6 Building, furnishings and building service systems

Building design, furnishings and building service systems are key potential contributors to health problems in indoor workplaces. In addition to construction and layout, the building materials and the technical equipment installed are of particular relevance.

6.1 Building parameters

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Questionnaire S2 (which can be found at www.dguv.de/ifa, webcode e650356) deals with the building situation and is intended to help ascertain whether employees' health complaints might be linked to the building in which they work. S2 must be completed based on the information gathered in the investigation of the work environment using questionnaire G2 (see Annex 3, page 115) which must always be carried out beforehand. To gain full benefit, both investigations should be carried out in collaboration with the people responsible for managing the building.

If a building has serious defects (e.g. water damage), experts must be brought in to provide advice on the necessary repair work. Questionnaire S2 can be backed up by investigations specifically dealing with:

- ventilation and air conditioning systems (see Section 6.2),
- lighting (see Section 6.3),
- building materials and their condition (see Section 6.4),
- furniture, soft furnishings and carpets (see Section 6.4) and
- cleaning procedures (see Section 6.4).

6.2 Ventilation and air conditioning systems

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G. Franke, Leipzig
T. von der Heyden, Sankt Augustin

Ventilation and air conditioning systems (VAC systems) include equipment for heating, cooling, humidifying and dehumidifying the supply air in rooms. Unlike heating systems, whose sole purpose is to heat indoor air during the winter months, ventilation and air conditioning systems are designed to keep purity, temperature, humidity, etc. of the air constant within certain ranges. Systems used for direct room heating (e.g. radiators or convection heaters) do not fall within the accepted definition of VAC systems. Nonetheless, just like VACs, they do have a certain impact on indoor air condition and quality.

Well-planned and regularly serviced VACs have a positive effect on indoor climate and the concentration levels of indoor air pollutants. By contrast, VACs that are poorly serviced or not serviced at all can generate complaints about the indoor climate as well as resulting in unwanted indoor odours. When filters, heaters, coolers or humidifiers are not serviced or designed in line with hygiene standards, biopollution can occur.

6.2.1 VAC classification

VAC systems form a subset of air handling technology [1] which can be divided into three categories:

- Natural ventilation:
  whereby the air is distributed by means of differences in pressure and temperature within and around the building
- Mechanical or forced ventilation:
  whereby the air is distributed via ventilators
- Hybrid ventilation:
  whereby natural ventilation is temporarily supported or replaced by mechanical ventilation.

There are various types of natural ventilation (see Figure 3). In all of them, the flow at which air is moved through a building can depend on the weather or the difference between the inside and outside temperature. As a result, these systems are unpredictable and unreliable.

Mechanical ventilation, on the other hand, allows the indoor air conditions to be defined irrespective of the weather and the conditions within the building. These systems are called ventilation, partial air conditioning or air conditioning systems, depending on the air handling method (see Table 2).

