

# New Standard for Designing Ventilation in Operating Theatres

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## Introduction

The Netherlands Board for Health Facilities, the NBHF, is focused on issues surrounding the accommodation of intramural healthcare. The board's work sphere includes hospitals, nursing homes and residential care, institutions for the mentally disabled and institutions for psychiatric healthcare. It is an organisation tasked with implementation by the Dutch Ministry of Health, Welfare and Sport.

A permit is required for new construction and major renovations in the healthcare sector. The governors of the NBHF consider applications for, and issue, building permits. The staff of the NBHF processes the applications and prepares preliminary decisions. The NBHF conducts research into, and reports on, the consequences of policy decisions by the Ministry of Health, as well as current developments in the field of planning, technical developments and construction. Research priorities are based on a program of work approved by the Ministry of Health.

Another important task for the NBHF is to provide basic quality requirements which describe the minimum functional and architectural quality that health institutions have to comply with. Good practice examples are also given as an aid to institutions during the preparation of a construction plan.

More than just an issuer of building permits, the NBHF is also recognised as an important provider of expertise. The knowledge and experience of the board is widely utilised to support healthcare institutions, and to provide the Ministry of Health, insurers and healthcare offices with information regarding construction for healthcare.

Healthcare legislation is undergoing substantial changes. A new healthcare system is on the way, and the Health Institution Admittance Act is replacing the Hospital Provision Act. In general it means that hospital facilities have to operate in a much more market oriented way.

## Basic quality requirements

### Hospitals

The minimum level of quality for hospitals is described in so-called basic quality requirements in the *General Hospital Building Guidelines*, in particular in relation to being reachable, accessible, flexible, spatial relationships and quality of the environment. Where applicable, these requirements also apply

to surgical departments. The above-mentioned building guidelines also deal with the location of the surgical department in the building as a whole.

### Surgical departments

As a supplement to the above, this paper lays down the specific basic quality requirements needed for surgical departments, taking into account the care provided in them. This particularly concerns basic quality requirements in relation to housing, technical installations and working conditions (mainly hygienic aspects and special climatological requirements, but also daylight penetration, view, lighting, and noise control). The latter is the case since there is no provision in the Building Guidelines for the indoor environment and technical installations in the healthcare sector.

For specifications in the field of safety and working conditions, we refer to third party regulations such as the National Building Decree and the Working Conditions Act. When defining the basic quality requirements for a surgical department, a distinction is made between different types of areas in the department.

A number of areas in the surgical department do not need to comply with special requirements. These are the areas used for work supervision, accommodation for personnel, the holding area and the recovery room. (An additional working conditions requirement concerning ventilation applies to the recovery room). The requirements are no different for other areas in the hospital where healthcare activities take place. The basic quality requirements concerning hygienic conditions are described in the Building Guidelines for indoor environment and technical installations in the healthcare sector.

#### *Areas with higher hygienic requirements for air quality*

Areas with high clean-air requirements include the operating theatre, any sterile preparation and pre-operative areas, sterile storage, the anaesthesia and equipment storerooms and the entrances and the exits. The highest clean-air requirements apply to the operation area and the sterile preparation area.

#### *Areas that fall under the working conditions policy regulations*

With respect to air treatment, the operating theatre and a number of adjacent areas have to comply with the provisions of

the working conditions policy regulation. This concerns areas where exposure to inhalation of anaesthetic agents is possible, in other words, where the patient stays for certain periods of time during and after the anaesthetic, such as the corridors and the recovery room.

### Basic quality requirements apply to the technical facilities:

#### Background

In the past few years, literature studies were published in which the role of air as a source of infection was investigated. There appears to be little reliable information about the role of air treatment in prevention of postoperative infections in the operation area. There is no evidence in the literature (except in the case of strictly aseptic interventions with introduction of large implants) that the air is a relevant infection hazard in the operation area as a means of contamination for endemic postoperative infections. In the case of operations involving the introduction of large implants, the air appears to be of importance without anyone being able to say explicitly how great this importance is. However, the study does show that air contamination in the immediate vicinity of the operating table and instrument tables can directly or indirectly cause contamination of the operation area. There are also many indications that contamination of the air during operations can play an important role in relation to postoperative infections. However, this can only be proven in very few cases. Other than this, the literature study revealed no evidence that the air in

adjacent rooms or areas located further away influences the risk of postoperative infections.

