International Standard

ISO 7615-1

Energy performance of building systems — Underfloor air distribution systems —

Part 1: General overview

First edition
2024-09

Reference number
ISO 7615-1:2024(en)

ISO copyright office
CP 401 • Ch. de Blandonnet 8
CH-1214 Vernier, Geneva
Phone: +41 22 749 01 11
Email: copyright@iso.org
Website: www.iso.org

Published in Switzerland

Contents

Page

Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular, the different approval criteria needed for the different types of ISO document should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

ISO draws attention to the possibility that the implementation of this document may involve the use of (a) patent(s). ISO takes no position concerning the evidence, validity or applicability of any claimed patent rights in respect thereof. As of the date of publication of this document, ISO had not received notice of (a) patent(s) which may be required to implement this document. However, implementers are cautioned that this may not represent the latest information, which may be obtained from the patent database available at www.iso.org/patents. ISO shall not be held responsible for identifying any or all such patent rights.

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

For an explanation of the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT), see www.iso.org/iso/foreword.html.

This document was prepared by Technical Committee ISO/TC 163, *Thermal performance and energy use in the built environment*, Subcommittee SC 1, *Test and measurement methods*.

A list of all parts in the ISO 7615 series can be found on the ISO website.

Any feedback or questions on this document should be directed to the user’s national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Energy performance of building systems — Underfloor air distribution systems —

Part 1:
General overview

1 Scope

This document provides a general overview, including terms and definitions and technical specifications for an underfloor air distribution (UFAD) system. A UFAD system includes a raised floor, a zone air handling unit (AHU), an underfloor plenum and underfloor air diffusers. This document is applicable to all types of systems which utilize underfloor plenum to supply conditioned air into the occupied space.

This document is not applicable to AHUs, ceiling-based air diffusers or displacement ventilation systems.

2 Normative references

This document referred to in the text in such a way that some or all of their content constitutes requirements of the following document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 7730, *Ergonomics of the thermal environment — Analytical determination and interpretation of thermal comfort using calculation of the PMV and PPD indices and local thermal comfort criteria*

ISO 13731, *Ergonomics of the thermal environment — Vocabulary and symbols*

ISO 16818, *Building environment design — List of test procedures for heating, ventilating, air-conditioning and domestic hot water equipment related to energy efficiency*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 7730, ISO 13731 and ISO 16818 and the following apply.

ISO and IEC maintain terminology databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at https://www.electropedia.org/

3.1
underfloor air distribution system
UFAD system
forced air delivery system which takes advantage of the underfloor plenum to supply the conditioned air produced from the air handling unit into the occupied space through underfloor air diffusers mounted on the raised floor

3.2
raised floor
elevated interior floor composed of modular panels above the structural slab to form the underfloor plenum for the passage of conditioned air supplied from the air handling unit

3.3
underfloor plenum
void space between raised floor and the slab, where technical services are placed, and the conditioned air is supplied from the air handling unit before being supplied into the occupied space

3.4
underfloor air diffuser
air supply outlet mounted on the raised floor through which the conditioned air produced from the air handling unit is supplied into the occupied space

3.5
thermal plume
movement of the occupied space air in the upward direction caused by the buoyancy effect above the internal heat gain components

Note 1 to entry: Internal heat gain usually includes occupants, lighting and electric equipment.

3.6
space air stratification
formation of a stratified environment in the air in the occupied space, having an elevated temperature with height caused by the thermal buoyancy

3.7
personal thermal comfort system
device, under the control of the occupant, to either heat or cool, or both, the immediate thermal environment of an individual occupant, without affecting the thermal environment of the other occupants

3.8
thermal decay
increase or decrease in temperature of the conditioned air supplied from the air handling unit as it travels through the underfloor plenum, mainly caused by the convective heat transfer from/into the upper surface of the slab and lower surface of the raised floor

3.9
pressurized plenum
underfloor plenum configuration where the conditioned air is blown from the air handling unit into the underfloor plenum to maintain positive pressure in the underfloor plenum relative to the occupied space

3.10
neutral plenum
underfloor plenum configuration where the conditioned air is blown from the air handling unit into the underfloor plenum to maintain almost the same pressure as the occupied space

3.11
ducted plenum
underfloor plenum configuration where the conditioned air is blown from the air handling unit into air ducts in the underfloor plenum

Note 1 to entry: Underfloor air diffusers are connected to ductwork, similar to conventional ceiling based air distribution systems.

