Hygienic Air Handling Units

Selected in accordance with
EN13053 – VDI6022-1 & **DIN1946-4** Standards

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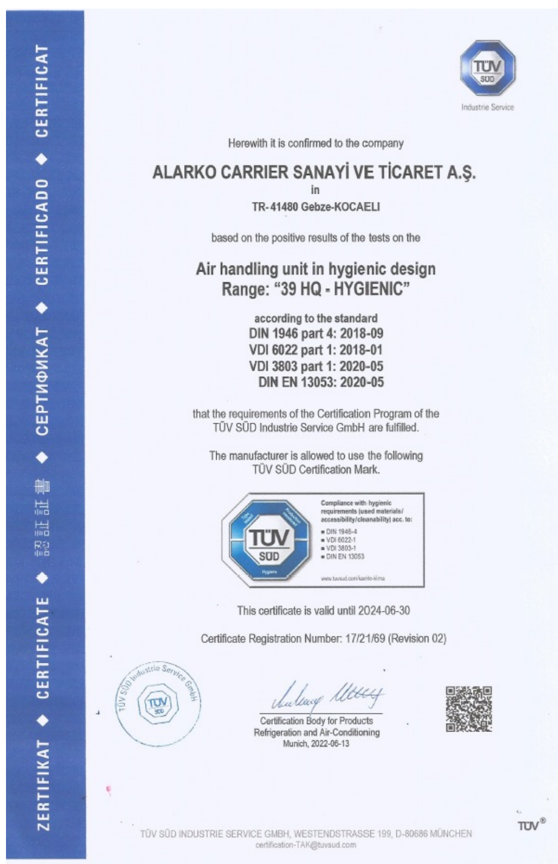
Introduction

Medical care, often life-saving, is provided in healthcare facilities. To meet their goal of saving and improving patient lives, healthcare premises need to create and maintain a safe and healthy environment for patients and working personnel alike. The heating, ventilation and air conditioning (HVAC) systems that the healthcare sector utilizes are of paramount importance in achieving this.

Standards such as **EN 13053, VDI 6022-Part 1** and **DIN 1946-Part 4** outline specific requirements for Air Handling Units (AHUs) in the healthcare sector. These standards address topics such as air quality and infection control and ventilation requirements of various hospitals, clinic, treatment room, and operating theater. By adhering to these standards, healthcare facilities ensure their HVAC systems meet high performance, hygiene, and patient safety standards.

This newsletter aims to provide comprehensive information on the aforementioned standards for AHUs in healthcare facilities. It explains the components of AHUs and the relevant requirements of the standards. It also discusses considerations, offering valuable insights to engineers, contractors and anyone interested in proper air conditioning in healthcare settings.



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Industrie Service

Herewith it is confirmed to the company

ALARKO CARRIER SANAYİ VE TİCARET A.Ş.
in
TR-41480 Gebze-KOCAELI

based on the positive results of the tests on the

Air handling unit in hygienic design
Range: "39 HQ - HYGIENIC"

according to the standard
DIN 1946 part 4: 2018-09
VDI 6022 part 1: 2018-01
VDI 3803 part 1: 2020-05
DIN EN 13053: 2020-05

that the requirements of the Certification Program of the TÜV SÜD Industrie Service GmbH are fulfilled.

The manufacturer is allowed to use the following TÜV SÜD Certification Mark.

Compliance with hygienic requirements (used materials/ accessibility/cleanability) acc. to:
- DIN 1946-4
- VDI 6022-1
- VDI 3803-1
- DIN EN 13053

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This certificate is valid until 2024-06-30

Certificate Registration Number: 17/21/69 (Revision 02)

Certification Body for Products
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Munich, 2022-06-13

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Figure 1. Hygienic AHU TÜV Certificate

Standard's Scope

The combined scope of **EN 13053**, **DIN 1946-4**, and **VDI 6022-1** covers the planning, construction, qualification, operation and performance of ventilation and air conditioning systems in various building environments, with a focus on the health sector and non-residential spaces. These standards share some common ground and provide guidance for air conditioning systems.

EN 13053:2020-05 is a European Standard that specifically addresses AHUs in non-residential buildings. It includes information about ratings, performance, testing, and classification of ventilation units, with provisions for AHUs in healthcare facilities. This standard applies to both mass-produced and tailor-made AHUs with an airflow above 250 m3/h. It promotes better air quality, infection control, and proper ventilation in healthcare settings.

VDI 6022-1:2018-01 focuses on hygiene requirements for ventilation and air-conditioning systems, with a primary focus on safeguarding human health while considering technical factors. It provides guidance to various stakeholders and emphasizes the assessment of indoor air quality. **VDI 6022-1** specifically concentrates on ventilating and air-conditioning systems, AHUs, and their respective components that influence air quality. It applies to spaces regularly used for extended periods of time.

DIN 1946-4:2018-09 applies to the planning, construction, and qualification of ventilation and air conditioning (VAC) systems in various healthcare facilities such as hospitals, day clinics, treatment rooms in doctor's offices/surgeries, operating rooms in outpatient facilities, dialysis centers, and internal/external medical device sterilization facilities. However, the standard does not address design of specialized treatment facilities meant for the management of highly infectious and life-threatening diseases.

Casing

In accordance with **EN 13053,** the casing of the AHUs should adhere to specific criteria to ensure optimal performance and functionality. These criteria include the incorporation of minimum double skin panels with sandwiched insulation, which enhances thermal efficiency and prevents heat transfer. Inside the casing, smooth surfaces should be maintained free from sharp edges or pointed objects to facilitate efficient airflow and ease of maintenance.

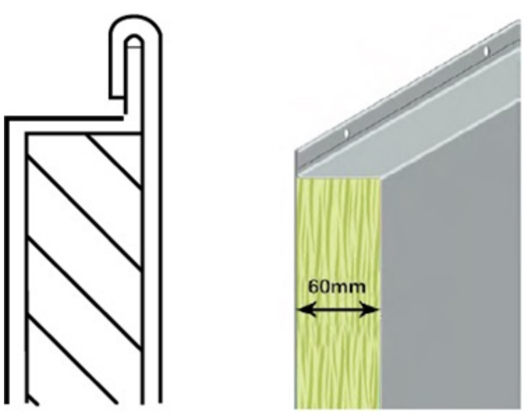

Figure 2. Standard Carrier 39HQ Panel

Moreover, it is essential to consider the seals used in the casing. The seals should be carefully selected to ensure they do not absorb any moisture and do not provide a nutrient substrate for microorganisms. This attention to detail helps maintain a hygienic environment within the AHUs and prevents the proliferation of harmful microorganisms.

In addition to the construction and sealing of the casing, easy accessibility and cleanability of equipment components are crucial factors. All equipment components, such as coils and other relevant parts, should be easily accessible for cleaning and maintenance. This can be achieved through the incorporation of upstream and downstream free spaces with access doors or inspection panels that allow for convenient and safe cleaning procedures to be carried out. Alternatively, the components can be designed to be easily and safely removable, ensuring efficient maintenance practices. Unit shall have double-skin casings in accordance with **DIN EN 13053** (insulation sandwiched between internal and external panels).

Figure 3. Door Gasket

VDI 6022-1 places significant emphasis on selecting suitable materials for air handling areas that are exposed to high humidity or water. Moreover, sealing materials used should be closed-pored to prevent the absorption of humidity or the release of odors. It is essential that these seals do not provide a conducive environment for the growth of microorganisms. Closed-pored seals are specifically used in filter sections to maintain optimal hygiene.

Accessibility is also a crucial consideration to ensure compliance with hygiene requirements. For unit housing with a clear height of 0.8 m or less, easily removable service panels should be implemented. In the case of larger housings and central chambers, a sufficient number of service doors should be provided. Additionally, it is recommended to install inspection windows, with a diameter of no less than 150 mm, accompanied by internal lighting to facilitate visual inspections of the components. Such windows are mandatory for sections such as humidifiers, fans, and filters, with a clear housing height of 1.3m.

Figure 4. Hinged Door

DIN 1946-4 establishes additional requirements for the casing of the Hygienic AHUs, ensuring their compatibility with healthcare environments. The materials used in contact with the airflow are carefully selected to withstand the disinfectants commonly employed in medical settings. This selection ensures that the AHU's components meet the requirements of both **EN 1886** and **EN 13053**, guaranteeing superior performance and reliability.

