Guidelines (draft): Designing and Operating Heating, Ventilation and Air-Conditioning (HVAC) in Hospitals

DGKH, German Society for Hospital Hygiene .
SGSH, Swiss Society for Hospital Hygiene
ÖGHMP, Austrian Society for Hygiene, Microbiology and Preventive Medicine
Heating, Ventilation and Air-Conditioning Task Group

Preamble by the Board of Directors of the DGKH

The third draft guideline is given below. This draft guideline is being published as a "yellowprint", indicating that it is now open for discussion.

This hygiene guideline is not intended as a substitute for the national technical guidelines and standards regulating heating, ventilation and air-conditioning systems in hospitals. But it is intended as a basis for drafting corresponding guidelines and standards and can be invoked in practice by competent specialists to justify meaningful deviations from existing guidelines and standards.

Now everyone is called upon to submit comments and make proposals for any changes, which should then serve as the basis for revising the draft guideline.

Please send your comments and proposed changes for this draft guideline to the Guidelines Coordinator of the DGKH

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Preface

Under the aegis of the three specialist societies DGKH, SGSH and ÖGHMP, an interdisciplinary "Heating, Ventilation and Air-Conditioning Task Group" representing the specialities hygiene, microbiology and engineering joined forces with the aim of defining uniform recommendations for drafting technical guidelines and for direct planning, construction and operation of heating, ventilation and air-conditioning installations in hospitals and outpatient surgical units.

To evaluate the role of room air as a source of infection, the current stock of knowledge was assembled in a review article based on the literature of the past four decades (1). This review shows that there is a paucity of reliable data on the role of ventilation and air-conditioning installations in the prevention of postoperative infections in the surgical domain. Apart from references to strict aseptic procedures involving implantation of large foreign bodies, the literature provides no definite proof that the air is implicated as a contamination pathway in endemic postoperative infections (POIs) in surgery (unlike epidemic).

The prime source of infections for the patient is his/her own endogenous flora (endogenous infection), followed by exogenous pathogenic sources such as irrigation solutions or the endogenous flora of personal (exogenous infection).

The prime aim of the recommendations enshrined in this guideline is to ensure that they are tailored to the actual needs of hospital hygiene. Furthermore, these recommendations should be easy to implement and serve as a basis for economical design and safe operation of heating, ventilation and air-conditioning (HVAC). Finally, an overview of the outline conditions for monitoring hygiene is given.

The recommendations outlined below are divided into five main categories:

- Aspects of air purity
- Aspects of comfort and occupational safety
- Aspects of operation and costs
- Aspects of training
- Qualification and requalification

1 Introduction

Ensuring asepsis to prevent postoperative infections in surgery has been an established practice since the end of the 19th century. When HVACs were first installed, about 1960, it was endeavoured to also incorporate the air into the concept of surgical asepsis. At that time air-conditioning systems were still uncommon and, indeed if at all present, they were even sometimes the cause of aerogenic infections. Instead of keeping to a minimum the number of microorganisms originating from the OR personnel by diluting them with pure primary air, in many cases the HVACs proved to be a source of contamination of the supply air. This was due to intake of outdoor air via areas rich in bioaerosols (plant growth), too few, humid and contaminated preliminary filters, conditions conducive to microbial growth in the cooling and air-humidifying components, ductwork with unhygienic internal insulation and too few terminal filters. Later on, hospital epidemiologists and HVAC engineers identified these weak points in the hospital HVACs and took remedial action by making selective improvements.

Only some 10 years ago these defects were also recognised as risk factors even for

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healthy persons in air-conditioned rooms. Malaise due to allergies, draughts and more or less perceptible noise nuisance, together with a number of other building defects, were recognised as "Sick Building Syndrome". Since then, not only have efforts been continued to eliminate the HVAC defects but also the outline structural conditions have been greatly improved. These improvements include above all energy-based measures such as better heat insulation of the entire core of the building, a more flexible protection against the sun for transparent components and the establishment of a link between the building's thermal storage masses and the occupied rooms. The outcome of these combined measures was that the heating, ventilation and air-conditioning (HVAC) systems no longer had to compensate for architectural shortcomings and hence could be planned and built on a smaller scale, while taking more precautions and ensuring impeccable hygiene.

In this context, the term "gentle air conditioning" was coined. This type of air conditioning can also be used in a hospital building and is urgently needed for several reasons. Hence the relevant aspects are outlined in this Guideline.