The highest specifications with respect to the aseptic and protective effect of the air apply to the immediate vicinity in the case of surgical/invasive interventions. From a technical point of view, this protective effect of the air surrounding the patient, operation team and instrument table, can be achieved by installing a large Laminar Air Flow (LAF) device (plenum). This LAF device with a downflow has a surface area of 8 to 9 m<sup>2</sup> (e.g. square or octagonal 3x3m, rectangular 2.8x 3.2m).

If aprons are used there is a possibility of combining this with a facility bridge into which all facilities and connections for medical gases are incorporated. Without aprons, pendants are used, preferably connected to the ceiling outside the air plenum.

The air velocity from the downflow plenum is 24 to 30 cm/sec. The airflow temperature from the LAF device is 1 to 2 °C lower than the ambient air.

In this scheme the fans for recirculation are placed above the plenum. There is also the possibility to place the recirculation fans outside the OT (lower sound level, construction height can be lower, extra air supply and exhaust ducts).

There are also possible solutions and satisfactory results in the environmental control using special LAF devices in which the supplied air has different speeds and temperatures and has also improved the thermal comfort of the surgical team.

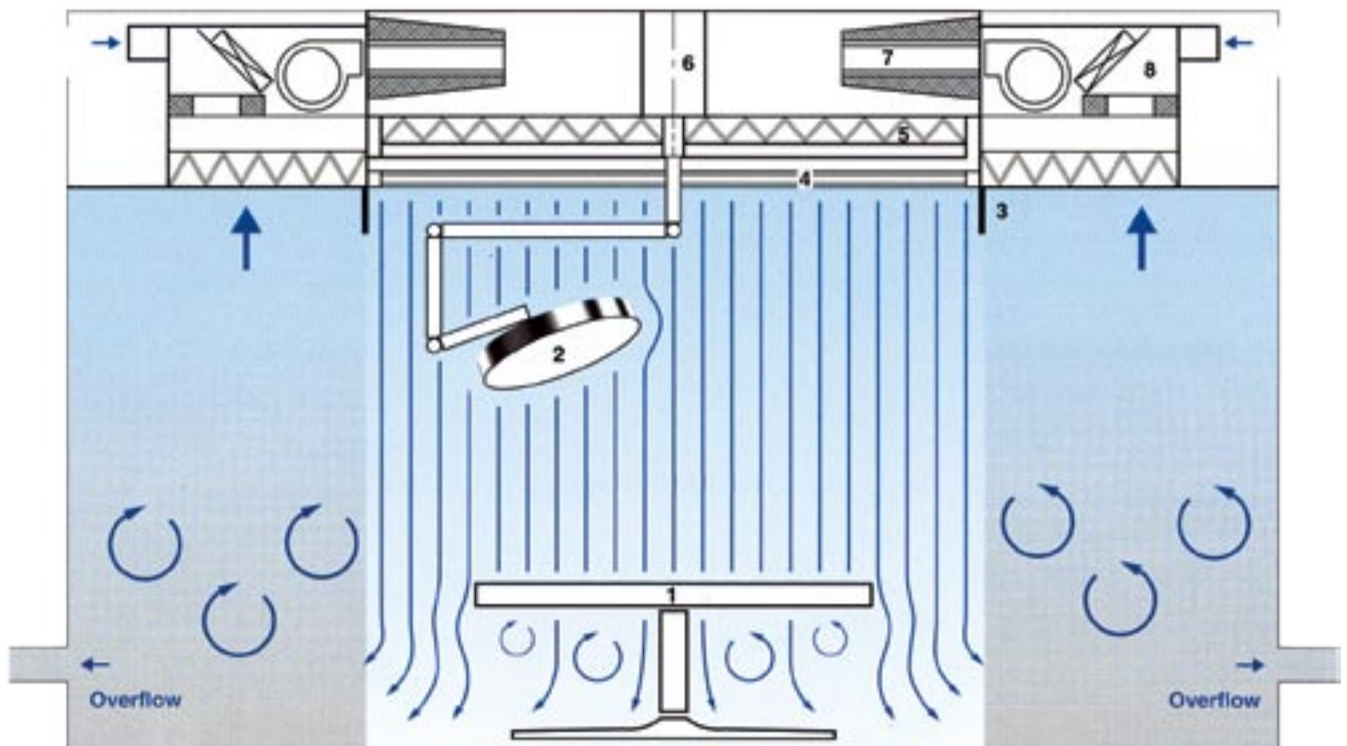


Fig. 1 Principal scheme of an operating theatre with a recirculation plenum.

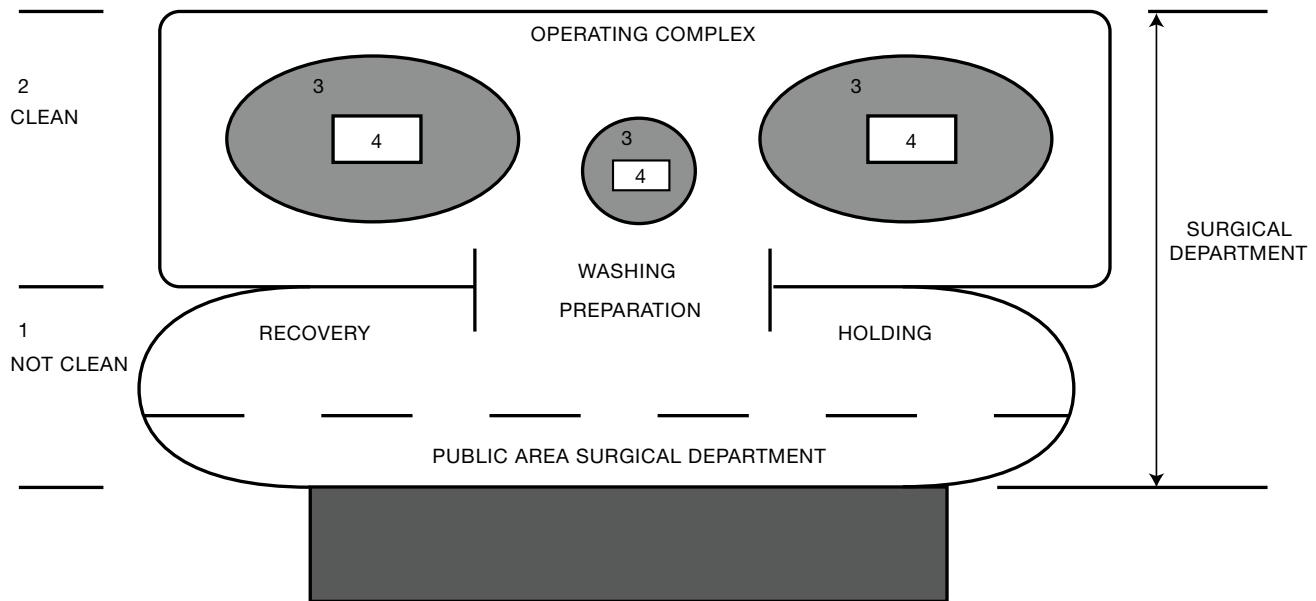


Fig.2 Zone sub-division of the surgical department

In order to be able to safeguard the requisite air quality in the operating theatre, a very large air flow is necessary. A recirculation downflow system can be installed for this purpose. Part of the air from the down flow system is recirculated via fans to the HEPA filter.

In order to be able to evaluate whether the air system, the air flow profiles and the displacement capacity onto the operating table are correctly functioning, a CFD calculation is recommended at the design stage. This also makes it possible to ascertain whether, at a specific internal heat load, the selected diffused air temperature and the selected air velocity

will not lead to an excessively high level of cooling in the operating theatre. This will also reveal at an early stage any short-circuiting between air supplied from the plenum and the site of the intake openings for air recirculation.

