Air Handling Systems for Medical Applications

robatherm
the air handling company
Hygiene and Comfort for Efficient Healing.

A hygienically perfect and comfortable room climate supports and accelerates the healing process. Treatment times are reduced and costs saved.

The health care sector is marked by an increasing cost pressure on medical facilities. Hospitals, in particular, must reconcile the task of cutting costs with the need for improving the quality of their services in the face of increasing competition.

Hygiene in a hospital is a self-evident prerequisite to the quality of services. Avoiding hospital-acquired, or so-called nosocomial infections, is top priority.

During surgical interventions, wound contamination is caused by the patient’s own flora (endogenous infection) or by pathogens from external sources (exogenous infection), such as the surgical staff.

Air handling systems are, therefore, indispensable for reducing or avoiding the introduction of airborne pathogens into the wound. They are designed to keep pathogens away from wounds, or at least dilute the pathogen concentration at the wound site to an unobjectionable level, by means of a flow of ultra-purified air.

Especially in aseptic interventions posing a very high risk of infection, as is the case in joint implants and in trauma surgery, air handling systems have to meet the highest demands. A hygienically impeccable and comfortable room climate creates a medically safe and undisturbed treatment environment. Additionally, patients’ treatment times are reduced to the minimum medically required, avoiding unnecessary long hospital stays. At the same time, the hospital’s operation costs can be reduced, and the staff’s work performance is maintained at a constant high level.

With regard to quicker recovery, enhanced comfort and a safe work environment, air handling systems for medical applications should be given particular attention.
The main tasks of air handling systems include supplying a sufficient amount of oxygen, removing carbon dioxide and maintaining a comfortable room climate that is unquestionable from the viewpoint of climate-physiology. In rooms having to meet special requirements, such as operating theatres, the supply air has further functions. The air handling system must also act as a barrier screening the specified protected area, reduce the concentration of microorganisms, provide temperature and humidity control and remove odours and contaminants.

Air cleanliness
Air cleanliness is of particular importance in hygiene applications. Air filters here fulfil a combination of several tasks: They protect patients and staff from infections, and air handling units (AHUs) and the ductwork from contamination.

Strupulous checking of filters for clogging prevents the ingress of dust and cuts the operating cost of the system as the pressure drop across filters is reduced.

Operation times
Depending on the medical facility, the operating hours of air handling systems may vary considerably. In hospitals, for instance, they range between 5,000 h/a and 8,760 h/a (non-stop operation). From the viewpoint of hygiene and energy consumption, but also for reasons of operational reliability, plug fans combined with frequency converters and energy-efficient motors are particularly convenient here. This combination offers highest efficiencies along with low operating costs.

Integrated chillers
Air conditioning by means of air handling units (AHUs) is required to create a comfortable room climate and a safe work environment. Ideally, the necessary refrigeration equipment is integrated directly into the AHU, which helps to save space in the engineering room. No further external devices are required, and considerably less sound is emitted to adjacent buildings. Also, the coefficient of performance (COP) of the refrigeration system is more favourable as the condensation temperature of exhaust-air-cooled condensers is lower than that of axial condensers installed outdoors. Moreover, the entire equipment is accessible for maintenance in one place, and its operation is more reliable compared to central external chilling.

New concepts
Innovative heat recovery systems significantly reduce the primary-energy demand of an air handling system. A reversible heat pump, for instance, allows cooling the air in summer and heating the air in winter. Additionally, electrical energy for driving the fans is saved, because only one heat exchanger is required in the air supply. The supply- and extract-air flows remain separated, without any risk of contamination of the supply air.

Ensure comfort for patients and staff.
Clean air thanks to professional design and maintenance.
Operating times between 5,000 h and 8,760 h per year.
Integration of compressors in AHUs saves space, increases the COP and facilitates maintenance.
Primary-energy demand reduced, e. g. by using reversible heat pumps for heat recovery.
Hygiene Thanks to Well-directed Airflow Routing.

The selection of the system for supplying air into the operating field is determined by the room class and the subsequent hygiene requirements.

**Scientific findings** revealed, that pathogens transmitted through the air, so-called airborne microorganisms, pose but a minor risk of infection. The classification of rooms has, therefore, been revised. The required protected area is maintained only where absolutely imperative.

**Room class Ia**
Aseptic interventions subject to particularly strict requirements in terms of hygiene, as is the case e.g., in trauma surgery or orthopaedics.