1.1 Air conditioning and infection prophylaxis

The decision whether to fit, and if so which type of, HVACs must be taken jointly by hospital epidemiologists, clinicians and engineers, working in close cooperation and taking account of the state of the art, the current stock of knowledge regarding the role of HVACs in infection prophylaxis (1) and in assuring occupational safety standards in surgical units. The following points must be borne in mind:

- There are no clinical or microbiological studies that show that the air is a relevant microbial reservoir for endemic postoperative infections (POIs) that do not entail implantation of a large foreign body (such as e. g. operations on the joints).
- There are enough data to show that, in operations entailing implantation of large foreign bodies, the air is implicated as a microbial reservoir for endemic POIs. Just how great is the role played by the air in these procedures compared with endogenous microbial reservoirs cannot be inferred from the findings of the studies carried out.
- There are convincing data that contamination of the air in the immediate vicinity of the operating table and instrument table results in direct or indirect contamination of the surgical site.
- There are myriad compelling indications that the air can play an important role in microbial transmission during surgery, thus linking it to POIs; but on the whole such cases are rare.
- Neither clinical nor microbiological studies have provided a single shred of evidence that the air in the rooms adjacent to the operating theatre, or even in more distant rooms within the OR department, influence the risk of postoperative wound infection.

1. 2 Old and new outline conditions

To evaluate ventilation and air-conditioning installations in accordance with the general rules of hygiene (i. e. not specifically related to hospital hygiene), the structural outline conditions must first of all be appraised today. In older buildings that have not been thermally sanitized, traditional air conditioning systems are accorded more importance than they are in buildings with modern thermal facilities, which need only very little artificial air conditioning to ensure comfortable conditions. The improvements made as a result of experience with the "sick building" and because of new energy regulations have in the meantime led to a new hygiene standard for air-conditioning systems in office buildings. This standard has been described since 1998 in VDI Guideline 6022 and is already being accepted on a broad scale in practice. Apart from a few exceptions, this standard also suffices in the hospital. Therefore any additional recommendations for HVACs in the hospital setting should apply only to special rooms. The special requirements should as far as possible be only applied locally and can therefore be adapted more easily to changes in the future. This relates for example to increased air volume flow rates with circulating air components and particulate filters or to locally increased outdoor air rates for elimination of foreign bodies in the air, such as above all anaesthesia gases and possibly disinfectant vapours or extremely unpleasant odours.

The old regulations inevitably continue to be valid for existing, older installations which lack modern local protection concepts. But by resorting to measures on a smaller scale, the latter can also be simplified and the operating costs can be reduced, while at the same time enhancing the quality.

1.3 New concepts

Just as in the case of gentle air conditioning, so hospital air-conditioning concepts too must make provision – at the time of designing a system – for a consistent division of tasks as regards the heating, cooling and ventilation requirements. The heating and cooling performances formerly achieved only with major air-conditioning volume flows can in many cases be superseded by using heated and cooled surfaces, while enhancing comfort. Ceilings, floors and, even in some cases walls, fitted with water-bearing pipe registers can be used to this effect (2).

Air should be used mainly only for oxygen supply, removal of humidity, odours and pollutants as well as in certain areas to protect against infection. By adopting this approach, investment costs and the space requirements for HVACs can be reduced in many cases. In any case, the operating costs will be greatly reduced, because it is the outdoor air rates that in principle determine the investment and operating costs of HVACs (3).

The major investments in HVACs for the rooms adjacent to the OR department attracted criticism already in the 70s. Now that no evidence has been found that these measures have any bearing on the postoperative infection risks, there is no longer any justification for continuing to invest a relatively large sum in HVACs for areas where room-air hygiene is of lesser importance such as in corridors, in the rooms used for induction of anaesthesia and in recovery rooms. Therefore, apart from rooms in which special room-air hygiene requirements apply, the ventilation can in principle be reduced to the amount of outdoor air needed, because it practically no longer has to perform any heating or cooling functions. As in the modern gentle air conditioning, air should now be used only for ventilation; heated and cooled surfaces (floors, ceilings and walls) are used for heating and cooling. For example, a floor that has been cooled to a comfortable temperature of 20 °C can manage a coaling load which, in the case of traditional ventilations systems, would need a fourfold greater air exchange with elaborate air-conditioned air. Because the cooling component needs considerably less space, the remaining ventilation installations can be designed without having to make compromises for space, and thus the quality can be enhanced.

Likewise, rooms with stringent air-hygiene requirements need only be supplied with the

outdoor air volume flow tailored to the number of persons and surface area. Then maximum air purity is to be provided for the relevant zone area of the room, i. e. within the operating theatre around the operating table and instrument table (known as the protected area) by means of dynamic screening with low-turbulence displacement flow and room-wise effective circulating air purification systems. The air flow required here is thus to a large extent composed of filtered, room-wise separated circulating air.