Internally, the casing surfaces should undergo sendzimir galvanized coating treatment, providing an extra layer of protection against corrosion. The lower portion of the casing, including slide-in rails and surfaces exposed to (condensation) water, should be constructed using corrosion-resistant stainless steel (1.4301) or an aluminum alloy (e.g., AlMg).

Attention should also be given to the seals used in the AHU. The sealing profiles should be made of closed-pore materials that do not absorb moisture. Seals on doors and filter mounting frames should be inserted, clamped, or foamed, as gluing is not permitted. Glued seals are only allowed on the filter insert and only for single use. These measures contribute to maintaining a hygienic environment within the AHU and preventing the growth of microorganisms.

Regarding accessibility, the AHU's design incorporates features that facilitate easy maintenance. For non-walk-in type casings (enclosures) with a clearance of less than 1.6m, enough removable covers or service doors should be provided to ensure accessibility. In the case of walk-in casings, an adequate number of service doors should be installed. This ensures that all components of the AHU can be accessed from both upstream and downstream directions, allowing for efficient inspection, cleaning, and maintenance. Alternatively, for casings with a clearance of less than 1.6m, the components should be designed to be easily and safely removable.

Figure 5. Inspection Window

Figure 6. Inox Interior without thresholds on the door

Figure 7. Flat Roof Coating

Outdoor Air Intake Section

The Outdoor Air Intake in AHUs, is a component that is vital for bringing fresh air from the outdoor environment into the building's ventilation system. It ensures the maintenance of indoor air quality. In accordance with **EN 13053**, for weatherproof units, suitable weatherproof devices such as louvres with maximum air velocities of 2.5 m/s for intake and 4.0 m/s for exhaust are necessary. All inlet and outlet apertures should be protected by a grid with holes not exceeding 20 mm x 20 mm to prevent clogging and maintain efficient airflow.

Alternatively, droplet eliminators or rain hoods can be used for effective moisture removal and rainwater ingress protection, with maximum air velocities of 4.0 m/s and 5.0 m/s for intake, and 4.5 m/s and 6.0 m/s for exhaust, respectively.

Figure 8. Inlet Section with Louvre

Furthermore, in both **EN 13053** and **DIN 1946-4** the floor area behind the suction opening shall be in the form of a basin for draining any cleaning water, precipitation of snow etc. The requirement for the quality of the sloped drain pan, as per **EN 13053**, is minimum galvanized and coated/painted steel sheet, powder coated or wet painted with primer and top coat of thickness ≥ 60μm or coil coated galvanized steel sheet.

In order to comply with standard **DIN 1946-4**, AHUs' outdoor air intake should have a sloped condensate basin with a minimum length of 500 mm and a connection drain pipe with a diameter of at least 40 mm for proper drainage. The unit's basin area must have sufficient slope and run via a siphon with backflow protection. The accessibility of this area shall be ensured by providing removable covers or service doors. Last but not least, basin must be from stainless steel (e.g. material no. 14301) or an aluminium alloy (e.g. AlMg) to enhance corrosion resistance.

Figure 9. Sloped Drain pan With a Connection Drainpipe

Dampers

Dampers find application when there is a need to modify the air flow rate or completely halt it. In line with **EN 13053**, the classification and testing of air regulating and shut-off dampers should adhere to **EN 1751**[1] guidelines. The velocity of the damper face should be limited to 8 m/s, except for recirculation air and bypass dampers. It is recommended to maintain a minimum inflow angle (α) of 25 degrees and a minimum outflow angle (β) of 35 degrees.

Figure 10. Stainless Steel Dampers

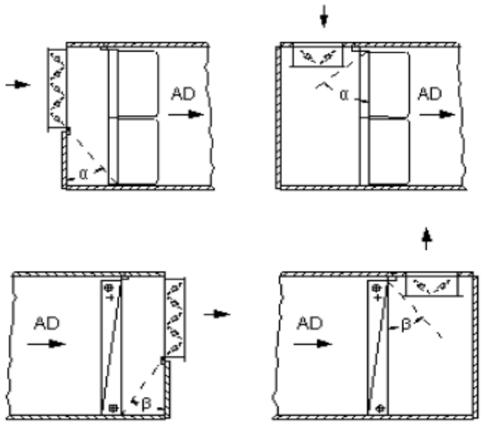

Figure 10a. inflow and outflow angles

Bypass dampers for heat recovery and recirculation dampers within the mixing section should adhere to air tightness class 2.

In accordance with **DIN 1946-4**, air handling units are mandated to incorporate multiple leaf dampers for openings and duct connections for outdoor, supply, extract, and exhaust air. They shall meet at least the criteria for leakage class 2 and where stricter tightness requirements apply, those of class 4, according to **DIN EN 1751**. This shall be demonstrated by a type approval test performed by a third party testing body.

For weatherproof (outdoor) units, the dampers should be positioned on the interior. In instances where AHUs are designed for indoor installation, the outdoor air dampers should either be placed inside or, if positioned externally, be equipped with a dual layer of insulating material.

The current position (open/closed) of the dampers should be easily visible from the outside. In relation to outdoor air shut-off dampers, corrosion-resistant materials such as stainless steel (1.4301) or an aluminum alloy (e.g., AlMg) should be employed. Furthermore, these dampers are required to possess an automatic closure mechanism in case of energy supply interruption, achieved through a spring return mechanism.

[1] **EN 1751**, Ventilation for buildings - Air terminal devices - Aerodynamic testing of damper and valve.

Filter Section

According with **EN 13053**, specific criteria are established to address air tightness, strength, and bypass leakage, following **EN 1886** standards.

Figure 11. Bag Filter

To facilitate maintenance and monitoring, the filter section should incorporate several features. An inspection door should be present, and the provision for a pressure loss gauge or manometer should be ensured through tapings. Enhancing visibility and internal inspection, an inspection window with a minimum diameter of 150 mm, coupled with internal lighting, is recommended.

In situations where frost accumulation is a possibility, slight preheating measures might be necessary. It's also worth noting that due attention should be given to prevent corrosion caused by the runoff moisture from the filters.

If a single stage filter system is used for supply air stream then a filter of minimum ISO ePM1 50% (F7) bag filter shall be installed. In case of two-stage filtering, the supply air fan shall be positioned between first and second filtration stages.

To avoid condensation, therefore microbial growth on air filters, relative humidity in the area of the filter must not exceed 90%. Dropping below dewpoint must always be avoided. For this reason, filters should not be directly positioned after dehumidification coils or humidifiers, except in the case of steam humidifiers. When employing bag filters, a filter area of at least 10m² per 1m² of equipment cross-section is recommended. To effectively seal against dust, a permanently tight fit should be maintained, operating from the dusty side.

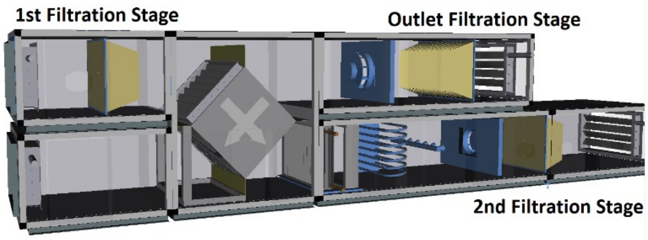

Figure 12. Filtration Stages

Each filter stage should display information on a nameplate that is durably and prominently visible. This information includes the nominal air flow rate of the AHU, the number of air filters in the filtration stage, filter type, filter class, dimensions, and the filter pressure difference in relation to the system's nominal air flow rate.

The operator is responsible for documenting important details such as the last filter change date, filter type, initial pressure loss, and recorded differential pressures during inspections. This information can be recorded on a visible tag or label placed near the nameplate.

In terms of fan selection, the filter pressure loss should be determined as the average of initial and final pressure losses for both clean and dust-loaded filters.

The minimum final pressure differences for filters, as directed by the following table, should be strictly adhered to, as stipulated.

Filter Class	Final Pressure Difference
ISO Coarse	The smaller value of either adding 50 Pa to the clean filter pressure difference or three times the pressure difference of clean filters.
ISO ePM1 ISO ePM2.5 ISO ePM10	The smaller value of either adding 100 Pa to the clean filter pressure difference or three times the pressure difference of clean filters.