**Room class Ib**
Medical interventions subject to high requirements in terms of hygiene, such as encountered in minimally invasive surgery or, in parts, in intensive-care wards.

**Room class II**
Other rooms and areas not allocated to room classes Ia or Ib, such as rooms ancillary to operating theatres, or anaesthetic recovery rooms, observation rooms and pre-operative rooms.

**Special areas**
Rooms where additional precautions are taken, such as isolation rooms (negative pressurisation with room-side H13 particulate extract-air filters), sterile-care rooms (positive pressurisation with room-side H13 particulate supply-air filters) or central sterilization units (packaging zone under positive pressure with respect to the cleaning zone).

**Air flow rates**
Given a passage velocity of 0.25 m/s, a unilateral-flow supply-air diffuser measuring 3.2 m x 3.2 m will yield a volume flow rate of approx. 9,200 m³/h per operating theatre. Thus, at a minimum outdoor-air flow rate of 1,200 m³/h, an additional supply of approx. 8,000 m³/h will be required. For this reason, systems relying exclusively on outdoor air are no longer state-of-the-art equipment.

**Supply-air temperature**
A low-turbulence air curtain will only form if the temperature of the supply air is constantly below that of the indoor air. The greater the temperature difference, the more stable the protected area will be. An excessive temperature difference, however, will have an utterly adverse effect on the energy demand and on the surgical staff’s comfort and well-being. Static panel heaters must be provided. In room class Ia, however, underfloor heating is inappropriate as it counteracts the unilateral airflow.

**Dynamic screening of the protected area**
Ensuring the protected area around the operating table, surgical staff and medical instruments by means of a stable top-to-bottom unilateral airflow.
- Positive air balance.
- Higher velocities in unilateral air flow centre improve protective effect.
- Supply-air temperature below indoor-air temperature.
- 3-stage filtration (at least F5/F9/H13).

**Static pressurisation**
Constant pressurisation with respect to ancillary rooms. Air intake by non-unilateral or unilateral air flow. Directed overflow of at least the volume of the minimum outdoor-air fraction. Inhalation of particles by humans or through open doors cannot be prevented.
- Positive air balance.
- No separate protected area
- 3-stage filtration (at least F5/F9/H13).

**Overflow / air-mixing principle**
Air intake can be based on the overflow principle or on the air-mixing principle with a neutral air balance. For these areas, provide an air flow pattern that ensures high ventilation effectiveness and effective removal of any contaminants from the emission source.
- For hygienically relevant areas, the requirements of VDI 6022 |1 apply.
- 3-stage filtration (at least F5/F9).

**Room classes and air routing systems**

<table>
<thead>
<tr>
<th>Room class Ia</th>
<th>Room class Ib</th>
<th>Room class II</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rooms subject to very strict hygiene requirements</td>
<td>Rooms subject to increased hygiene requirements</td>
<td>Rooms subject to general hygiene requirements</td>
</tr>
</tbody>
</table>

**Design**
Modern air-conditioning layouts for operating theatres are based on central conditioning of outdoor air plus a central or local treatment of recirculated air. In case of indoor-air recirculation, central systems are beneficial because outdoor air and recirculation air will be completely homogeneously mixed. No cooling below dew point can occur inside the unilateral air flow diffuser. In addition, the permissible sound pressure levels are easier to observe. Furthermore, all components provide greater ease of access for maintenance.

**Control**
The nominal temperature must be selectable by a control element in the operating theatre. This nominal value is compared to the extract-air temperature. The temperature rise due to internal room loads is compensated by means of the supply air. The supply-air temperature is thus sure to be below indoor-air temperature.

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1. Valid in Germany; deviating or additional national rules and regulation to be observed as well!
Design.
Cornerstone of Success.
Solution-oriented job implementation.

Boundary conditions to be defined at an early stage of design.

A specification sheet forms the basis of a contract.

Experience joins rules of technology to facilitate design.