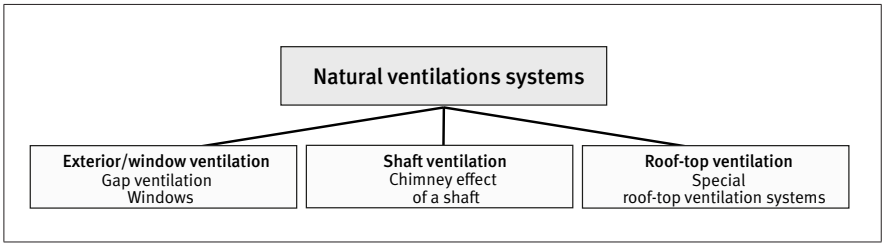


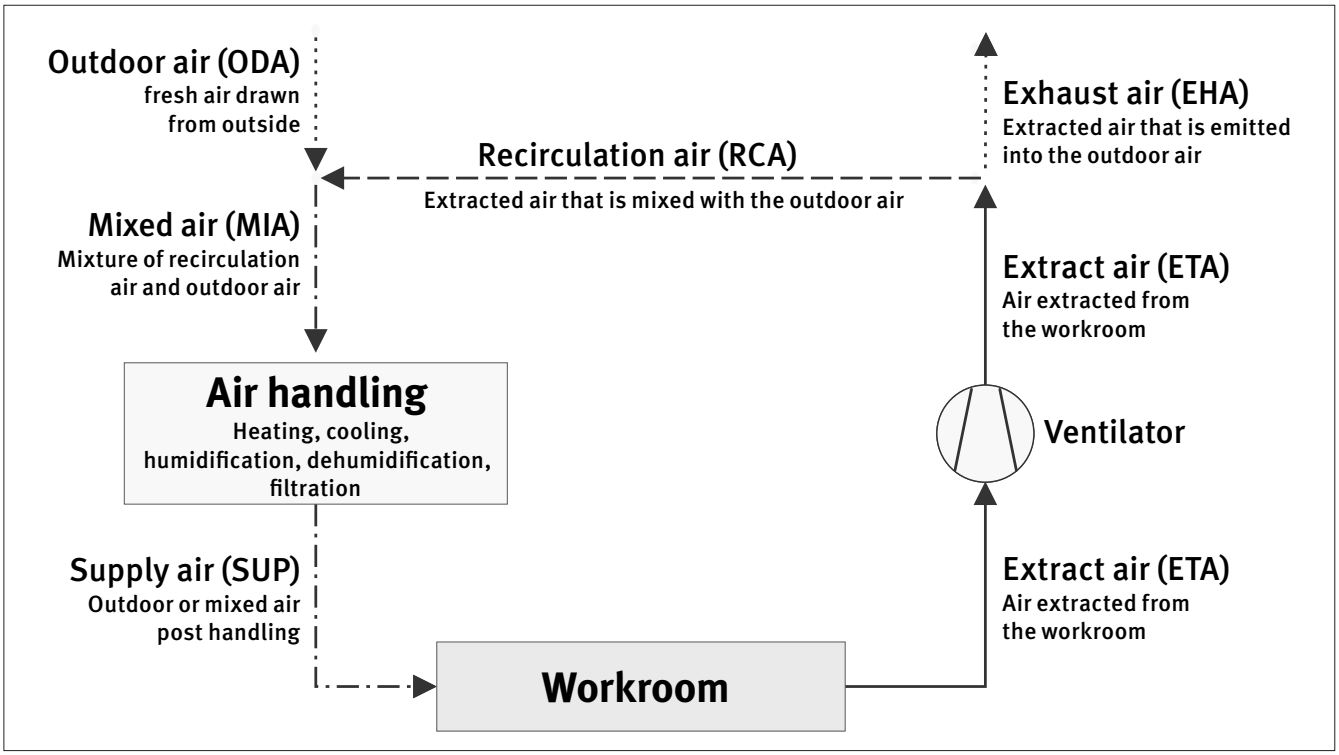
Figure 3:
Natural ventilation system types

Table 2:
VAC system types

Type of VAC system	Air handling method
Exhaust system	None
Ventilation system	Heating Cooling Humidification Dehumidification
Partial air conditioning system	Heating and cooling Heating and humidification Heating and dehumidification Cooling and humidification Cooling and dehumidification Humidification and dehumidification Heating, cooling and humidification Heating, cooling and dehumidification Cooling, humidification and dehumidification Heating, humidification and dehumidification
Air conditioning system	Heating, cooling humidification and dehumidification

Ventilation, partial air conditioning and air conditioning systems work using either outdoor air (ODA) or mixed air (MIA) – a combination of outdoor air and recirculation air (RCA) (Figure 4). There are certain exceptions, for example the warm-up phase outside of working hours, where these systems can also be operated using recirculation air only. They are then referred to as air recirculation systems.

Figure 4:
Airflows in VAC systems (mechanical ventilation)



6.2.2 Conducting the investigation

The question of whether there is a VAC system in the workplace is initially answered during the investigation of the work environment using questionnaire G2 (see Chapter 3). A special questionnaire (S3, which can be found on the internet at www.dguv.de/ifa, webcode e650356) is also available assessing heating and VAC systems in as much detail as possible. This information can then be used to assess the systems' impact on the quality of the indoor air and to detect fault sources. The questionnaire is divided into the following sections:

- Section A:
  Data pertaining specifically to the VAC system

- Section B:
  Data pertaining specifically to humidifiers (if present)

- Section C:
  Data pertaining specifically to the heating system

It is customary for the organisation to complete the questionnaire itself. Later, when the workplace is inspected, the answers on the questionnaire should be checked and, where necessary, corrected and information added. Figures 3 and 4, Tables 2 and 3 and the references listed at the end of this section provide guidance on key technical details.