Assuming that the air from the HEPA filter is sterile, the only possible emission source will be the operation team, the OT staff, the patient, the material used and the equipment. With respect to the sterile preparation area with direct access to the operating theatres, a higher pressure is recommended compared to all rooms adjacent to this area.

In areas to which high hygienic specifications apply, it is advisable to establish an air pressure hierarchy, whereby more air is supplied than extracted in the “cleanest” area. By installing overflow grids between the rooms, via openings along access doors, a forced air flow is created from the “cleanest” room to less “clean” areas.

This means that the most important basic quality requirements for the technical facilities are:

- > the surgical department has to be equipped with a mechanical ventilation system;
- > the operating theatre has to be equipped with a laminar downflow system with a large air plenum (8 to 9 m<sup>2</sup>). Under working conditions with operation lights switched on and the presence of the operation team, the air supply and blast air profile are chosen in such a way that the air does not pass through any sources of contamination before flowing into the operation area or over the instrument table;
- > if sterile preparation (setting up) does not take place under the large downflow plenum, a sterile preparation area with its own laminar downflow system must be created in the sterile preparation area or the place where sterile preparation takes place (e.g. the clean corridor);
- > there must be no windows that can be opened; outside walls must be completely sealed.

The surgical department can be subdivided into zones (fig.2):

- Zone 1, non-clean. This includes all public areas (reception area, work areas, consultation rooms and staff accommodation) and the recovery, holding and preparation areas.
- Zone 2, clean. The actual OT complex with operating theatres, the primary side-rooms to the operating theatres, the sterile storage, the anaesthesia and equipment storage areas and the corridor(s) within the OT complex. The washroom(s) are a non-clean transition area in a clean zone.

- Zone 3, sterile. The operating theatres, sterile preparation area(s) and where applicable, sterile store (day supply).
- Zone 4, operation area. The zone under the downflow area where the operation takes place and the downflow area beneath the sterile preparation island.

The reason for having a zoning system in the surgical department is to minimise the risk of micro-organisms from the hospital (the dirty area) reaching the OT complex. While the zone concept may result in a different air conditioning solution per zone, it means that staff and visitors coming from the dirty hospital corridor have to comply with the clothing regulations and rules of conduct applicable to that zone. The incoming and outgoing goods flows also have to comply with a specific protocol. An essential aspect of this zoning and the lay-out of the surgical department is the routing of the operation team, the anaesthesia team, the patients and any visitors, and the sterile and dirty goods flows.

### Basic quality requirements to the spatial relationships

The basic quality requirements described in the guidelines particularly concern accessibility, location and size of areas to which patients have access. Minimum requirements are laid down governing the free width of traffic areas and the floor area of operating theatres.

The most important basic quality requirements concerning spatial relationships are:

- > the surgical department is independent of traffic flows in the rest of the hospital; through traffic is not permitted through this department
- > airlocks physically and hermetically seal a surgical department from the rest of the hospital
- > staff working in the operating theatre complex can move from one ‘clean’ area to another without needing to pass through ‘non-clean’ areas.

### Basic quality requirements - spatial needs

Description of the area	min.usable area in m <sub>2</sub>	comments
operating theatre, general	36	
operating theatre, specific (orthopaedics,cardiac surgery, neurosurgery)	42	
patient airlock or holding area	20	
preoperative area	15	If present ditto

## Other basic quality requirements

The following basic quality requirements apply to the use of equipment, operational reliability of installations and finish in a surgical department:

- > health risks to staff such as exposure to microbiological and chemical contamination, lasers and ionising radiation can be avoided as far as possible by drawing up guidelines and protocols
- > operational reliability of the technical installations and an optimal indoor environment for both patients and staff form the basis of the design and maintenance of the mechanical engineering and electro technical installations
- > the finish of floors, walls and ceilings will be smooth, seamless or closed. Corners and transitions between floors and walls will be rounded so as to prevent accumulation of dirt. The different areas should be constructed and furnished in such a way as to allow effective cleaning and if necessary disinfection with commonly used cleaning agents and permitted disinfectants.