2
Guideline Regulating Aspects of Air Purity

2.1 General requirements

The supply air must be filtered with class F8 or F9 filters (EN779). As preliminary filters, classes F5 to F7 can be recommended[1]. The tight fit of all F filters must, unlike the recommendations of EN779 – meet the requirements for class F9 filters (with provision for changing filter combinations in accordance with experiences based on service life). The amount of dust carried into the supply air processing units, into the ductwork and into rooms with HVACs is reduced by means of effective two-stage filtration of the outdoor air. This is also advantageous as far as maintenance tasks and intervals are concerned (e. g. the service life of terminal particulate filters) and is therefore advisable for business management reasons. One of the tasks covered by economical and ecological business management is to estimate the service life of filters, replacement costs, rising air resistance and correspondingly greater energy consumption[2].

Appropriate measures must be taken to protect the first filter stage against outdoor air humidity above 85 % relative humidity[3]. After the second filter stage, only dry heat exchangers as well as air pipes, control equipment and vents which are easy to clean can be used.

In the case of HVACs with single-stage filtration, it must be ensured that the design of the HVAC components do not permit any particles to be introduced after the filter stage and that a tight ductwork is provided in accordance with Eurovent 2/2 class C between the filter and ventilator suction side[4].

The volume flow rates and vents must be designed and arranged such that a high ventilation efficiency is ensured in the rooms[5]. If the amount of outdoor air needed as fresh air replacement[6] does not suffice for simultaneous removal of the thermal loads, it can be marginally increased or cooling of the respective building component should be considered[7].

2.2 The OR department

2.2.1 Operating theatres

The aim here is to reduce to a minimum the risk of microbial contamination of the surgical site posed by the air. Therefore within the operating theatre the area around the operating table and instruments table (= protected area) should be separated from the surrounding area by a stable flow of air that has been filtered to remove particles. The protected area is thus flooded with air that is practically free of microbes and is dynamically screened off from the surrounding area, i. e. also from the microbially contaminated skin particles shed by those persons present. This principle is designated below as "dynamic protected area maintenance"[8]. Future developments in surgical clothing (including protective clothing) will possibly be able to reduce the amount of ventilation needed .

A vertical, low-turbulence displacement flow with a primary degree of turbulence of < 5 % is deemed to be an appropriate form of flow[9]. Ceilings panels with outlets for low-turbulence displacement flow, also called laminar air flow (LAF), are suitable here, e. g. with an outlet positioned above the protected area. The size of such low-turbulence displacement-flow ceiling panels is based on the size of the protected area needed and on the flow conditions for piston-like air flow of the supply air.

To ensure adequate protection of the operating table and instrument table, a protected area measuring around 2.8 m x 2.8 m should be aimed at. As a rule, this would call for a low-turbulence displacement-flow ceiling panel measuring 3.2 m x 3.2 m. Aprons measuring at least 5 to 50 cm in length are absolutely necessary close to the active exhaust surfaces (4). Particulate class H 14 filters are recommended as a terminal filter stage (EN 1422)[10]. While the retention capacity of intact filters of lower classes (H10 to H13) would suffice for retaining microorganisms they cannot, or only with difficulty, be tested for any leaks that might occur (VDI 2083/3)[11].

Because qualification and requalification of the protective effect and visualisation of the protected area periphery can be easily effected with physical methods (e. g. for per-

[1] European Standard EN 779 regulates the test procedure and classification of coarse and fine dust filters. For practical information on using filters in air-conditioning systems, please consult SWKI Guideline 96-4 "Guideline for using filters in ventilation and air conditioning installations" (www.swki.ch).

[2] If the volume flow is kept to a constant value, the pressure loss and energy consumption increase to meet the increased ventilation demands. By adopting careful business management practices, this increased pressure loss can be monitored and the optimal time point identified for changing the filter (balancing energy consumption against filter replacement costs).

[3] Möritz and Rüden describe in „Verhalten von Mikroorganismen auf Luftfiltern" ("Behaviour of Microorganisms on Air Filters"), a possible contribution to sick building syndrome, which can be halted by keeping the first filter stage dry. Suitable measures here are pre-heaters which are not sensitive to dirt and can be easily cleaned; these should heat the air by about 2–3 °C and thus reduce the relative humidity by around 15 % relative humidity.

[4] Quality Class C stipulates that per m^2 surface of the air conduction system at 400 Pa positive pressure not more than 0.15 l/s/m^2 may be lost.

[5] The term "ventilation efficiency" describes how quickly a contaminant is transported from the source to the exhaust air opening. A high ventilation efficiency is achieved by means of the source air principle.