Table 1. Final Pressure Difference according to **EN 13053**

Furthermore, in accordance with **VDI 6022-1**, microbial growth on air filters shall be prevented with similar measures, as mentioned in **EN 13053**, regarding the levels of Relative Humidity and the positioning of humidifiers. Lateral extraction of filters is permissible. In the case of unit heights of 1,6 or more, an additional door shall be arranged on the clean – air side. Filters must not lie flat on the floor, therefore in case of bag filters, the pockets must be installed in a vertical position near the floor.

In contrast with **EN 13053**, two filter stages are recommended for filtering the outdoor air. In the case of belt driven fans used in the airflow (except for flat belt drives) one filter stage shall lie downstream of the fan. Minimum requirements for filter classes are mentioned in the table below depending on the outdoor air quality.

Moreover, in line with **DIN 1946-4**, it is imperative that the process of changing air filters takes place on the dusty air side, ensuring the provision of adequate space for filter replacement. This space should be conveniently accessible upstream of the filter through a designated door or inspection opening. If there is an air coil with dehumidification installed outside the AHU, an additional class ISO PM1 80% filter should be promptly added downstream.

Standard **DIN 1946-4** shares some common ground with the aforementioned standards regarding the humidity levels near air filter area and the positioning of the filters. More specifically, in this standard, the treated air must be reheated by at least 3K by using preheaters with fin spacing of at least 4 mm (fin thickness at least 2 mm) or bare tube heat exchangers.

In addition, maintenance of the air filters must be taken into account. Space required for filter change upstream of it shall be at least equal to its construction depth. As it must be for all components of the AHU according to **DIN 1946-4**, for cleaning purposes, access shall be provided both upstream and downstream of the filter.

The placement of the 3rd filtration stage within the AHU is permissible only under specific circumstances and with proper justification, as stipulated by the hygienist's report.

In the pursuit of maintaining optimal hygiene, **DIN 1946-4** recommends that the maximum service life for the 1st filtration stage be limited to 12 months, while for the 2nd filtration stage, it should not exceed 24 months.

Filtration Stages	For Class I rooms, a 3-stage supply air filtration is required. The first 2 filtration stages installed in the AHU and the 3rd stage installed at the end.
1st	ISO ePM_1≥50% (previously class F7)
2nd	ISO ePM_1≥80% (previously class F9)
3rd	Class H13 HEPA Filters
Extract Air	ISO ePM_1≥50% (previously class F7)

Filtration Stages	For Class II rooms, a 2-stage supply air filtration is required. The 2 filtration stages installed in the AHU.
1st	ISO ePM_1≥50% (previously class F7)
2nd	ISO ePM_1≥80% (previously class F9)
Extract Air	ISO ePM_1≥50% (previously class F7)

Table 2. Filter Classification as per **DIN 1946- 4**

Heat Recovery Section

Heat recovery in an AHU refers to the process of capturing and utilizing waste heat from the exhaust air stream to preheat or pre-cool the incoming fresh air. The section should be designed with a thermal bypass capability. In addition to heat recovery, the inclusion of evaporation cooling on the extract air stream is recommended as per **EN 13053**.

Heat recovery shall feature four pressure tapping points, positioned on both sides of the heat exchanger for comprehensive monitoring.

In the context of category I and II heat exchangers within the heat recovery section, provision is made for a dedicated drain pan to effectively manage condensate accumulation.

DIN 1946-4 goes a step further by categorizing the conditioned spaces as follows:

Room Classes	Room Types
Class I (Ia)	Orthopedic and Trauma Surgery (e.g. total endoprostheses TEP) of the knee or hip). Neurosurgery associated with a particularly high risk of infection. Gynecological Surgery (e.g. breast prostheses). General Surgery (e.g. net implants for hernia treatment). Cardiovascular Surgery (e.g. vascular prostheses). Transplants (e.g. of whole organs). Operations lasting over several hours (e.g. tumor operations with large operation field). Operations where the total operation time is particularly long (including the approximate operating time, sterilization time of instruments, and incision to closure time).
Class I (Ib)	Class Ib rooms can also be used for operations such as inserting small implants (e.g. coronary stents), invasive angiography, heart catheterizing, MIS procedures and endoscopic examinations of sterile body cavities.
Class II	Are all rooms, corridors and areas for medical use which do not fall under class Ia or Ib.

Table 3. Conditioned Spaces as per **DIN 1946-4**

For category III heat exchangers, a purge sector is incorporated, with the exception being situations where recirculation air is utilized. This requirement might not be necessary in cases where the recirculated air is already treated or purified to meet indoor air quality standards.

In order to comply with EU 1253/2014, the minimum thermal efficiency for balanced mass flow of all HRS except run-around in BVUs must be at least 73% and for run-around HRS at least 68%.

Class	$n_{e\ 1:1}$ min [%]
Class I	≥ 74
Class II	≥ 70
Class III	≥ 65
The values are valid for balanced mass flow (1:1). The classes define the quality of the HRS and they have a strong influence on the thermal energy consumption. In Nordic countries, higher classes and in southern countries lower classes are common	

Table 4. Heat Recovery Section Classification

When the depth exceeds 1200 mm, plate heat exchangers with a minimum fin space of 3 mm are to be installed. In scenarios involving larger distances between fins, the maximum depth can be linearly expanded, ensuring flexibility in design and performance.

In accordance with **VDI 6022-1**, when it is not possible to prevent harmful or odorous substances from the extracted air using other methods, the heat recovery section should only be used if the recirculated air can be employed in a hygienic manner.

Figure 13. Plate Heat Exchanger

Carryover of harmful substances due to rotational entrainment or switchover volumes shall also be assessed. If such carryover cannot reliably be prevented, the use of these heat recovery systems shall only be allowed if the use of recirculated air in the system is also hygiene compliant.

In accordance with **DIN 1946-4**, it is essential that heat recovery section is equipped with a corrosion-resistant drip pan, either made of AISI 304 (SS1.4301) or Aluminum alloy (AlMg) and designed with a gradient for effective condensate drainage. The condensate basin should be sloped all around, and the connection drainpipe should have a diameter of no less than 40 mm and a sufficient slope to ensure efficient drainage.

For optimal system performance, the heat recovery section should be positioned downstream of the initial filtration stage. In environments where stringent hygienic requirements are imperative and air recirculation between rooms is restricted, it is recommended to exclusively employ heat recovery systems that prevent substance transfer, such as Run Around Coil systems and Plate Heat Exchangers.

Utilizing rotating regenerative heat exchangers, like heat wheels with brush or felt seals, doesn't prevent air leakage between air streams. In order to minimize exhaust air transfer ratio, positive pressure is required on fresh air side and negative pressure on exhaust air side. For this reason, return air fan shall be position downstream of the heat exchanger and supply air fan upstream. In this case, pressure differential across the rotary heat wheel shall not exceed 1.500 Pa due to risk of deforming heat exchanger's channels.

Coil Section

To ensure optimal performance, several factors concerning the construction of coils are imperative as dictated by **EN 13053**. They should be crafted from materials resistant to corrosion, thereby ensuring their longevity. Additionally, their fins should be designed for easy cleaning, exemplified using smooth fins.

Moreover, coil capacities should be evaluated following **EN 1226**[2] guideline.

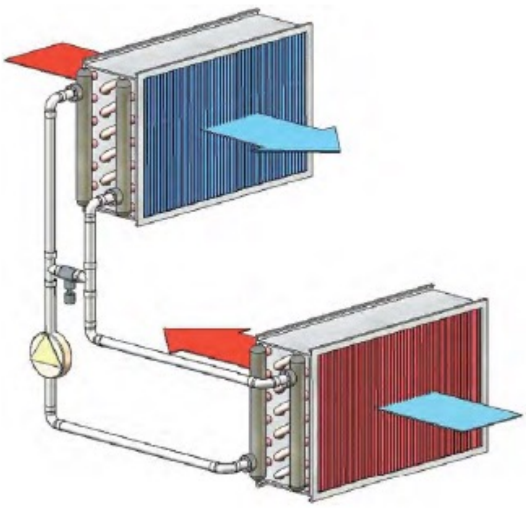

Figure 14. Run-Around Coil Heat Exchanger

The spacing between fins is crucial, requiring a minimum of 2.0 mm for air heating coils and 2.5 mm for air cooling coils.