## Treatment rooms

In addition to operating theatres, the treatment room is also mentioned in the guidelines. No interventions under general

inhalation anaesthesia may take place in this room because the air treatment does not comply with the specifications of the Working Conditions Policy Regulations. Nor may interventions take place that require a high level of air quality since the installation cannot provide this.

A treatment room can be located centrally, for example in an outpatient treatment centre, or de-centrally in the outpatient unit of the relevant specialisation. Generally speaking, the structural and technical provisions required are limited.

The following basic quality requirements apply to the conditions in treatment rooms:

- a treatment room is equipped with a mechanical ventilation system
- the minimum permissible amount of outside air is 100 m<sup>3</sup>/h per person.

An appendix to the guidelines gives an indication of spatial requirements that can be considered customary for surgical departments on the basis of recommendations. In combination with the financial basic principles formulated in the guidelines, an upper limit can be determined for the investment framework. The normative cost of building a new surgical department is approximately 60% higher than the normative cost included in



the regulations for building a new general hospital as a whole. This includes the cost of infrastructural provisions.

In the chapter on building concepts, examples of 'good practice' are given for different aspects that are of importance for surgical departments. This concerns client perception, location, organisational and spatial design and technical equipment. It is the intention to replace these examples of 'good practice' by new, recent material on a regular basis.

### European developments

Within the European Normalisation Commission (the CEN), a new working group has formed to develop a European guideline for Operating Theatres.

The Netherlands is now one of the four countries in Europe that has (draft) guidelines in the field of designing and operating the heating, ventilation and air-conditioning in operating theatres. In Germany there are two draft guidelines, the *DIN-Entwurf 1946-4: 2005-04: Raumlufttechnik- Teil4: Raumlufttechnische Anlagen in Krankenhäusern* and the *Entwurf der VDI-Richtlinie 2167-1:2004-12: Technische Gebäudeausrüstung von Krankenhäusern - Heizungs- und Raumlufttechnik*. Switzerland has the *Richtlinie 99-3: Heizungs-, Lüftungs- und klimanlagen in Spitalbauten*) and Austria the *Entwurf ÖNORM H6020:2005-09-01: Lüftungstechnische Anlagen in Krankenanstalten und Pflegeheimen*).

In the first comparisons made between these four guidelines, it would seem that there are a lot of common techniques. To ensure the highest level of protection of the operating table, all four guidelines should be aimed at a protected area of about 8 to 9 m<sup>2</sup>. Some countries recommend so called aprons close to the active exhaust surfaces. Also the classification of operating rooms differs: Switzerland and the Netherlands accept only one type (Type 1a), Germany and Austria accept two types depending on the type of intervention which takes place (Type 1b).

Type 1a: Operating rooms with laminar downflow (unilateral) air distribution systems for achieving a protected area in which the operation can be carried out and the instrument tables are positioned.

Type 1b: Operating rooms with mixed flow, displacement flow or smaller laminar downflow air distribution systems.

In the next few years these countries will try to generate a common format.

### Operating theatres in developing countries

Post-operative infections by polluted air are one of the possible causes of infection. Other causes are non sterile clothes, instruments, or liquids.

In an investigation in operating theatres in the Netherlands (140 000 operations /interventions) during the years 1996 and 2004, the post operative infection percentage was 3.3%. It was impossible to get information as to by which mechanism the infection took place.

An important and effective method of prevention is the use of antibiotics. Antibiotics can reduce the post operative infections by 75%. On the other hand, antibiotics have side effects and bacteria are developing resistance against it. So of course the prevention of infections in the wound is better than to attack them later on.

Another important means of minimising the risk of infections is the zoning system in the surgical department, which minimises the risk of micro-organisms from the hospital (the dirty area) reaching the OT complex. This means that staff and visitors coming from the dirty hospital corridor have to comply with the clothing regulations and rules of conduct applicable to that zone.

The third important way of minimising the risk is the routing. This means that in the design stage the routing of the operation team, the anaesthesia team, the patients and the sterile and dirty goods flows should be considered very carefully. All these risk minimising methods are effective and low budget.

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