Table 3:
Classification of air filters in accordance with DIN EN 779 [2] and DIN EN 1822 [3; 4]

Designation	Filter class
Coarse filter	G1 G2 G3 G4
Medium filter	M5 M6
Fine filter	F7 F8 F9
Highly efficient particulate air (HEPA) filter	E10 E11 E12 H13 H14 U15 U16 U17

The requirements concerning how the planning, design, customer approval, operation and servicing of VAC systems should ensure maximum hygiene are laid down in, amongst other documents, the standards DIN EN 13779 [5] and DIN EN 12599 [6] as well as in the Guideline VDI 6022, Part 1 [7].

To comply with the hygiene requirements and to ensure the VAC systems are properly maintained, trained employees (from the organisation) must check the systems at regular intervals. The intervals are also set out in Guideline VDI 6022, Part 1. They include the disinfection unit, which must be checked every six months to ensure it is in good working order, and the air filters, which need to be checked every three months for soiling, damage (leakage) and odours. The entire VAC system must undergo periodic hygiene inspections – carried out and documented by trained employees – every two years if the system has a humidification component and every three years if it does not.

Guidance on best practice in the maintenance and servicing of VAC systems, and specifically humidifiers, is available from a variety of sources. Examples are the servicing information drawn up by the Arbeitsgemeinschaft Instandhaltung Gebäudetechnik (AIG; Association for the Servicing of Building Service Systems) [8 to 10] and the humidification information pack produced by the Berufsgenossenschaft Energie Textil Elektro Medienerzeugnisse (BG ETEM; German Social Accident Insurance Institution for the energy, textile, electrical and media products sectors) [11], which also deals with humidification in VAC systems.

6.2.3 Carrying out the evaluation

Experience has shown that specialist knowledge is generally required in order to appraise and assess VAC systems. Experts should therefore be commissioned to perform this work. Nonetheless, it is still useful to keep a record of one's initial visual impression during the investigation.

It is possible to determine beforehand whether the hygiene-related design and operating requirements for VAC systems specified in Guideline VDI 6022, Part 1 [7] have been complied with. This assessment concerns, inter alia, the air filters, humidifiers and the servicing (maintenance, inspection and repairs). Prior evaluation is possible because hygiene checks, cleaning and disinfection are usually documented, e.g. in a maintenance record or operating log. Experience shows that there are often records concerning air flow rate and indoor climate measurements. If these documents are already several years old, the information is usually no longer relevant. Another crucial aspect of the hygiene inspection is that the employees involved must have the necessary qualification (hygiene training category A, B, C or RLQ).

The Guideline VDI 6022 specifies that filters for central VAC systems must be at least class F7 (cf. Table 3). If the outdoor air is polluted, the filter requirements are higher. In special circumstances, the recommendation is to use two-stage filters with filter classes F7 + F9 (see VDI 6022, Part 3 [12]).

Where VAC systems cause noise pollution, the noise level must be between 35 and 45 dB(A) depending on the nature of the room (see Guideline VDI 2081 [13]).

Information concerning compliance with indoor climate parameters (including mean air velocity at the workplace ‹ 0.15 m/s, see also ASR A3.6 "Ventilation" [14]) is given in Chapter 9, "Indoor climate".

The water used in humidifiers must be of drinking quality. The total viable count (TVC) in the humidifier water should be no higher than 1,000 CFU/ml (CFU = colony forming unit). The total colony count for legionellae must not exceed 100 CFU/100 ml [7].

6.2.4 References

[1] DIN EN 12792: Lüftung von Gebäuden – Symbole, Terminologie und graphische Symbole (01.04). Beuth, Berlin 2004

[2] DIN EN 779: Partikel-Luftfilter für die allgemeine Raumlufttechnik – Bestimmung der Filterleistung (10.12). Beuth, Berlin 2012

[3] DIN EN 1822 Blatt 1: Schwebstofffilter (EPA, HEPA und ULPA) – Teil 1: Klassifikation, Leistungsprüfung, Kennzeichnung (01.11). Beuth, Berlin 2011

[4] Schwebstofffilter neu genormt – DIN EN 1822. VDMA Luftfilterinformation 06/2011. Published by: Verband Deutscher Maschinen- und Anlagenbau (VDMA), Frankfurt am Main 2011

[5] DIN EN 13779: Lüftung von Nichtwohngebäuden – Allgemeine Grundlagen und Anforderungen für Lüftungs- und Klimaanlagen und Raumkühlsysteme (09.07). Beuth, Berlin 2007