3.12
stratification height
height of the virtual horizontal surface separating two zones with different air temperature profiles

3.13
occupied space
volume of the conditioned space vertically between the floor and the ceiling, which can be divided into the lower occupied zone and the upper mixed zone

3.14
lower occupied zone
volume of the occupied space below the stratification height

3.15
upper mixed zone
volume of the occupied space above the stratification height

3.16
interior zone
volume of the occupied space usually farther than 5 m from the exterior envelope, whose thermal loads are not typically affected by the exterior conditions, such as outdoor air temperature and solar radiation

3.17
perimeter zone
volume of the occupied space adjacent to the exterior envelope, usually within 5 m, whose thermal loads are highly affected by the exterior conditions (e.g. outdoor air temperature and solar radiation)

3.18
underfloor terminal unit
unit installed under the raised floor at the end of an air distribution system intended to control air flow rate, pressure or temperature, or to mix air flows

4 Symbols and subscripts

Symbol	Quantity	Unit
A	area	m^2
B	buoyancy flux	m^4/s^3
H	height	m
m	number of plumes	–
n	number of diffusers	–
Q	airflow	m^3/s
T	temperature	°C
W	room convective heat extraction (also known as cooling load)	W
θ	discharge angle from vertical	°
Φ	dimensionless number representing the stratification in the occupied space[3]	–
Γ	dimensionless number representing the ratio of momentum to buoyancy forces[3]	–

Subscripts	Significance
DA	diffuser discharge air
diff	diffuser
eff	effective
os	occupied space
oz	lower occupied zone
RA	return air

5 Technical specifications and considerations

5.1 Technical specifications

5.1.1 Major approaches to designing underfloor plenums

UFAD systems can take advantage of the underfloor plenum by blowing conditioned air into the occupied space through the underfloor plenum, which allows UFAD systems to operate as the personal thermal comfort system. Typical plenum heights integrated with UFAD systems are 0,15 m to 0,45 m from the structure slab. According to the pressure condition of the underfloor plenum, four different approaches commonly used in designing underfloor plenum in UFAD systems are described in Table 1:

— pressurized plenum;

— neutral plenum;

— a combined feature of pressurized and neutral plenums;

— ducted plenum.

Table 1 — Different design approaches for underfloor plenums

Approach	Description
Pressurized plenum	In the pressurized plenum approach, passive diffusers are placed in the occupied spaces and no local fans in the underfloor air diffusers are needed. Due to the maintained pressure difference between the underfloor plenum and the occupied space, conditioned air can be provided into the occupied space from the underfloor plenum without the operation of local fans in the underfloor air diffusers.
Neutral plenum	Local fans are embedded inside the underfloor air diffusers to provide enough of the conditioned air into the occupied space.
Combined (pressurized + neutral) plenum	This approach is the combined feature of pressurized and neutral plenum designs. The zone AHU or central AHU blows the conditioned air into the underfloor plenum to maintain positive pressure in the underfloor plenum relative to the occupied space. Passive diffusers serve in interior zones having a relatively stable thermal load profile, while underfloor air diffusers integrated with local fans are placed in the perimeter zones where thermal load fluctuates rapidly due to the building envelope.
Ducted plenum	The zone AHU or central AHU supplies the conditioned air into the underfloor plenum through ductwork, similar to conventional ceiling-based air distribution systems. Underfloor air diffusers on the raised floor are connected to the underfloor ductwork to provide the conditioned air from the underfloor plenum into the occupied space.

Details of different approaches in designing underfloor plenums are provided in Annex A. Examples of the two commonly used UFAD system designs in practice are provided in Annex D.

5.1.2 Major types of diffusers

Different types of underfloor air diffusers commonly used in UFAD systems are provided in Table 2.