For coils employed in heating processes before the initial filter stage, a minimum fin spacing of 4.0 mm is recommended to ensure protection against low air temperatures. In addition, a critical practice is to securely seal all coils within the casing using sealing strips to prevent any potential air leakage.

As per air cooling coils, it is crucial to avoid their immediate placement before air filters or silencers. To promote durability and efficient performance, cooling coils should incorporate a corrosion-resistant drip pan, selecting either AISI 304 (SS1.4301) or Aluminum alloy (AlMg) materials. This drip pan should possess a gradient designed to facilitate effective condensate removal.

[2] **EN 1226**, Heat exchangers - Forced circulation air-cooling and air-heating coils - Test procedures for establishing the performance.

Furthermore, headers, the connecting components for these coils, should be appropriately insulated where they pass through the casing. Choosing copper headers is advisable due to their corrosion durability. Alternatively, if galvanized headers are utilized, they should be made of hot dip coated galvanized steel to ensure resistance against corrosion and ensure durability. These considerations collectively contribute to an optimal and effective coil system.

Figure 15. Coil Section with Droplet Eliminator as per **DIN 1946-4**

In accordance with **VDI 6022-1**, condensate pan of air-cooling coils shall have sufficient sloping on all sides towards a water drain with siphon. The drip pan shall be made of corrosion resistant material such as steel 1.4301. Face velocity of air-cooling low shall be low enough to prevent the entrainment of droplets by the airflow. If this is not possible, then mist collectors shall be provided. Coil shall be accessible from both sides for visual inspection and cleaning. A minimum lamella spacing of 2 mm is recommended for air heaters and 2.5 mm spacing for dehumidifying heat exchangers.

Both **DIN 1946-4** and **EN 13053** share some common ground regarding the geometrical characteristics of the coil, both air cooling and heating, such as finned depth, fin spacing and the type of materials used for headers, drain pan, tubes etc.

Furthermore, **DIN 1946-4** requires that drip pans for cooling coils should feature a gradient towards the drain for efficient condensate removal with sloping on all sides. The connection drainpipe should possess a minimum diameter of 40 mm and should have an adequate slope to ensure effective drainage. The frame of the heat exchanger shall be from stainless steel (e.g. material no. 1.4301) or an aluminium alloy (e.g. AlMg).

Preferably, air cooling coils shall be designed in such a way that face velocity precludes the need for droplet separators. If the installation of droplet separator cannot be avoided due to risk of water droplets entering downstream components, then they shall be positioned upstream of the second filtration stage. They shall be corrosion-resistant, cleanable and it shall be possible to remove them for cleaning purposes from the casing via covers or service doors.

Staggered Coil (Triangular Tube Arrangement)	
Tube Size	**Maximum number of Rows**
3/8	14 Rows
1/2	10 Rows
5/8	8 Rows

Figure 15a. Fin depth and number of rows

Fan Section

In accordance with **EN 13053**, it is required to minimize suction side air leakage by strategically arranging supply air fans. To control relative humidity, it is advisable to position fans between dehumidification coils and filters or silencers. All three standards mandate the inclusion of inspection windows, with a minimum diameter of 150 mm, and require internal lighting with a smooth surface to facilitate easy visual inspection. For improved operational monitoring, the fan sections should incorporate an airflow rate indication, either directly within the fan chamber or on the control board.

Figure 16. Plug Fan Section

As indicated in **VDI 6022-1**, it is crucial to prioritize fans and fan drives that minimize the risk of compromising air quality due to belt abrasion, such as plug fans type.

For supply-air fans equipped with V-belt drives (except for flat-belt drives), it is required to incorporate a filter stage downstream in the airflow. This precaution contributes to maintaining air quality.

Figure 16a. EC Fans Section

Preventing water accumulation within the fan housing is essential to avoid any potential issues. As a part of maintenance considerations, accessibility to the fans should be guaranteed.

Radial fans are best suited with free-wheel impellers that lack housing, as these impellers are straightforward to clean. In the case of radial fans with housing, the provision of a sealable water drain for cleaning purposes is crucial. Alternatively, ensuring easy removal of the entire unit is necessary for maintenance. For fan housing with nominal impeller diameters of 400 mm or more, the incorporation of an easily removable inspection lid is a requirement.

Similarly, **DIN 1946-4** suggests that supply fans should be positioned between the 1st and 2nd filtration stages to prevent any water precipitation inside the fan. Fans lacking spiral casings (plug fans) shall be used because they are easier to clean. Belt-driven fans are not permitted.

The entirety of the fan unit, including the impeller and the base frame, should be effectively shielded against corrosion, with a minimum protective measure of sendzimir galvanization and coating.

Each fan section should have permanent affixation of the following information:

- Type and year of construction
- Operating mode
- Nominal flow rate
- Total pressure increase
- Nominal and maximum rotational speed
- Nominal motor power
- Rotational direction of the fan impeller

Humidifier Section

Standard **EN 13053** requires that the plastics used should not contain any substances that could support the growth of microorganisms. Except for steam humidifiers, supply air humidifiers should be positioned between the first and second filter stages, with the condition that they should not be right before air filters or attenuators.

Sealing materials should be of the closed-cell type, capable of resisting moisture absorption. The manufacturer's maintenance instructions need to be available and adhered to.

During operation, adequate overflow measures should be incorporated in evaporative humidifiers. During periods of non-operation, it is necessary to completely empty the tray. Ultraviolet treatment and regular flushing are advisable.

To prevent the formation of droplets downstream of the humidifier, the section's length should be appropriately designed and/or droplet eliminators should be installed. In all three hygienic standards, an inspection opening (minimum diameter 150 mm) and internal lighting is mandatory.

For more detailed information about humidifier classification, please refer to section 6.8 of **EN 13053**.

In accordance with **VDI 6022-1**, air humidifiers, in conjunction with preheaters and after heaters, should be adequately sized to prevent the downstream relative humidity from surpassing 90% along the humidifier line.

To avert microbial growth, particularly during periods of standstill, stringent measures are in place. These extend to scenarios involving extended standstills of the ventilation and air-conditioning system, requiring careful attention to prevent lingering areas of high humidity downstream of humidifiers or coolers. To achieve this, a strategic approach involves timely shutdowns of humidifiers and coolers, accompanied by stepwise air duct drying.

Accessibility and functional design are paramount for air-humidifying components. They should facilitate inspection, checks, and cleaning of water-carrying regions at any time. Notably, installation of humidifiers immediately upstream of filters or silencers is to be avoided, along with any potential for cooling below dew point and water carryover into these components.

To manage condensate effectively, humidifiers should incorporate downstream droplet eliminators and a condensate tray with all-around sloping towards the drain and a siphon equipped with a trap. The system should be programmed to automatically switch off humidifiers during shutdowns or system failures. A stepwise shutdown approach guarantees thorough drying of the humidifier chamber prior to intended shutdowns.

Different configurations apply to air humidifiers operating with or without recirculating water. For those utilizing recirculating water, the blow-drying control system shall be checked for proper functioning at regular intervals and shall be readjusted if necessary. During times of operation when no humidification of the air is required, the water-carrying system parts shall automatically be emptied completely and dried after 48 hours at the latest. In cases of recirculating water absence, measures should ensure that no aerosols enter the air ducting. This requires an adequately long humidifier line and uniform humidity distribution across the airway cross section.

The minimum required length for a steam humidifier must be at least 960 mm.

Figure 17. Steam Humidifier Section

Furthermore, in accordance with **DIN 1946-4**, humidifiers should be equipped with a drip pan resistant to corrosion, constructed from either AISI 304 (SS1.4301) or Aluminum alloy (AlMg), and designed with a drain-friendly gradient. This ensures efficient condensate drainage, facilitated by the sloped configuration of the condensate basin on all sides, along with a connection drainpipe possessing a minimum diameter of 40 mm.

