter lighting system, flow stabilizers and the remaining ceiling installations.

The OR ceiling OP-U-32/32 realised for the hospital 'Dreifaltigkeits-Krankenhaus Wesseling', is the best solution for air conditioning of an operating room. With dimensions of 3.2 x 3.2 m and a protected area of 3 x 3 m the ceiling corresponds to the DIN standard. The total volume flow rate is 2 556 l/s [9 200 m³/h]. A 77-fold indoor air change, which is realised by a decentral recirculated air distribution of 2 222 l/s [8 000 m³/h] and an outdoor air volume flow rate of 333 l/s [1 200 m³/h], provided by an HVAC system, ensures that the air discharges with a velocity of an average 0.25 m/s. So an optimum displacement for the highest demands to comfort is realised.

After a successful assembly and commissioning made by trained personnel, both ORs of the 'Dreifaltigkeits-Krankenhaus Wesseling' have been qualified and released for room class Ia by an independent hygiene institute.



Decentral recirculated air system for operating rooms class Ia



Functional principle of low-turbulence displacement flow (LTF) with differential flow

Functionally optimised OR ceiling system

The correct use of ventilation and air conditioning technology in hospitals, especially in operating rooms, can be an important contribution in avoiding pollution of indoor air with particles. It is an essential element within a multi-barrier system, consisting of a large number of hygienic and ventilation measures, altogether giving priority to the protection of the patient and the staff.

DIN 1946-4 (12-2008) provides the basis for a system with highest demands to absence of particles. For room class Ia it defines a dynamically protected area with low-turbulence displacement flow, that encompasses the operating table and the instrument table. Filtered and conditioned air of highest purity reduces the germ level in the air and consequently the risk of infection.

The following features characterize a recirculated air ceiling for operating rooms:

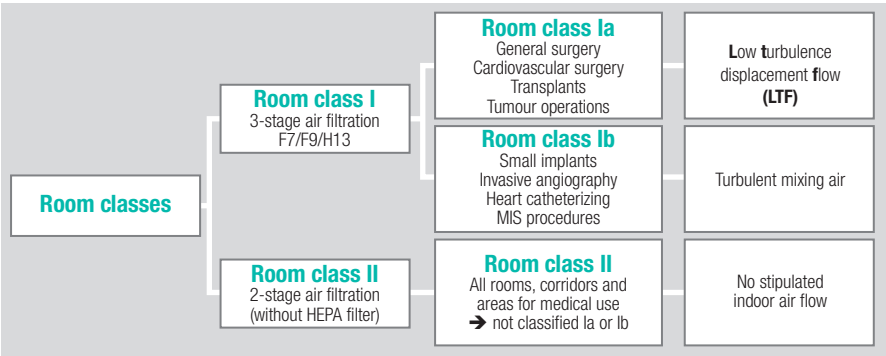
- Modular design
- High-performance mixing chamber
- Double differential flow
- Active light lead-through
- Recirculated air suction in the corners

With a low-turbulence displacement flow, the pollution of the air with germs and particles in the operating field and on the instrument table is significantly lower in comparison to turbulent mixing air (class Ib) which works with the dilution of the particle concentration.

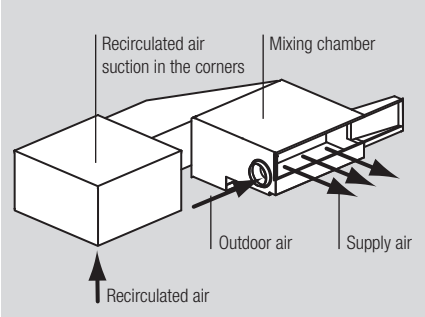
Besides best utilization of the space, because there is no need of an air lock, and saving of energy by low filter pressure drops, the low-turbulence displacement flow offers other advantages:

Low-turbulence displacement flow (LTF)

- prevents from infiltration of germs and particles,
- displaces risky emissions like surgical smoke from the OR staff,
- avoids accumulation of particles and germs below the OR lighting,
- safely leads away thermal loads and hazardous substance emissions,
- supports the thermal comfort in the room.