[6] The technical report of Task Group 7 of Technical Committee 156 of CEN (Centre Européen de Normalisation, Brussels) prEN1752 outlines recommendations for three comfort categories for person-related outdoor air rates. For hospital operation, this present hygiene guideline recommends the following values:

- Therapy and examination rooms 50 m^3/h per person (smoking prohibited)
- General rooms 36 m^3/h per person (smoking prohibited) (Excellent air quality)
- Smokers' rooms 75 m^3/h per person (100 % smokers) (Typical air quality). If only 40 % smokers, "Excellent air quality" is achieved.
- Psychiatry 75 m^3/h per person (100 % smokers) (Typical air quality). If only 40 % smokers, "Excellent air quality" is achieved.

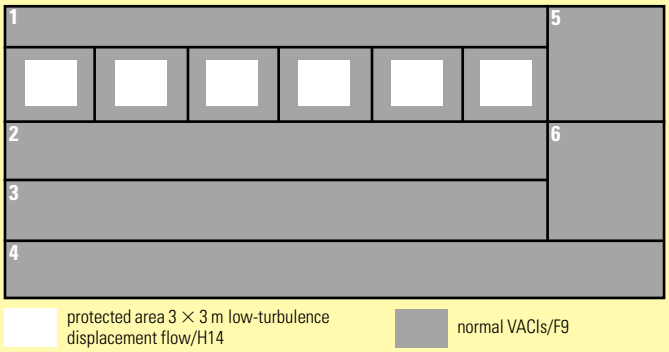
[7] The term "building component temperature control" denotes surfaces into which pipes are fitted, carrying either hot or cold water. The requisite water temperature is based on the desired room temperature.

[8] Rooms with dynamically screened-off, protected areas or with static pressure maintenance are, first of all, characterised by the fact that the incoming supply air volume flow is higher than the outgoing exhaust air flow. The difference between the two is that in the case of dynamic protected area maintenance, the area to be protected is flooded, over a large surface, with low-turbulence and microbe-free supply air. In the case of static pressure maintenance, there are no specifications as regards the type of incoming supply air; for example, the generally more attractively priced – but less favourable in terms of the degree of air purity that can be achieved – incoming air can also be implemented according to the mixed-air principle.

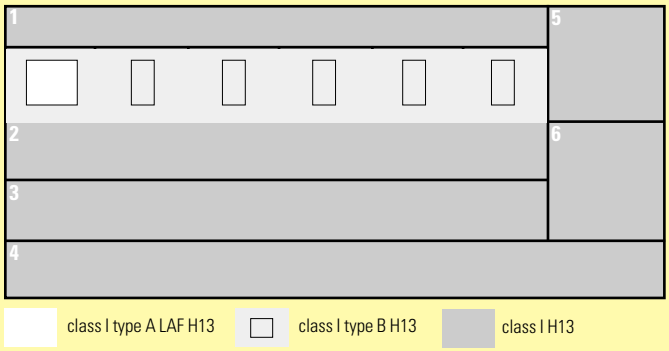
[9] The degree of turbulence describes the standard deviation from the mean flow velocity. For perceptions of warm or cold (perceived by means of heat flow on the skin surface), the degree of turbulence plays an important role because it essentially influences the intensity of heat transfer on the skin surface. See also DIN 1946/2.

[10] European Standard EN 1422 regulates the test procedure and classification of particulate filters. For practical information on using filters in air-conditioning systems please consult SWKI Guideline 96-4 "Guideline for using filters in ventilation and air conditioning installations" (www.swki.ch).

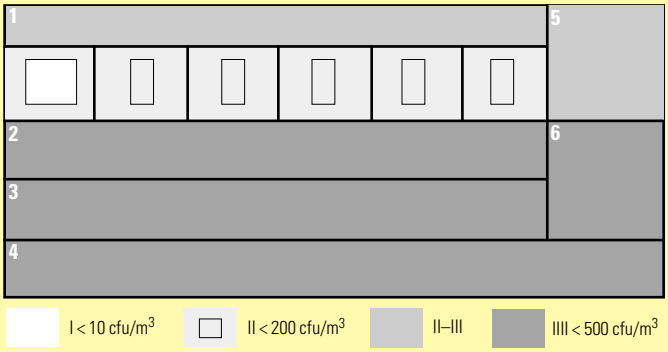
[11] To be able to reliably detect any leak, the entire filter exhaust surface, including the pressure mechanism must be carefully scanned. The forward velocity is based on the magnitude of the raw air concentration, the filter class and the specific class of leak criterion. This is regulated by VDI Guideline 2083/3.