For optimal results, in contrast to **EN 13053**, it is recommended to install all air humidifiers before the second filtration stage (F9 filter class) within the AHU. This design approach prioritizes preventing the formation of droplets in the supply air flow. It is also advisable to maintain the relative humidity at the end of the humidified area below 90%. Additionally, the accessibility, inspection, and thorough cleaning of air humidifier components from all sides are vital considerations.

Importantly, **DIN 1946-4** specifies that, for hygiene reasons, only air humidifiers using steam that do not pose a health risk are permitted.

Sound Attenuation Section

In alignment with **EN 13053**, the assessment of sound attenuation sections' effectiveness should adhere to the testing protocols delineated in **EN ISO 7235**[3]

When incorporating attenuators (if relevant), it's recommended to install them right before and/or after the fan section. It's crucial to avoid placing attenuators directly after dehumidification coils or humidifiers. To ensure unhindered inflow and outflow, it is significant to maintain a minimum distance from other installed components, which should be equivalent to 1.0 x Maximum splitter thickness for inflow and 1.5 x Maximum splitter thickness for outflow.

For practical realization, splitters should be thoughtfully designed to allow easy removal for cleaning convenience. Moreover, these splitters should be constructed from materials exhibiting enduring abrasion resistance and confirmed to be safe from a health perspective.

In accordance with **VDI 6022-1** it is advised to exercise caution and avoid situating silencers in regions with unfiltered outdoor air. Additionally, the placement of silencers directly downstream of coils equipped with dehumidifiers or heat recovery units with dehumidifiers should be avoided to ensure optimal functionality.

To uphold efficiency and ease of maintenance, silencers and acoustic baffles should be designed for easy replacement. The components responsible for sound absorption within these silencers should be lined with materials exhibiting permanent abrasion resistance, capable of withstanding cleaning procedures, and safe for human health, such as fiberglass. Alternatively, these sound-absorbent components themselves could be constructed from materials inherently possessing permanent abrasion resistance and the ability to endure cleaning processes.

Figure 18. Sound Attenuator

Similarly, following **DIN 1946-4**, the strategic positioning of sound attenuators is emphasized. It is recommended that they are placed downstream of the initial filtration stage and, if possible, upstream of the second filtration stage.

However, certain limitations are also applied to their placement. Specifically, sound attenuators should not be installed directly after a dehumidification coil or a humidifier. Similarly, their placement should avoid being directly positioned after the third filtration stage in the direction of the airflow.

To ensure optimal functionality, the surfaces of the splitters housed within the sound attenuators should possess attributes like smoothness, resistance to abrasion, water repellency, and the ability to resist decay.

[3] **EN 7235**, "Acoustics — Laboratory measurement procedures for ducted silencers and air-terminal units — Insertion loss, flow noise and total pressure loss."

How does Carrier's 39HQ comply with the standards?

The **Carrier 39HQ Hygienic AHUs** is engineered to harmonize with these standards, these units assure superior air quality. Their adaptability, backed by a hygiene certificate from TUV, underscores their compliance with **EN 13053**, **DIN 1946-4**, and **VDI 6022-1**.

The units are equipped with removable panels, allowing for easy access and maintenance. The panel and profile connections are designed to eliminate the need for drilling into the panel body, ensuring the integrity of the casing.

To ensure the mechanical performance of **Carrier's 39HQ** air handling unit aligns with the **EN 1886**[3] and **EN 13053** standards, it is necessary to establish the characteristics of the casing wall construction. This process involves conducting measurements on both a model box and a real unit.

Specifications as per EN 1886 - 2007:

Specifications (EN 1886)						
Thermal Transmission	T5	T4	T3	T2	T1	
Thermal Bridging	TB5	TB4	TB3	TB2	TB1	
Filter Bypass Leakage	G1-G4	F5	F6	F7	F8	F9
Body Sealing	L3	L2	L1			
Mechanical Strength	D3	D2	D1			

Table 6. The standard construction model Carrier 39HQ is marked in blue, moving to the right to enhance the quality.

Internally, the **Hygienic AHUs** feature high-quality stainless steel interior panels, available in either 316 or 304 type with a thickness of 0.8 mm. These panels provide excellent durability and corrosion resistance, making them ideal for demanding environments. The external panels, available in 0.8 - or 1.25 mm thickness, undergo rigorous testing to ensure their resilience. Surface treatment includes a zinc density of 225 gr/m² and are pre-painted with polyurethane – polyamide (Pur-Pa) 35 µm. These panels are resistant to the harshest conditions, even enduring a salty water test for 500 hours, as per ASTM B 117.

To enhance cleanliness and ease of maintenance, the units are designed with a door threshold that aligns perfectly with the floor panel, facilitating effortless cleaning. The units feature hygienic ABS corners, carefully constructed to resist corrosion, and ensure their longevity. The doors, available in various sizes and types, are accompanied by accessories for enhanced functionality. Special foam gaskets are utilized on the doors to minimize air leakage, ensuring optimal performance and energy efficiency. Moreover, all screws used in the indoor panels are made of stainless steel, providing added strength and reliability.

[3] **EN 1886**, "Ventilation for buildings - Air handling units - Mechanical performance."

On the exterior AHUs, Carrier goes the extra mile to ensure maximum protection and longevity. A UV-resistant and water-tight special roof coating is applied, safeguarding the units against the harmful effects of environmental elements. The application of extra silicon enhances airtightness and hygiene. All screws used in the exterior components are made of stainless steel, offering superior corrosion resistance. Additionally, the units are equipped with louvres and cowls on the air inlets and outlets, providing flexibility and control in air distribution.

The coil section includes various types, such as hot water coils, cold water coils, direct expansion (DX) coils, and steam coils. These coils are designed with materials resistant to corrosion, featuring a corrosion-resistant drip pan and headers made of either copper or galvanized steel. The frame of the coils is also constructed with high-quality stainless steel either 316 or 304. Furthermore, the coils are equipped with eliminators made from stainless steel to enhance their durability and performance.

As per fan sections, the utilization of EC plug fans without belt-drive mechanisms is recommended. In situations calling for belt-driven fans, the initial preference should be for straight belt types, as emphasized in **VDI 6022-1**. Moreover, for enhanced performance, additional filter integration after the fan is advised.

To ensure effortless maintenance and operational transparency, the units feature a door equipped with sight glass, facilitating easy access to the fan section. Within this cell, an LED light armature with a smooth surface ensures optimal visibility. Furthermore, each comes equipped with informative labels, offering valuable insights into fan specifications and characteristics.

Carrier's 39HQ hygienic units prioritize the use of heat recovery systems that maintain a clear separation between return air and fresh air, such as those utilizing plate, run around coil, or heat pipe configurations. Wheel-type heat recovery systems are not the preferred choice.

Lastly, these units are designed with access available from both sides of the heat recovery section. To ensure efficient drainage of condensed water, a drain pan and syphon system are integrated beneath the section.

EN 13053:2020-5

General and Documentation	AHUs shall have permanently attached type plates with permanent labeling.
	A drawing of the unit with all the main and duct connection dimensions, a design data sheet, a spare part list plus assembly, commissioning and maintenance instructions shall be supplied with the AHU.

Casing	Minimum double skin panels with sandwiched insulation.
	Minimum galvanized steel sheet.
	Smooth surfaces inside the casing. No sharp edges or pointed objects.
	Casing air leakage shall not exceed class L2 (R) and thermal bridging factor as per **EN 1886**.

Seals	The seals used shall not absorb any moisture and shall not form a nutrient substrate for microorganisms.

Access	All equipment components shall be easily accessible and able to be cleaned. Both upstream and downstream access doors or inspection panels or they shall be easy and safe to remove.

Outdoor Air Intake	Shall be provided with a drain pan.
	Floor surface minimum galvanized and coated/painted steel sheet, powder coated, or wet painted with primer and top coat of thickness ≥60 µm or coil coated galvanized steel sheet.
	Weatherproof units shall have inlet and outlet apertures with weatherproof devices e.g.
	Louvre with max air velocity 2.5 m/s for intake and 4.0 m/s for exhaust.
	All inlet and outlet apertures shall be protected by a grid of maximum 20 mm x 20 mm but not very small grid holes because of the effects of clogging.

Fans	Arrange the supply air fans so the suction side leakage air flows are minimized.
	Use backward curve blades fans with increased efficiency motors.
	Fans should be arranged between dehumidification coils and filters or silencers to limit relative humidity.