### Design parameters | 1, 2

<table>
<thead>
<tr>
<th>Temperature</th>
<th>Outdoor</th>
<th>Indoor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Winter:</td>
<td>16 °C to 12 °C</td>
<td>19 °C to 26 °C</td>
</tr>
<tr>
<td>Summer:</td>
<td>28 °C to 35 °C</td>
<td>22 °C to 26 °C</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Humidity</th>
<th>Indoor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Summer:</td>
<td>37 % r. h. to 64 % r. h.</td>
</tr>
<tr>
<td>(temperature and humidity depending on climatic conditions)</td>
<td></td>
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<tr>
<td>(VDI 6022, Category A).</td>
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</table>

<table>
<thead>
<tr>
<th>Sound pressure level (TA-Lärm)</th>
<th>1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Daytime (6h-22h):</td>
<td></td>
</tr>
<tr>
<td>Residential areas:</td>
<td>55 dB (A)</td>
</tr>
<tr>
<td>Mixed-use areas:</td>
<td>60 dB (A)</td>
</tr>
<tr>
<td>Commercial areas:</td>
<td>65 dB (A)</td>
</tr>
<tr>
<td>Industrial areas:</td>
<td>70 dB (A)</td>
</tr>
</tbody>
</table>

| Night-time (22h-6h): | |
| Residential areas: | 40 dB (A) |
| Mixed-use areas: | 45 dB (A) |
| Commercial areas: | 50 dB (A) |
| Industrial areas: | 70 dB (A) |

<table>
<thead>
<tr>
<th>Minimum outdoor-air rate</th>
<th>Indoor-air temperature</th>
<th>Indoor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operating theatres: 1,250 m³/h</td>
<td>OP theatres (Classes Ia, Ib):</td>
<td>19 °C to 26 °C (selectable from inside the operating theatre)</td>
</tr>
<tr>
<td>Intervention rooms: 150 m³/ (h·patient)</td>
<td>Intensive-care areas:</td>
<td>22 °C to 26 °C</td>
</tr>
<tr>
<td>Sterilization: 120 m³/ (h·patient)</td>
<td>Standard-care rooms:</td>
<td>22 °C</td>
</tr>
<tr>
<td>Kitchenettes, corridors:</td>
<td>Baby-care rooms:</td>
<td>24 °C</td>
</tr>
<tr>
<td>Sterilization:</td>
<td>Examination rooms:</td>
<td>26 °C</td>
</tr>
<tr>
<td>Stores:</td>
<td>Kitchenettes, corridors:</td>
<td>28 °C</td>
</tr>
<tr>
<td>Medical gas equipment rooms:</td>
<td>Sterilization:</td>
<td>28 °C</td>
</tr>
<tr>
<td>Intensive-care area:</td>
<td>Stores:</td>
<td>depending on goods stored</td>
</tr>
<tr>
<td>Intensive-care rooms:</td>
<td>Indoor humidity:</td>
<td>30 % r. h. to 60 % r. h. (mandatory year-round)</td>
</tr>
<tr>
<td>Other rooms:</td>
<td>Other rooms:</td>
<td>≥ 25 % r. h.</td>
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<tr>
<td></td>
<td></td>
<td>≤ 60 % r. h. or max. 12 g/kg</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Sound pressure level</th>
<th>14</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operating theatres: 48 dB(A)</td>
<td></td>
</tr>
<tr>
<td>Wards: 25 dB(A) to 35 dB(A)</td>
<td></td>
</tr>
<tr>
<td>Bedrooms: 25 dB(A) to 35 dB(A)</td>
<td></td>
</tr>
<tr>
<td>Corridors: 35 dB(A) to 45 dB(A)</td>
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</tbody>
</table>