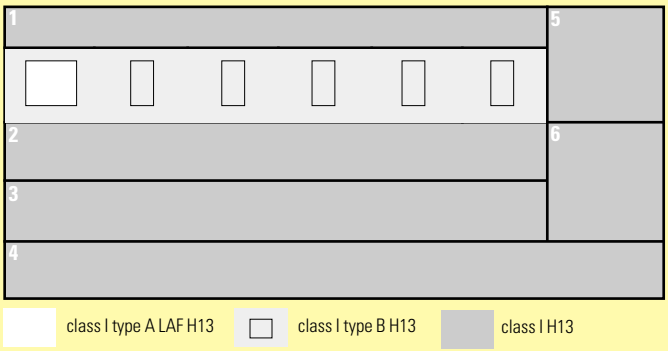
Guideline concept with only two purity levels



Former concept based on DIN 1946/4 (for example with an I A OR)



Concept based on SKI 35/87 (for example with one class I OR)



Concept based on Ö 6020-1 (for example with one class I OR)

Figure 1:
Previous air purity areas (Germany, Switzerland, Austria) compared with the new concept.
1 Sterile supply distribution, 2 Anaesthesia-induction room/recovery room, 3 Corridor, 4 Adjacent rooms/sluices, 5 Clean material, 6 Unclean material

sonnel training), the remaining rooms throughout the entire OR department can be fitted with a traditional comfort air-conditioning system (basic ventilation plus surface temperature control) (2). This form of ventilation is endowed with static protective pressure and, thanks to closed windows and doors with at least a passive sluice function, no major technical investment is required.

To meet the special requirements dictated by hospital hygiene, the possibility outlined in Figure 1 of using a simple and low-cost comfort air conditioning in all other rooms throughout the OR department can be entertained only in conjunction with the dynamic protected area maintenance mentioned above, where ceiling panels are provided for all surgical workplaces.

As a rule sterile instruments and materials for the operation should be prepared in the dynamically screened off protected area (i. e. beneath the low-turbulence displacement-flow ceiling panel). If this cannot be complied with, the respective preparation areas must ensure the same hygienic conditions (e. g. niches equipped with low-turbulence displacement flow for moveable instruments' and materials table).

2.2.2 Corridors for sterile supply

With the doors and windows closed, the corridors used for sterile supply for the operating theatres must be endowed with static positive pressure vis-à-vis their surroundings. In accordance with the type of packaging being used (open storage, i. e. on the shelf, and/or closed storage, i. e. in a cabinet) and the duration of storage for the respective item, the hospital epidemiologist decides whether a class F9 terminal filter stage is generally sufficient or whether particulate filters have to be fitted (e. g. H10 to H14). If class H filters are required, they should not be fitted, as in the case of the F filters, in the central device, but rather as terminal filters in the vents.

The sterile supply corridors can be endowed with positive pressure vis-à-vis the operating theatres, because there the microbial load in the air is essentially higher due to the high density of persons and because the protected area within the operating theatres is protected against penetration of contamination thanks to the dynamic screening provided by the low-turbulence displacement-flow ceiling panels. In summary, the protected area screened off dynamically by means of the low-turbulence displacement-flow ceiling panel in the operating theatre guarantees the highest degree of air purity, while the second highest level of purity is available for sterile supply and all other rooms in the OR department need take no measure for maintaining a protective pressure (see above "Operating theatres").

2.2.3 Anterooms immediately adjacent to the operating theatre

Since the great amount of outdoor air flow for anaesthesia (at least 800 m^3/h[12] to 1200 m^3/h[13]) is needed either in the operating theatre or in the rooms used for induction of anaesthesia and in recovery rooms, supply air can be provided for these anterooms by simply using the overflow from the operating theatres. In the anterooms this overflow is removed to compensate for the incoming outdoor air.

2.2.4 The remaining rooms and areas in the OR department

If HVACs are in operation, an outdoor air volume flow of 50 m^3/h per person tailored to the number of persons and to the respective process with a centrally positioned class F9

[12] Switzerland (12) and Austria (as per ÖN 6020-1)
[13] Germany (formerly as per DIN 1946/4)

terminal filter stage is sufficient for basic comfort ventilation. Windows in the recreation and working rooms which can be opened must be protected with insect grids.

2.3 Therapy and nursing rooms

2.3.1 Normal wards

Mechanical ventilation can be advisable to ensure a physiologically comfortable climate or for energy reasons (e. g. heat recovery). Such a form of ventilation has to meet the general requirements, but generally ventilation provided by an open window is enough.

2.3.2 Intensive care units

If a HVAC is to be fitted in intensive care units (ICUs), in which patients are being cared for after undergoing internist procedures, anaesthesia or surgery, class F9 filters are adequate for terminal stage filtration of the supply air. But since it is also possible that patients with potentially aerogenically transmissible infections (e. g. open tuberculosis of the respiratory tract, varicella pneumonia, viral haemorrhagic fever) are being cared for in the ICUs, the hospital epidemiologist must decide whether a HVAC is needed for dilution of the microbial air count and/or for maintaining a static negative pressure as well as an active sluice[14] (5–10). If a HVAC is fitted to ventilate these rooms, provision must be made for an effective exhaust air filtration facility (H13) so as to ensure the protection of persons in other rooms of the building in the event of malfunctioning of the HVAC.