[6] DIN EN 12599: Lüftung von Gebäuden – Prüf- und Messverfahren für die Übergabe raumlufttechnischer Anlagen (01.13). Beuth, Berlin 2013

[7] VDI 6022 Blatt 1: Raumlufttechnik, Raumluftqualität – Hygieneanforderungen an Raumlufttechnische Anlagen und Geräte (VDI Lüftungsregeln) (07.11). Beuth, Berlin 2011

[8] AIG-Information Nr. 4: Luftbefeuchter in raumlufttechnischen Anlagen. Published by: Arbeitsgemeinschaft Instandhaltung Gebäudetechnik (AIG) der Fachgemeinschaft Allgemeine Lufttechnik im Verband Deutscher Maschinen- und Anlagenbau (VDMA), Frankfurt am Main 2004

[9] AIG-Information Nr. 6: Wartungsschwerpunkte bei Lüftungs- und Klimaanlagen. Published by: Arbeitsgemeinschaft Instandhaltung Gebäudetechnik (AIG) der Fachgemeinschaft Allgemeine Lufttechnik im Verband Deutscher Maschinen- und Anlagenbau (VDMA), Frankfurt 2001

[10] AIG-Information Nr. 7: Hygieneanforderungen in der Raumlufttechnik. Published by: Arbeitsgemeinschaft Instandhaltung Gebäudetechnik (AIG) der Fachgemeinschaft Allgemeine Lufttechnik im Verband Deutscher Maschinen- und Anlagenbau (VDMA), Frankfurt am Main 2001

[11] Informationen zur Luftbefeuchtung (03.12). Published by: Berufsgenossenschaft Energie Textil Elektro Medienerzeugnisse (BG ETEM), Köln 2012

[12] VDI 6022 Blatt 3: Raumlufttechnik, Raumluftqualität – Beurteilung der Raumluftqualität (07.11). Beuth, Berlin 2011

[13] VDI 2081 Blatt 1: Geräuscherzeugung und Lärmminderung in Raumlufttechnischen Anlagen (07.01). Beuth, Berlin 2001

[14] Technische Regeln für Arbeitsstätten: Lüftung (ASR A3.6). GMBl. (2012) No. 6, p. 92-97; last revision GMBl. (2013) No. 16, p. 359

6.3 Office lighting

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6.3.1 General aspects

Lighting requirements for workplaces are set out in the Arbeitsstättenverordnung (Ordinance on Workplaces) [1] and the Technical Rule for Workplaces ASR A3.4, "Lighting" [2]. DGUV Information 215-442, formerly BGI 856, "Office lighting" [3], adds more specific detail and recommendations.

This section outlines the salient requirements of ASR A3.4 and the DGUV Information 215-442 as well as providing guidance on how to assess lighting systems (see Section 6.3.5). The S4 questionnaire can also be downloaded from the internet (www.dguv.de/ifa, webcode e650356) as an aid.

6.3.2 Daylight

Daylight plays an important role in indoor lighting. An adequate supply of daylight, combined with as little obstruction of the outside view (undistorted and unaltered) as possible, has a positive impact on employees' sense of wellbeing and thus on morale and productivity.

Consequently, it is important that office rooms have adequately sized windows. This can be said to be the case if

- the area of the transparent window surfaces is equal to at least one tenth of the room's floor area or
- the daylight factor[2] at the workstations is at least 2%.

In addition, the proportions and balustrade heights must be such that, as far as possible, they do not obstruct employees' view of the outside environment. Where circumstances allow, the workstations should therefore be positioned near the windows, not in the middle of the room.

At the same time, the windows must be fitted with suitable, adjustable solar protection solutions (see DGUV Information 215-444, formerly BGI 827, "Sun protection in offices" [4]) so as to minimise glare and illuminance[3] caused by daylight shining on display screens.

Daylight alone is not enough to ensure good quality lighting (particularly adequate illumination) throughout the entire working day, whatever the season. This is true even if the workstations are positioned directly next to the window and make optimum use of the daylight. As a result, artificial lighting has to be used. The quality parameters described below refer to artificial lighting but the aims they serve in terms of protection can also be applied to daylight. It should be pointed out, however, that employees appreciate the positive effects of daylight and the

[2] The daylight factor is the ratio of the illuminance at a given point inside to the illuminance outside without any obstruction. The sky must be overcast [2].

[3] Illuminance is a unit of measurement for the light that hits a given surface. It is measured in lux (lx) [2].