Coils	They shall be made from corrosion resistance materials and fins shall be easily cleanable, e.g. smooth fins.
	Capacities rated in accordance with **EN 1216**.
	Min fin spacing 2.0 mm for air heating coils and 2.5 mm for air cooling coils with dehumidification.
	Heating coils for drying before first filter stage min fin space 4.0 mm.
	All coils shall be sealed within the casing by means of sealing strips.
	Dehumidification coils shall not be arranged immediately before air filters or silencers.
	Coolers shall be fitted with corrosion resistance drip pan, AISI 304 (SS1.4301) or Aluminum alloy (AlMg) with gradient towards the drain.
	Headers shall be insulated where they pass through the casing. Copper headers are recommended. If galvanized are used, then should be hot dip galvanized steel.

Heat Recovery	The Heat Recovery system shall have a thermal bypass facility. In addition to heat recovery, evaporation cooling should be installed on the extract air.
	All heat recovery sections should have 4 pressure tapping points, one for each air flow side of the heat exchanger.
	Within the heat recovery section for category I and II heat exchangers, shall be a drain pan for condensate.
	Category III heat exchangers shall include a purge sector, except when recirculation air is used.
	Plate heat exchangers with a min fin space 3 mm should be installed, when the depth exceeds 1200 mm. In case of larger distances between the fins the max depth can be expanded linearly.

Damper Sections	Air regulating and shut off dampers classification and testing shall be according to **EN 1751**.
	Damper face velocity shall be limited to 8m/s. (exception: recirculation air and bypass dampers).
	Min inflow angle α = 25°, min outflow angle β = 35° is recommended.
	Supply air and exhaust air shut-off dampers (will be installed) shall meet air tightness class class 2 or class 3 in installations with high requirements for hygiene or energy economy.
	Bypass dampers for heat recovery and recirculation dampers for mixing section shall meet air tightness class 2.

Humidifiers	The plastics used shall not contain sources of nutrition for microbiological growth.
	Supply Air Humidifiers (exception: steam humidifiers) should be arranged between first and second filter stage, but not immediately before air filters or attenuators.
	First filter stage should by ISO ePM1 50%.
	Sealing materials shall be made of closed cell type, not absorb any moisture.
	Manufacturer's maintenance instructions shall be available and observed.
	Sufficient overflow shall be arranged in evaporative humidifiers during operation. For nonoperation time, a complete emptying of the tray shall be done. Ultraviolet treatment and regular flushing are recommended.
	In order to avoid droplets downstream of the humidifier, the length of the section shall be adequate and/or droplet eliminators shall be installed.

Sound Attenuation	Performance of sound attenuation sections shall be tested according to **EN ISO 7235**.
	Attenuators (if any) should be placed in the AHU immediately before and after the fan.
	Attenuators shall not be arranged immediately after dehumidification coolers or humidifiers.
	Minimum distance from other installed components of 1.0x(inflow) and/or 1.5x(outflow) maximum splitter thickness shall be provided.
	Splitters should be removable for cleaning and shall consist of permanently abrasion-resistant material which is safe from a health point of view.

Filter Sections	Air tightness, strength and bypass leakage are specified in **EN 1886**.
	Filter section shall be equipped with inspection door.
	Filter section shall be equipped with tapings for a pressure loss gauge / manometer.
	Filter section shall be equipped with inspection Window (min D150 mm) and internal light.
	For possible frost accumulation a slight preheating might be required.
	The moisture running off the filters may require corrosion protection.
	First filter stage is fitted as close as possible to the outer intake. The second filter stage is arranged at the beginning of the supply duct (in the AHU).
	If a single stage filter is used for supply air system then it shall be at least ISO ePM1 50%.
	If two stage filtering is used, supply fan shall be arranged between first and second filter stage.
	Max RH in the filter area is 90%.
	Air filters shall not be arranged immediately after dehumidification coolers of after humidifiers (exception: steam humidifiers).
	If bag filters are used filter area should be at least $10m^2$ per $1m^2$ equipment cross section.
	A permanent tight fit shall be used for seal, operating from dusty side.
	For fan selection the filter pressure loss shall be the average of the initial and final pressure loss for clean and dust loaded filters.
	Filter section shall be equipped with measuring devices for pressure difference (e.g. signaling or alarm).
	The following data shall be displayed in a clear, visible form (e.g. label) on the filter section: filter class, filter medium, final pressure difference. On changing the filter, the user shall check and update this information.

VDI 6022-1:2018-01

General and Documentation	It is recommended that after commissioning and prior to hand-over to the customer, the system is equipped with new, clean air filters.

Casing	Materials used in air handling areas where high values of relative humidity, or large quantities of water, are inherent in the intended use, must not provide o nutrient substrate for microorganisms.
	Porous materials with open pores such as linings, insulating materials (except acoustic baffles), or seals in contact with the airflow are not permitted. Units shall have double-skin casings in accordance with **DIN EN 13053** (insulation sandwiched between internal and external panels).

Seals	Sealing materials in air handling areas shall be closed pored. They shall not absorb any humidity or release any odors and, in particular, must not provide a nutrient substrate for microorganisms.
	Closed-pored seals shall be used in filter sections

Access	In order to ensure compliance with hygiene requirements, unit housings with a clear height of 0.8 m or less shall at least have easily removable service lids or, in case of larger housings and central chambers, a sufficient number of service doors. Installing inspection windows (with a diameter of not less than 150 mm) plus internal lighting to facilitate visual inspection for checking the components is recommended. Such windows are mandatory for all humidifiers, as well as for fans and air filters with a clear housing height of 1.3 m or more.

Outdoor Air Intake	Water drain near outdoor-air intake

Fans	For hygiene reasons, fans and fan drives which are unlikely to impair the air quality through belt abrasion are most preferrable.
	Outdoor Air Intake
	Water precipitation in the fan housing shall be prevented.
	Fans shall be accessible for maintenance.
	Free-wheel impellers without housings are recommended for radial fans as they are easier to clean.
	For cleaning purposes, radial fans with housing shall have a water drain which can be sealed; otherwise easy removal of the overall unit shall be possible.
	In case of nominal impeller diameters of 400 mm or more, the fan housing shall have an easily removable inspection lid.

Coils	Surfaces in contact with the air shall be smooth and corrosion resistant.
	The lamella spacing shall be matched to the expected dust load.
	Air filtration is recommended in order to reduce contamination and extend cleaning intervals; in the case of central air-handling units use, e.g., a filter stage of class M5.
	Heat exchangers shall allow sufficient access from both sides for visual inspection, for any sampling required and for cleaning; they shall allow extraction, if necessary.
	Depending on the lamella spacing and the air cleanliness, the internal depth as measured along the direction of the flow shall be limited to such extent that thorough cleaning using commercially available tools and equipment is still easy; if necessary, the heat exchanger shall be of split design.
	A condensate tray, sloping sufficiently on all sides towards a water drain with siphon, preferably with trap, shall be provided underneath. The condensate tray shall be made of corrosion resistant material, such as steel 1.4301. The condensate tray shall be easily accessible for cleaning and disinfection.
	The construction shall ensure that the tray empties itself completely during standstills, allowing any residual water adhering through surface tension to dry off by "dry-blowing" the system.
	Prevent the entrainment of droplets by the airflow (e.g. by keeping airflow velocities low); if necessary, provide mist collectors.
	Any mist collectors shall be accessible for checking and cleaning at reasonable effort and shall allow extraction or a similarly convenient method of disassembly.

Spray Cooling	In case of extended standstills of the ventilating and air-conditioning system (for more than 48 hours), it shall be ensured, in addition to the precautions specified in Section 4.2.3, that no humid areas are left downstream of humidifiers or coolers. For this purpose, switch off humidifiers and coolers in due time and blow the air ducts dry (stepwise shutdown).
	Use of effective mist collectors.
	At the lowest point of the tray, drainage allowing complete emptying shall be provided.
	Provide an inlet sieve or an installed, easily cleanable filter to protect the water circulation pump.
	Install a mesh in order to avoid taking in coarse airborne contaminations.
	Any packing elements installed shall be removable.