2.3.3 Special units for haematology and oncology patients with pronounced immunosuppression

If, in the course of treatment, extreme immunosuppression is manifest in haematology and oncology patients, a supply air that is as far as possible free of microbes should be used to prevent aspergillosis during the phase of severe granulocytopenia (< 1000 leucocytes/µl or < 500 granulocytes/µl) (11). Accordingly, mechanical ventilation of patient rooms with particulate-filtered supply air is deemed necessary to provide a supply air that has a low microbial count, and that above all is free of aspergillus spores. In addition, static pressure vis-à-vis the surrounding area must be maintained, so that air with a normal microbial count does not enter from the environment when the doors are opened; the use of an overflow sluice as a passive sluice[14] helps to underpin this.

2.3.4 Nursing patients with infections

There are no special requirements for the air-conditioning system when nursing and caring for patients with certain transmissible diseases (e. g. patients with salmonellosis or hepatitis). But in the case of potentially transmissible aerogenic diseases (open tuberculosis of the airways, varicella pneumonia, viral haemorrhagic fever), measures should be taken to dilute the microbial air count and/or for maintaining static negative pressure, and provision should be made for an active sluice (5–10). The hospital epidemiologist must be consulted to find a suitable solution if enough space is not available when carrying out reconversion works (see above "Intensive Care Units").

2.4 Endoscopic diagnosis and imaging procedures

From the point of view of infection prevention, the use of a HVAC is not mandatory in rooms in which endoscopic diagnosis and imaging procedures such as CT, MRI and angiography are being performed. But during imaging procedures increasingly more invasive interventions are being carried out, e. g. with implantation of foreign material. Depending on the type of interventional procedure, the respective risk of infection must be considered; the HVAC concepts must be adapted accordingly.

If for reasons relating to a physiologically comfortable climate or for olfactory reasons, (e. g. thermal loads, pollutant removal due to anaesthesia procedures or extremely unpleasant odours), it is necessary to install a HVAC, central filtration of the supply air is sufficient with an F9 terminal stage. It may be necessary to fit bronchoscopy rooms with HVACs to protect against infection. Such a decision must be taken in cooperation with the responsible hospital epidemiologist.

2.5 Sterile supply processing

From the infection prevention point of view there is no need to install a HVAC in the sterile supply department. But if HVACs are fitted to ensure a physiologically comfortable climate, central filtration of the supply air with an F9 terminal stage is adequate. In line with the conditions prevailing within the room, the air flow is adapted to the comfort and process requirements. The air rate can be kept low by ensuring good management of the room air while identifying the sources of heating and humidity loads.

2.6 Laboratories

From the infection prevention point of view, there is no need to fit a HVAC for ventilating laboratory rooms. But it must be borne in mind that laboratories in large hospitals are also in operation during the night and that opening windows to provide ventilation of brightly lit rooms would lead to problems with insects. For information on compliance with occupational safety regulations, please consult the regulations of the respective countries.

3
Guideline Regulating Comfort Aspects

3.1 Thermal comfort and room air humidity

It is assumed that in hospitals personnel and patients wear light clothing of 0.5 clo. Surgical clothing where wrap gowns of approx. 1.2 clo are worn are an exception to this rule is (clo is the unit for measuring the heat insulation value of clothing, prEN 1752).

The degrees of activity that determine temperature perception are between 0.8 met for patients who are lying down, 1.2 met for anyone working while sitting, 1.6 met for anyone performing light work while standing and 2.4 met for a surgeon performing a major orthopaedic operation (met is the unit for measuring metabolically mediated heat emission from persons, prEN 1752).

In winter these conditions call for an operative (= perceived, in accordance with DIN 1946/2) room temperature (as mean value of the radiation temperature of the surrounding surfaces and of the room air temperature) of at least 22 °C, while in nursing areas 1–2 °C higher temperatures are by all means reasonable[15]. In the surgical workplace, it must be possible at all times to select temperatures between 18 °C and 24 °C (if necessary as high as 27 °C in paediatric surgery). In summer with the exception of the surgical workplace, operative room temperatures up to 25 °C are by all means possible. If provision is made for surface cooling, the room air temperature can even increase to 26 °C, without exceeding the

[14] In general, air sluices are composed of a small corridor with two doors, which cannot be opened simultaneously. Hence when someone walks through the sluice, an uncontrolled overflow of air is prevented between the two room zones adjacent to this sluice. The active sluice, unlike the passive sluice, is equipped with its own exhaust air suction mechanism to prevent contaminated air from one zone being able to enter into the other zone.