Overview room classes and required indoor air flows in the operating room



Functional principle of the high-performance mixing chamber

Arithmetic example for the mixture of outdoor air and recirculated air proportions (units of the equation adjusted)

$\dot{Q} = \dot{V}_{AL} \cdot \Delta\vartheta \cdot 0.336$

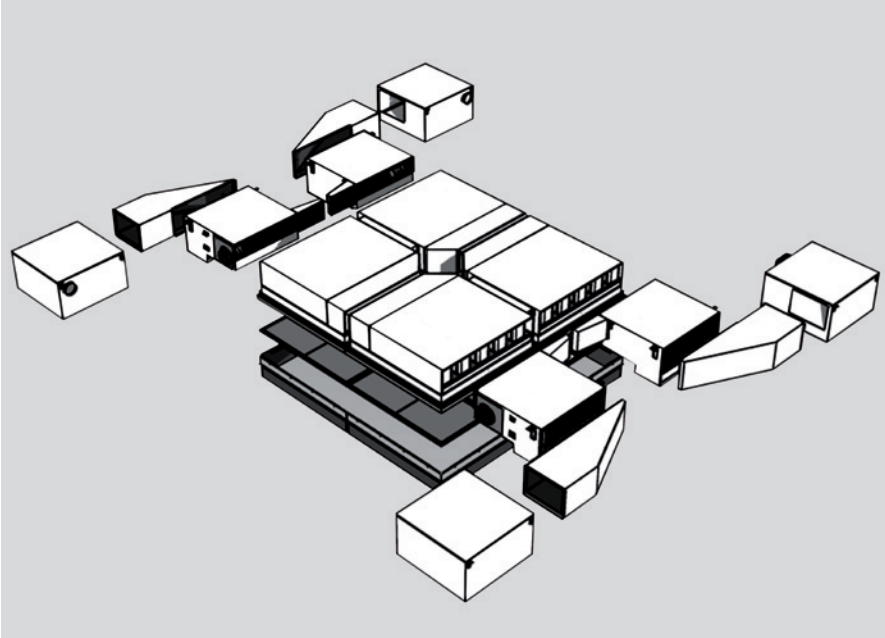
$\vartheta_{outdoor\ air} = 14\,°C$

$\vartheta_{room\ air} = 24\,°C$

$\Delta\vartheta = 10\ K$

$\dot{V}_{AL} = 333\ l/s$ [1 200 m^3/h]

$\dot{Q} = 4\ kW$



Modular design of a Krantz recirculated air ceiling for operating rooms

Characteristics

Modular design

The systematic modular design of the OR ceilings made by Krantz, in which no element is larger than 1 600 x 1 600 mm leads to technical and economic advantages in the value chain: engineering, manufacture, storage, transport, handling on site, assembly, commissioning, inspection, operation, maintenance, stock of spare parts.

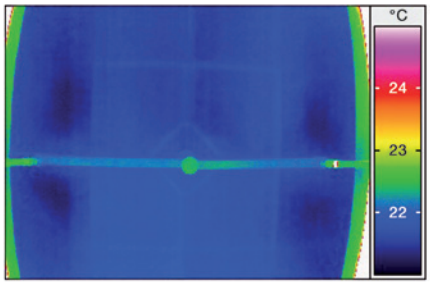
High-performance mixing chamber

Recirculated air is mixed homogenously with outdoor air in a patent pending high-performance mixing chamber. Consequently it is possible to do completely without decentral coolers in the ceiling of the OR, on condition that there is a sufficient temperature difference between recirculated air and conditioned outdoor air. Thus, the system monitoring and control can be dropped which would otherwise be necessary in order to avoid that the temperature falls below dew point and would be hygienically critical.

At a minimum outdoor air proportion of 333 l/s [1 200 m^3/h], fed in with 14 °C, a cooling capacity of 4 kW will be achieved. If the outdoor air proportion is increased to 667 l/s [2 400 m^3/h] for example, having the same temperature, cooling capacities of up to 8 kW are possible (see arithmetic example).

The outdoor air that has been cooled for drying and not warmed up again can directly be used for humidity control. This contributes to the energy efficiency of the entire system.