Heat Recovery	Heat recovery units in which the carryover of harmful and/or odorous substances from the extract air cannot be prevented by means of other measures may only be used where the use of recirculated air would be possible from the point of view of hygiene.
	Leaky heat recovery units shall be considered as an instance of air recirculation unless a sufficient, controlled pressure drop is ensured in the heat recovery unit from outdoor air to exhaust air. Carryover of harmful substances due to rotational entrainment or switchover volumes shall also be assessed. If such carryover cannot reliably be prevented, the use of heat recovery systems shall only be allowed if the use of recirculated air in the system is also hygiene-compliant.

Damper Sections	In case of short standstills of the ventilating and air-conditioning system, as, e.g., when switched off during night times or for maintenance purposes, automatic closing of the dampers to be installed in the air ducting (outdoor air, exhaust air, supply air, if any) shall prevent air from flowing through the system due to wind or buoyant forces.

Humidifiers	Air humidifiers together with preheaters and after heaters shall be so dimensioned that a relative humidity of 90 % is not exceeded downstream of the humidifier line.
	Microbial growth in humidifier units, also during standstills, shall be avoided.
	In case of extended standstills of the ventilating and air-conditioning system (for more than 48 hours), it shall be ensured, in addition to the precautions specified in Section 4.2.3, that no humid areas are left downstream of humidifiers or coolers. For this purpose, switch off humidifiers and coolers in due time and blow the air ducts dry (stepwise shutdown).
	Air-humidifying components shall be easily accessible. In particular, they shall be so designed that water-carrying ranges can be inspected, checked and cleaned at any time.
	Droplet eliminators downstream of air humidifiers, including condensate trays and drains, shall meet the same requirements as droplet eliminators downstream of air coolers.
	Humidifiers must not be installed immediately upstream of filters or silencers. Cooling below dew point and the carryover of water into the air filter or silencer shall be avoided at any rate.
	An inspection opening (with a diameter of not less than 150 mm) and lighting of the humidifier chamber shall be provided. A means for darkening the inspection opening shall be available except in the case of steam humidifiers.
	No external light must enter through the housing of the lighting. It shall be possible to recognize the condition of the lighting (on/off) from outside.
	Humidifiers shall be equipped with a condensate tray sloping towards the drain on all sides and having a siphon with trap.
	In case of shutdown or failure of the ventilating and air-conditioning system, the humidifier shall be switched off automatically. Ensure, by means of stepwise shutdown, that the humidifier chamber is blown dry before intended shutdowns.
	Air humidifiers operating with recirculating water shall be equipped with a system for desalinating the recirculating water.
	Air humidifiers operating without recirculating water shall be so designed and operated that no aerosol can enter the air ducting. For avoiding the formation of condensate in downstream air duct sections, the humidifier line must be sufficiently long, and homogeneous distribution of the humidity over the airway cross section must be ensured.
Sound Attenuation	At temperatures > 0 °C, high relative humidities (> 80 %) at components of ventilating and air-conditioning systems may cause problems due to microbial growth. Humidities > 90 % at air filters will cause problems, e.g. at air filters even if they occur only for short periods. If, at this temperature level, high humidities over extended periods are to be expected for an installation location, or moistening of air filters or silencers is likely (as is the case in areas with a high probability of fog or with frequent extended rainfall periods), suitable precautions against microbial growth shall be taken especially on air filters or silencers. In this case, the air shall be reheated proximately 3 K.
	If possible, do not place silencers in regions with unfiltered outdoor air.
	Silencers must not be installed directly downstream of coolers with dehumidifiers or heat recovery units with dehumidifiers.
	Silencers and acoustic baffles shall be designed to be replaceable.
	The sound-absorbent components shall be lined with a material that is permanently abrasion resistant, withstands the effects of cleaning and is harmless to human health, such as fiber-glass. Alternatively, the sound-absorbent components proper may be manufactured of permanently abrasion-resistant material withstanding the effects of cleaning.

	At temperatures > 0 °C, high relative humidities (> 80 %) at components of ventilating and air-conditioning systems may cause problems due to microbial growth. Humidities > 90 % at air filters will cause problems, e.g. at air filters even if they occur for short periods only. If, at this temperature level, high humidities over extended periods are to be expected for an installation location, or moistening of air filters or silencers is likely (as is the case in areas with a high probability of fog or with frequent extended rainfall periods), suitable precautions against microbial growth shall be taken especially on air filters or silencers. In this case, the air shall be reheated proximately 3 K.
	Air filters shall be tested in accordance with **EN 779** or **EN 1822**, and which are labelled individually. Filter selection, installation and maintenance shall also comply with the requirements specified in VDI 3803 Part 4.
	Changing air filters shall be possible from that side which is laden with dust. Lateral extraction is permissible.
	In case of unit heights of 1.6 m or more, an additional door shall be arranged on the clean-air side.
	Filters must not lie flat on the floor of the chamber. Pocket filters shall always be installed with the pockets in a vertical position near the floor.
	For AHUs, the following data shall be permanently marked on the outside of the air-filter chamber: nominal air volume flow of the system, not the value given by the filter manufacturer, number of air filters installed at the respective filter stage, filter class, dimensions (height × width), final pressure drop recommended by the system planner or installer on the basis of the fan characteristic.
	Irrespective of the existence of further monitoring devices, each filter stage of a ventilating and air-conditioning system or air-handling unit (with an air volume flow in excess of 1000 m3/h) shall be equipped with a differential-pressure gauge having an appropriate working range, for monitoring the current pressure loss over the air filter. The measuring display shall be easy to read. In the case of ventilating and air-conditioning systems and air-handling units with an air volume flow of less than 1000 m3/h and of terminal devices, monitoring the time of operation or another suitable method is sufficient.
Filter Sections	The following data shall be recorded for each filter change and for each routine check on a card supplied by the installer, which is affixed to the filter chamber (Recording the data in the maintenance record only does not suffice.): filter change – date, initial pressure drop reading, latest time of next filter change, name of person performing the change, routine check – date, pressure gauge or differential pressure gauge, zero position checked – differential pressure reading, name of person performing the check.
	Using two filter stages for filtering the outdoor air is recommended. The use of air filters of higher classes is recommended for hygiene reasons, in order to minimize the carryover of viable and non-viable airborne contaminants into the ventilating and air-conditioning system.
	Regarding the arrangement of the air filter stages, observe that one filter stage shall lie downstream of the fan if a fan with drive belt is used in the airflow (an exception being made for flat belt drives).
	In central ventilating and air-conditioning systems and air-handling units, the outdoor air shall be cleaned using filters of class F7 or better. Recirculated air shall be cleaned using filters of class F5 or better. Air cleaning requires mixed air to be filtered using filters of at least class F7; as for fine dust, filters shall be at least class F9.
	Depending on the outdoor-air quality (AUL 1 through AUL 3 in accordance with **EN 13779**), varying air filter classes and stages are required, as per bellow.
	Air filter inserts shall be changed at the latest if the permissible final pressure drop has been reached or when technical and/or hygiene deficiencies are observed.
	The air filters of the first stage shall be changed after one year at the latest, those in further filter stages (except high-efficiency particulate air filters) after two years.
	The above maximum filter life can be extended by a year if an additional hygiene check of the respective filter stage is performed and the protection goal is achieved.

Outdoor-air quality as per VDI 6022 part 3[1]	**ZUL 1 (very High)**	**ZUL 2 (high)**	**ZUL 3 (medium)**
AUL 1 (clean)	ISO ePM10 50% + ISO ePM1 50%	ISO ePM1 50%	ISO ePM1 50%
AUL 2 (contaminated)	ISO ePM2,5 65% + ISO ePM1 50%	ISO ePM10 50% + ISO ePM1 50%	ISO ePM10 50% + ISO ePM1 50%
AUL 3 (highly contaminated)	ISO ePM1 50% + ISO ePM1 80%	ISO ePM2,5 65% + ISO ePM1 50%	ISO ePM10 50% + ISO ePM1 50%

Table 5. Recommended filter classes as per VDI 6022-1

[1] definition identical with ODA 1(AUL 1) to ODA 3 (AUL 3) as per **DIN EN 16798-3**

DIN 1946-4:2018-09

General and Documentation	A test report (e.g. Eurovent) issued by an independent body attesting compliance with the requirements of mechanical characteristics of the equipment casing shall be provided.