[15] Operative temperature (recommended temperature) as arithmetic mean value from room air temperature and the mean temperature of the surrounding surfaces.

comfort range. If the outdoor air volume flow as per DIN 1946/2 does not suffice for simultaneous removal of the room thermal loads, the possibility of cooling the building component should be considered first of all.

Because of the protective clothing worn by OR personnel, which is designed to counteract vapour diffusion, the maximum relative room air humidity should not exceed the value of 50 % relative humidity. No dehumidification measures are needed for other hospital rooms. Humidification is generally not needed in most hospital rooms in winter thanks to the good air filtration and low-dust room air. A target value of 30 % relative humidity should be aimed at in places where humidification is used (13).

3.2 Limiting gas concentrations

In principle the occupational safety aspects that have led to formulation of the ventilation conditions in disinfection and solvent stores apply here. To limit the danger posed by anaesthesia gases in operating theatres the outdoor air flow should be between 800 m^3/h and 1200 m^3/h. The higher value for the outdoor air flow is required or desirable if, because of the room air flow in proximity to the workplace of anaesthesia personnel, poorer air circulation is expected. The lower value suffices in operating theatres with large low-turbulence displacement-flow ceiling panels.

Due to continuous exhalation of anaesthesia gases – 150–200 m^3/h per bed – outdoor air is recommended, which as rule leads to mechanical ventilation (13). If this outdoor air volume flow does not simultaneously suffice for removal of the room thermal loads, the possibility of cooling the building component should be considered first of all.

4
Guideline Regulating Operating Aspects

Structural prerequisites serve as a basis for heating, ventilating and air conditioning (HVAC) systems, which are supposed to provide reasonable comfort while being operated at a reasonable cost. Therefore at the time of planning the building, the necessary prerequisites for the HVAC must be formulated and implemented in the drawing. Assuming that the HVAC is designed in accordance with present-day hygiene dictates, (VDI 6022), no technical or energy requirements apply for hospital systems. With practically continuous operation and high room temperatures, basic mechanical ventilation systems with heat recovery are advisable.

Operation of patient-oriented local facilities (e. g. low-turbulence displacement-flow) can be restricted to the required duration of use. It is suggested that operation be reduced to approx. 30–25 %, so as to still be able to maintain controlled operation. The electricity costs decline almost in line with the third potency of the volume flow and are thus hardly relevant. The energy required for temperature control (heating, cooling) is proportionally reduced and the humidity can be fully switched off. When implementing the stipulations for protecting the building against fire, it should be ensured at the planning stage in the hospital that, by making provision for a distributed flame-retardant ductwork, a minimum number of flame-retardant caps are needed.

For surgical operation the temperature of the supply air flow must always be at least 0.5 less than the ambient temperature. Otherwise, the maintenance of the dynamic protected area will be jeopardised. This means that the vents for low-turbulence displacement flow cannot be used for heating.

5
Guideline Regulating Training Aspects

Personnel training can also be carried out effectively in the local, well-demarcated zones using HVACs specially designed for the hospital setting. In the case of the room flow concept outlined and the overflow structures, appropriate clean-room behaviour can be demonstrated for personnel in the peripheral area bordering the dynamically screened off protected area if smoke pipes are used.

How the static pressure is maintained can also be demonstrated in single rooms with smoke pipes . For functional units where personnel have to comply with clean-room requirements in terms of clean-room clothing and clean-room behaviour, the responsible hospital epidemiologist should define the necessary specifications.

6
Guideline Regulating Functional Testing Aspects

6.1 Fundamental requirements for low-turbulence displacement-flow ceiling panels

In rooms with the most exacting requirements for air purity, uniform and verifiable functional and quality guarantees are needed for outlets in low-turbulence displacement-flow ceiling panels. It should be possible to check these periodically. It is not enough to merely furnish proof of suitability of a low-turbulence displacement-flow ceiling panel on the basis of a type test.

The size of the protected area that can be achieved and the air purity beneath low-turbulence displacement-flow ceiling panels depend to a large extent on where the protected area is located within position the room, on the type and arrangement of the surgical lamps beneath the ceiling panel and to a lesser extent on the OR personnel and other loads in the room. Hence already when awarding the contract a minimum size and a minimum screening efficiency as well as a load arrangement, with which this screening performance should be achieved, must be agreed.

The relevant investigations and recommendations (14) should be consulted to decide how the loads can be arranged. To measure the screening performance, the particulate count technology conventionally employed for clean air technology should be used.