#### Design guidance | 1, 2

<table>
<thead>
<tr>
<th>Analysis stage</th>
<th>In general</th>
<th>Air handling systems</th>
</tr>
</thead>
<tbody>
<tr>
<td>Actual-state inventory and assessment of building project.</td>
<td>• Outdoor-air intakes at least 3 m above ground level.</td>
<td></td>
</tr>
<tr>
<td>Basic evaluation including process description. Planning of available resources. Identification of infrastructure and drafting of job description.</td>
<td>• Outdoor air taken in without interference from emission sources. Provide openings for drainage and cleaning.</td>
<td></td>
</tr>
<tr>
<td>Compilation of current standards.</td>
<td>• No outdoor-air intakes along the main wind direction; for roof intakes, observe a minimum distance to the surface of 1.5 x snow height.</td>
<td></td>
</tr>
<tr>
<td>Analysis stage finalized upon signature of the declaration of intent for drafting a requirements specification.</td>
<td>• Exhaust-air discharge via the roof.</td>
<td></td>
</tr>
<tr>
<td>Goal-definition stage</td>
<td>Install silencers, heat exchangers and dampers in the AHU (for ease of maintenance).</td>
<td></td>
</tr>
<tr>
<td>Analysis of utilization requirements (utilization concept, intended range of surgical services, comfort conditions, deadlines, design data, occupancy, additional internal loads, periods of use, etc.).</td>
<td>Volume flow controllers and shutoff dampers to be installed in the mechanical equipment rooms, where possible.</td>
<td></td>
</tr>
<tr>
<td>Drafting of a requirements specification on the basis of current standardization (hygienic acceptance test of unilateral air flow system, specification of cleaning procedure, etc.).</td>
<td>Position and size of inspection openings must be indicated in the ground plan.</td>
<td></td>
</tr>
<tr>
<td>Approval of project requirements specification at the beginning of the design stage.</td>
<td>Inspection openings in air ducts.</td>
<td></td>
</tr>
<tr>
<td>Design stage</td>
<td>• Both sides: heat exchangers, silencers, heat recovery.</td>
<td></td>
</tr>
<tr>
<td>Implementation of design in accordance with the specification sheet. Implementation of design in terms of hygiene (cleaning), maintenance (accessibilities), safety concepts (redundancy, self-closing dampers, etc.) and any specific requirements.</td>
<td>One side: dampers, fire dampers, volume flow controllers.</td>
<td></td>
</tr>
<tr>
<td>Coordination of the initial, and all further, hygiene inspections by qualified specialists (VDI 6022, Category A).</td>
<td>Flexible air ducts only permissible for connections to air terminal units (L°m = 1.0 m).</td>
<td></td>
</tr>
<tr>
<td>Updating of the standards list upon finalization of the design stage.</td>
<td>Max. permissible specific leakage of air ducts must correspond to Class C as defined in DIN EN 13779.</td>
<td></td>
</tr>
</tbody>
</table>

Example: single room at recirculation air operation
Excellent hygiene characteristics of the robatherm AHUs were tested and certified by the TÜV Nord. Proper operation and maintenance provided, our hygiene AHUs will ensure hygienically impeccable air quality. Moreover, the operating costs of the optimally configured AHUs have been reduced to a minimum.

High variability With its outstanding versatility and the broad throughput range from 1,000 m³/h to 320,000 m³/h, the robatherm product line meets a wide variety of customer requirements. Restrictions in available space or particular installation conditions are taken into account at the project design stage.

Excellent hygiene Periodic maintenance ensures hygienic conditions throughout the life time. The maintenance-friendly robatherm AHUs ensure impeccable cleaning as all components are arranged in the unit to be easily accessible.

Low heat losses A panel construction with thermal break guarantees very high thermal insulation and high air tightness. The energy demand is minimized, as is the tendency of condensation inside the casing.

Antimicrobial The antimicrobial powder coating of air handling units inhibits the growth even of multiresistant germs. Its high and sustained effectiveness has been tested and confirmed in a long-term study.

Certified energy efficiency in accordance with EUROVENT and German AHU manufacturers’ association.

Integrated control- and refrigeration technology.

Safety and Hygiene. Solutions Made by robatherm.

AHU concepts specifically optimized to suit your application.

The physical characteristics of the AHU casing as specified in DIN EN 1886:

- Thermal transmittance: Class T2
- Thermal bridges: Class TB1
- Casing leakage: Class L1 (M), L2 (R)
- Filter bypass leakage: Class F9
- Casing deflection: Class D1/D2

The antimicrobial powder coating of air handling units inhibits the growth even of multiresistant germs. Its high and sustained effectiveness has been tested and confirmed in a long-term study.

Low energy demand The top efficiency classes are reached as a result of smart dimensioning and the use of optimized built-in components. Our AHUs are certified in accordance with the energy-efficiency classes of the Herstellerverband Raumluft-technische Geräte e.V. and the guideline of the European certification body EUROVENT.
Detailed Optimization.
Controls and Cooling
Combined Logically.

Customized, factory-integrated control systems and chilling equipment allow you to make the most of potential savings.

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**The control system** is optimally adjusted at the factory. The various thermodynamical requirements to be met by a central AHU can thus be fulfilled along with optimizing the operating cost. For this reason, robatherm has developed the DDC software “Smart Control”.