Casing	Casing materials which come in contact with the air flow shall be resistant to disinfectants.
	AHU's components shall meet the requirements of **EN 1886** and **EN 13053**.
	Inside surfaces shall be at least sendzimir galvanized and coated (25µm min for coil coating, 60µm min for powder coating or double layered wet coating with base coat and top coat) and the lower part of the casing, including slide-in rails of components and all other surfaces which could potentially come in contact with (condensation) water, shall be corrosion resistant and made of stainless steel (1.4301) or an aluminum alloy (e.g.AlMg).
	Smooth surfaces inside the casing. No sharp edges or pointed objects.
	AHUs casings as per **EN 1886** shall be:
	Mechanical stability: at least D2
	Casing air leakage: at least L2
	Filter bypass leakage: max 0.5% of the nominal air flow rate
	Thermal transmittal of the casing: at least T2
	Thermal bridging factor shall be at least TB3. If the temperature inside the outdoor air chamber < -7 °C, OR where the casing is designed to be weatherproof (outdoor installation), Thermal bridging factor shall be TB2.

Seals	Shall not be harmful to health, shall not emit odors or harmful substances and shall not provide a nutrient medium for microorganisms.
	Sealing profiles shall be of closed-pore materials and shall not absorb any moisture. Seals on doors and filter mounting frames shall be inserted, clamped or foamed, they cannot be glued. Glued seals are only permitted on the filter insert and only for single use.

Access	In the case of non walk-in type casings (enclosures) (clearance < 1.6m), a sufficient number of Removable Covers or Service Doors shall be provided.
	For walk-in casings a sufficient number of Service Doors will be provided.
	All AHU's components shall be accessible from both upstream and downstream, or, as an alternative for clearance < 1.6m they shall be easily and safely removable.

Outdoor Air Intake	Shall be provided with a pan, corrosion resistant made of stainless steel (1.4301) or an aluminum alloy (e.g. AlMg). The accessibility of the basing area shall be ensured by providing removable covers or service doors. Condensate basing shall be sloped all around. The connection drainpipe shall have a diameter of at least 40 mm and a sufficient slope.
	All inlet and outlet apertures shall be protected by a corrosion resistant wire mesh grating of maximum 20 mm x 20 mm which shall be accessible on the dirty side for mechanical cleaning.

Fans	Supply fans shall be located between the 1st and 2nd filtration stages to exclude any precipitation of water inside the fan.
	Fans without spiral casings shall preferably be used.
	Centrifugal fans shall be provided with water discharge opening and a closure in the fan casing. For nominal sizes ≥ 400 mm an easily removable inspection lid is required.
	The entire fan unit including the impeller and the base frame shall be protected against corrosion (at least sendzimir galvanized and coated).
	The following information shall be permanently affixed to every fan chamber: Type/year of construction/mode, Nominal flow rate, Total pressure increase, Nominal and maximum rotational speed, Nominal motor power, rotational direction of fan impeller.
	Fans sections shall be equipped with inspection windows (min D150 mm) and internal lighting with smooth surface.
	AHU fans chamber shall be equipped with air flow rate indication at the fan chamber or the control board.

Coils	Coolers shall be fitted with corrosion resistance drip pan, AISI 316 (SS1.4301) or Aluminum alloy (AlMg) with gradient towards the drain. Condensate basing shall be sloped all around. The connection drain pipe shall have a diameter of at least 40 mm and a sufficient slope.
	All condensate connections shall be located on the same side.
	Min fin spacing 2.0 mm for air heating coils and 2.5 mm for air cooling coils with dehumidification.
	Corrosion resistant materials shall be used, such as aluminum for fins, copper for tubes and copper or galvanized steel for collectors.
	The frame of the coils shall be corrosion resistant and be made from stainless steel (1.4301) or an aluminum alloy (e.g. AlMg).
	It shall be possible to inspect the air cooler from both sides when it is installed.
	Headers shall be insulated where they pass through the casing. Copper headers are recommended. If galvanized are used, then should be hot dip galvanized steel.
	Droplet eliminators shall be positioned upstream of the 2nd filtration stage. They shall be corrosion resistant and it shall be possible to remove them from the casing via covers or service doors.

Heat Recovery	Heat Recovery units shall be fitted with corrosion resistance drip pan, AISI 304 (SS1.4301) or Aluminum alloy (AlMg) with gradient towards the drain. Condensate basing shall be sloped all around. The connection drain pipe shall have a diameter of at least 40 mm and a sufficient slope.
	Heat recovery systems shall be installed on the supply air side downstream of the first filtration stage.
	In rooms subject to stricter hygienic requirements and where air may not be recirculated between rooms, only heat recovery systems in which a transfer of substances can be excluded shall be used.

Damper Sections	AHUs shall be equipped with (multiple leaf) dampers for outdoor, supply, extract, and exhaust air openings/duct connections and they shall at least meet the criteria for leakage class 2. Where sticker tightness requirements apply, those of class 4, in accordance with **EN 1751** shall meet.
	Dampers for weatherproof (outdoor) units shall be located on the inside. For units which are intended for indoor installation, the outdoor air dampers shall either be located on the inside or, if located on the outside, be provided with a double-layer of insulating material.
	The current damper position (open/closed) shall be visible on the outside of the damper.
	Outdoor air shut-off dampers shall be corrosion resistant, made of either stainless steel (1.4301) or an aluminum alloy (e.g. AlMg) and shall close automatically in the case of an interruption in the energy supply (spring return).

Humidifiers	Humidifiers shall be fitted with corrosion resistance drip pan, AISI 304 (SS1.4301) or Aluminum alloy (AlMg) with gradient towards the drain. Condensate basing shall be sloped all around. The connection drain pipe shall have a diameter of at least 40 mm and a sufficient slope.
	Humidification sections shall be equipped with inspection windows (min D150 mm) and internal lighting with smooth surface.
	In general air humidifiers shall be located upstream of the 2nd filtration stage (filter class F9) inside the AHU.
	Air humidifiers shall be designed so that droplets do not form in the supply air flow.
	The relative humidity at the end of the humidified area shall not exceed 90%.
	Air humidifier components shall be easy to access, inspect and clean from all sides.
	Only steam humidifiers are to be used.

Sound Attenuation	Sound attenuators shall be installed downstream of the 1st and preferably upstream of the 2nd filtration stage.
	Thy shall not be installed immediately downstream of a cooler with dehumidification function or a humidifier, nor immediately downstream of the 3rd filtration stage in the direction of flow.
	Splitters surfaces shall be smooth, abrasion proof, water repellent and non-decaying.

Room Classes	Room Types
Class I (Ia)	Orthopedic and Trauma Surgery (e.g. total endoprostheses TEP) of the knee or hip).
	Neurosurgery associated with a particularly high risk of infection.
	Gynecological Surgery (e.g. breast prostheses).
	General Surgery (e.g. net implants for hernia treatment).
	Cardiovascular Surgery (e.g. vascular prostheses).
	Transplants (e.g. of whole organs).
	Operations lasting over several hours (e.g. tumor operations with large operation field).
	Operations where the total operation time is particularly long (including the approximate operating time, sterilization time of instruments, and incision to closure time).
Class I (Ib)	Class Ib rooms can also be used for operations such as inserting small implants (e.g. coronary stents), invasive angiography, heart catheterizing, MIS procedures and endoscopic examinations of sterile body cavities.
Class II	Are all rooms, corridors and areas for medical use which do not fall under class Ia or Ib.

Filtration Stages	**For Class I rooms, a 3 stage supply air filtration is required.**
	The first 2 filtration stages installed in the AHU and the 3rd stage installed at the end.
1st	Class ISO ePM1 50% (F7) filters.
2nd	Class ISO ePM1 80% (F9) Filters
3rd	Class H13 HEPA Filters
Extract Air	In the extract air systems with particle loading a filter class ISO ePM1 50% (F7) filters.

Filtration Stages	**For Class II rooms, a 2 stage supply air filtration is required.**
	The 2 filtration stages shall be installed in the AHU.
1st	Class ISO ePM1 50% (F7) filters.
2nd	Class ISO ePM1 80% (F9) Filters
Extract Air	In the extract air systems with particle loading a filter class ISO ePM1 50% (F7) filters.