6.2 Technical acceptance at the time of commissioning and periodic monitoring

To qualify for acceptance, the filter tight-fit test and the leakage test pursuant to VDI 2083/3 (measurement technology for clean air systems) must have been passed and proof furnished for the control stability of the installation; this must be performed using a rated load and in backup operation. The filter tight-fit and leakage tests are repeated at least every two years or after interventions in the terminal-filter stage. When measuring noise, the sound volume at full performance with product-specific rated air flow should not exceed the value 48 dB (A) in the centre of the field at a height of 1.75 m above the floor; above the anaesthesia area a value of 45 dB (A) should not be exceeded.

When checking the flow, the protected area achieved in the operating theatre supply-air ceiling panel is determined by measuring particles inside and outside the protected area. The acceptance procedure is described by Külpmann (14). The acceptance is supervised and assessed by the responsible hospital epidemiologist.

6.3 Hygienic acceptance at the time of commissioning and periodic monitoring

To qualify for hygienic acceptance, the technical acceptance test must have been passed and basic cleaning performed. Hygienic acceptance comprises an inspection of the HVACs and of the rooms serviced by the HVACs as well as examination of the HVACs for all aspects of hygiene. The periodic investigation of flow conditions along the periphery by means of a flow test pipe should be repeated at least once every three months during normal routine OR activities (with the natural thermal loads); the responsible hospital epidemiologist should conduct spots checks to supervise and assess this (control effect plus learn effect to ensure that OR personnel comply with clean-room dictates).

The responsible hospital epidemiologist must decide whether microbiological and hygiene checks are required after technical acceptance and during operation (15).

References

1. Kappstein I: Literaturübersicht über die Bedeutung der Luft als Erregerreservoir im OP-Gebiet. Begleitendes Dokument zur vorliegenden Leitlinie, 2001; http://www.dgkh.de
2. Meierhans R: Radical Changes in HVAC-Planning – Also in Hospitals. Hyg Med 1999; 24 (3): 88–97.
3. Külpmann R, Meierhans R: Wirtschaftlichkeitsvergleich von Operationsraum-Klimatisierungskonzepten. KI Luft- und Kältetechnik 2001 (3): 125–129.
4. Seipp H-M et al.: Operative Reinraumtechnik Teil 1: Partikelreduktionsfaktoren zur Bewertung der Schutzfunktion installierter Laminar-Airflow-Zuluftdeckensysteme. Hyg Med 1998; 23 (12): 526–546.
5. Leclair JM, Zaia JA, Levin MJ, Congdon RG, Goldman DA: Airborne transmission of chickenpox in a hospital. New England Journal of Medicine 1980; 302: 450–453.
6. Gustafson TL, Lavely GB, Brawner ER Jr, Hutcheson RH Jr, Wright PF, Schaffner W: An outbreak of airborne nosocomial varicella. Pediatrics 1982; 70: 550–556.
7. Centers for Disease Control and Prevention: Management of patients with suspected viral hemorrhagic fever. Morbidity and Mortality. Weekly Report 1988; 37: 1–16.
8. Centers for Disease Control and Prevention: Guidelines for preventing the transmission of Mycobacterium tuberculosis in health care facilities, 1994. Morbidity and Mortality. Weekly Report 1994; 43: 1–132.
9. Centers for Disease Control and Prevention: Notice to readers update: Management of patients with suspected viral hemorrhagic fever – United States. Morbidity and Mortality Weekly Report 1995; 44: 475–479.
10. Garner JS and the Hospital Infection Control Practices Advisory Committee: Guideline for isolation precautions in hospitals. Infection Control and Hospital Epidemiology 1996; 17: 53–80.
11. Centers for Disease Control and Prevention: Guidelines for preventing opportunistic infections among hematopoietic stem cell transplant recipients. Morbidity and Mortality. Weekly Report 2000; 49: 1–125.
12. SUVA (Schweizerische Unfallversicherungsanstalt): Umgang mit Anästhesiegasen; Arbeitsmedizin 1996; 29.
13. Eidgenössisches Bundesamt für Energie: Merkblatt Luftbefeuchtung, EDMZ, 1998.
14. Külpmann R: Abnahmevorschlag für TAV-Lüftungsdecken in OP-Räumen. Proceedings DGKH, 6. Internationaler Kongress, Berlin 2002. Hyg Med 2002; 27 (Suppl. 1): im Druck.
15. Mangram AJ, Horan TC, Pearson ML, Silver LC, Jarvis WR and the Hospital Infection Control Practices Advisory Committee: Guideline for prevention of surgical site infection, 1999. Infection Control and Hospital Epidemiology 1999; 20: 24.