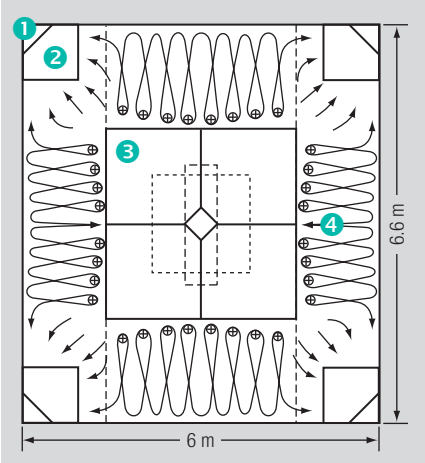
The second decisive advantage is the highly intensive mixing of the volume flow rates different in amount. This enables to achieve a temperature homogeneity of ±0.3 K over the complete discharge surface of the OR ceiling (10 m^2) at a temperature difference of up to −12 K. Consequently an uneven flow and a resulting entry of particles are avoided. This means a higher safety for both the statutory inspection and the operation of the OR ceiling.



Homogenous temperature distribution over the complete discharge surface of the OR ceiling (10 m^2)

Double differential flow

With a double differential flow a particularly effective displacement flow is created above the operating table, which guarantees a well-directed displacement of the loads produced by the operating staff. The velocities of the air flows discharging from the outer, central and inner ceiling segments can be staggered and optimized correspondingly so that a particular steady low-turbulence displacement flow can be maintained which is directed vertically downwards. Interruptions of the flow by lighting are easily reduced. Here, the active light lead-through is very important.



Positioning of the recirculated air suction in the corners

Key

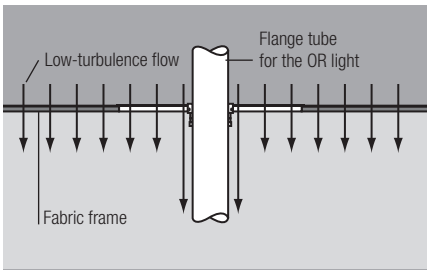
1. Exhaust air
2. 25% recirculated air (at the top)
3. OR ceiling 3.2 x 3.2 m
4. Tangential air patterns

Active light lead-through

Characteristics

Active light lead-through

Supply air flows through a purpose-made fabric frame in the critical area surrounding the central flange tube for OR lights. This is a decisive advantage for the low-turbulence displacement flow: at this point there is less disruption of the LTF and below the flange tube this disruption is reversed by a special effect. The low-turbulence displacement flow is available over the complete area above the OR table.



Active light lead-through – construction and flow

Functional principle of a low-turbulence displacement flow

Recirculated air suction in the corners

Because of the high 77-fold indoor air change (resulting from 2 556 l/s [9 200 m^3/h] supply air and the usual room volume of an operating room of 120 m^3) and as a result of corresponding detailed tests, Krantz Components recommends the recirculated air suction in the corners of the false ceiling. This produces both an indoor air flow that is compatible with the low-turbulence displacement flow and the possibility to use the whole space deep into the room. Lees and areas of uncontrolled air distribution, as they often appear at a two-sided recirculated air suction, are totally avoided. The exhaust air proportion can be sucked off individually in the floor area. With the proposed recirculated air distribution it has no or only little influence on the LTF.

Based on intensive measurements and years of project experience Krantz Components has developed special recirculated air modules. A uniform air distribution is achieved in the whole operating room because of their special design and the placement of the recirculated air suction in the ceiling area of the four room corners.

Recirculated air ceiling for operating rooms, Fraunhofer inHaus-Centre, Duisburg

Radial outlet as return air inlet, hospital 'Dreifaltigkeits-Krankenhaus, Wesseling'

Application

Finally one can say that demanding requirements have to be complied with when designing and building a complete 'operating room' system. An essential criterion is that the air flow in the operating field must guarantee a very high protective effect against infiltration of particles and germs.

The recirculated air ceilings of Krantz Components reliably fulfil the required standards and guidelines for operating rooms, without neglecting thermal comfort and energy efficiency.

For further information about the recirculated air ceiling OP-U-32/32 click here!

For further information about the radial outlet RA-N3 click here!

R. Busse, 27.01.14

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