**Control technology**
Instrumentation and control are integrated into the AHUs at the robatherm factory. All that remains to be done is parameterizing the function blocks of the control system. The commissioning cost is, therefore, minimal.

**Integrated maintenance management**
The maintenance management included in Smart Control records immobilization and operating times of the components and automatically generates inspection reports which are displayed in plain text. Appropriate descriptions of the components are also given.

Particularly in AHUs for hygiene applications, the maintenance management ensures increased operational reliability and hygienically impeccable conditions.

**Communicative and open**
Various communication options are at your disposal, such as:
- Cost-effective “Remote Terminal”:
  Operating, monitoring and parameterizing of up to 15 AHUs via a dedicated local network.
- Open communication:
  Communication with higher-level building automation systems via Modbus, BACnet or LON.

**Refrigeration** equipment can be integrated at the robatherm factory. The AHU, the control and cooling equipment will then form an optimal unit. Central AHUs with integrated compressors and exhaust-air condenser have proven the ideal all-in-one solution for architectural reasons as well as in terms of operating cost and operational reliability.

**Advantages**
Easy installation and fast commissioning are vital in the health care sector, particularly where existing buildings are concerned. Medical facilities being subject to continual extension, conversion or renovation, intelligent all-in-one solutions clearly have an edge here. In the case of all-in-one solutions, commissioning is performed by robatherm. A connection to a higher-level building automation can be established at the same time.

robatherm supplies everything from a single source: central multifunctional AHUs, weatherproof or for indoor installation, completely assembled and parameterized in short: ready for hook-up.

Benefit from our know-how, also in the medical sector.

We offer AHU concepts specifically optimized for medical applications. The AHU concepts provide you with quick, specific and competent information concerning the design of a unit and its performance data – optimized in terms of performance, function and price. And all this tailored to your individual requirements. You require further details or the documented “TrueBlue” evidence of efficiency? We will be glad to give you competent advice!

AHU concepts specially for medical applications.

TrueBlue evidence of efficiency.

Equipment features

- AHU designed for outdoor installation (weatherproof)
- Rotor heat recovery
- Cross-flow plate heat exchanger
- Heat recovery loop
- Free-wheeling fan
- High-efficiency electric motor
- Controls integrated into AHU
- Direct refrigeration integrated into AHU
- Reversible heat pump integrated into AHU
- Hydraulic set integrated into AHU
- Steam humidifier integrated into AHU
- Silencer integrated into AHU

Optimization features

- Low investment cost
- Reduced operating cost
- High energy efficiency
- Compact design
- Easy-to-install
- Easy-to-maintain

Abbreviations for types of air (as specified in DIN EN 13779): ODA=outdoor air, SUP=supply air, ETA=extract air, EHA=exhaust air, RCA=recirculation air
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AHU description

Favourable investment cost, easy to maintain. Compact dimensions thanks to modular and stacked design. Only suitable where recirculation between rooms is permissible, or where recirculated air is returned to the same room with functionally related ancillary rooms (same room class).

AHU equipment

Design: indoor installation
AHU inside: wall powder-coated / floor 1.4301
Filters:
Supply-air pre-filter: G4 (flat type)
Supply-air main filter: F7-F9 (pleated type)
Heat recovery: Constant-volume heat recovery unit with built-in hydraulic set
Heater: $t_E = 0^\circ C$, $t_A = 26^\circ C$
Cooler: $t_E = 32^\circ C$, $\phi = 40\%$ r.h., $h_E = 62.8\ kJ/kg$

Accessories:
Filter differential pressure indicator (for main filters without sealing liquid)
Frequency converter with service switch
Lights in all relevant areas

AHU schematic

AHU equipment

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Accessories:
Filter differential pressure indicator (for main filters without sealing liquid)
Frequency converter with service switch
Lights in all relevant areas

AHU description

Favourable investment cost, easy to maintain. Easy to assemble thanks to only 6 sections plus hydraulic set. Only suitable where recirculation between rooms is permissible, or where recirculated air is returned to the same room with functionally related ancillary rooms (same room class). Supply- and extract-air totally separated Pleated filters (classes F7 + F9) ensure long-term compliance with the required supply-air quality. Direct-drive fans allow trouble-free operation. Frequency converters are factory-installed, wired and parameterized.
Best choice.  
Best references.

Trust and confidence emerge from quality.

That is why many well-known companies favor robatherm’s solutions.