Table 2 — Major types of underfloor air diffusers

Type	Description
Passive swirl diffuser	The passive diffuser has small openings to supply the conditioned air into the occupied zone with a swirling conditioned air. It allows the zone air and the conditioned air to be mixed from the underfloor plenum. It is usually a round shape diffuser, but a square or rectangular diffuser can be applied with the shape of air openings. Generally, it is preferable to place it in the interior zone instead of perimeter zones.
Displacement ventilation diffuser	In the displacement ventilation diffuser, the air is supplied into the zone with its main velocity component parallel to the floor, which tends to create high stratification.
Variable-area variable air volume (VAV) diffuser	It has internal air regulators like an air damper in the diffuser to control the flow rate of the supply air with automatic or manual control. To control air flow rate or flow velocity of the supply air by motor drive, it commonly requires a motor drive and thermostats of the zone. It is a type of the passive diffuser which does not require fan but still controls supply air volume.
Linear bar grilles	Bar grilles have narrow and long openings which can supply the conditioned air with a targeted direction. When controlling the air flow direction, it is usually placed in the perimeter zones near the exterior windows and walls where the thermal load changes by time.
Fan powered VAV diffuser	The underfloor fan powered VAV diffuser is composed of an inlet, an outlet and control dampers, integrated with the fan operation. The operation of the control dampers and fan is governed by different modes, i.e. heating, cooling and recirculation.
Air permeable carpet tile integrated with perforated access floor	The air permeable carpet tile is laid over the perforated and fully accessible floor system. The system supplies fresh cool air or fresh heated air at a very low velocity up through the double floor, a space that also accommodates wiring and cabling. The rising air carries with it impurities and heat generated by people, appliances, and other sources, continuing upward all the way to air-release slots in the ceiling. This purifying process prevents the recirculation of airborne contaminants in the indoor environment.

Details of different types of underfloor air diffusers are provided in Annex B.

5.1.3 Major types of underfloor terminal units

The thermal environment of perimeter zones is typically more dynamic than interior zones. These spaces have time-variant thermal loads and often require additional heating. Underfloor terminal units in the perimeter zones generally supply a larger volume of conditioned air to control the envelope load than those of the interior zone. Different types of underfloor terminal units commonly used in UFAD systems are provided in Table 3.

Table 3 — Major types of underfloor terminal units

Type	Description
Variable-area VAV diffusers with constant speed heating fan coils	Variable-area VAV diffusers with constant speed heating fan coils are composed of a set of two diffusers and constant-speed fans which allows the underfloor plenum air to be supplied into the occupied space by the pressure difference between the upstream and downstream of the fan. During the cooling operation, the fan is switched off and the volume of the air is modulated by the internal damper depending on the cooling load. During the heating operation, the constant-speed fan is switched on so that return air can be pulled through one diffuser from the occupied space and can be supplied back into the occupied space after heated up by the internal heating coil as illustrated in Figure D.3.
Variable speed fan coil unit (FCU)	A fan coil unit (FCU), or vertical fan-coil unit (VFCU), is a device that has either a heating or cooling coil, or both, and a fan to either heat or cool, or both, the occupied space without ductwork. Air moves over the coil and the coil heats or cools the air before returning it into the room. The supply air flow rate can adjust in the case of variable speed FCUs. A variable frequency driver (VFD) is a popular equipment to control the speed of the fan motor.
Fan powered VAV with reheat	A VAV unit can change the operational mode either between recirculating the space air or suppling plenum air to the space, or both. It has control dampers to switch the air flow. This allows the conditioned air to be re-heated if it is necessary. The flow rate can be adjustable depending on the space thermal environment.
Natural convection floor convector	Floor convectors are based on the principle of natural air convection. They are designed for secondary room heating.
Floor convector with fan (underfloor fan-coil unit)	Floor convectors use the fan for obtaining forced air convection, achieving higher capacities than natural convection floor convectors. They use secondary (e.g. room, recirculating) air and can also be used for cooling.
Underfloor induction unit	Underfloor induction units provide centrally conditioned primary air (fresh air) to the room. The secondary (room) air is induced, and passed across the heat exchanger used for either additional cooling or heating, or both. The mix of primary and secondary air is supplied to the room.
Decentralised ventilation unit	Decentralised ventilation units are supply and extract units with secondary (room) air addition used for room ventilation and either heating or cooling, or both, of the room.

Details of different types of perimeter terminal units in UFAD systems are described in Annex C.

5.2 Technical performance consideration

5.2.1 Space air stratification

The rated space air stratification of diffusers in different operating conditions (characteristic curve) should be evaluated experimentally. Space air stratification is influenced by discharge angle and effective area of diffusers, supply airflow, number of plumes, number of diffusers and thermal load of the occupied space.

5.2.2 Thermal decay

The rated thermal decay of the underfloor plenum in different operating conditions (characteristic curve) should be evaluated experimentally. Thermal decay of the underfloor plenum is influenced by the supply airflow, insulation of slab and raised floor, airflow pattern within the underfloor plenum, thermal load of the occupied space and air leakage of the underfloor plenum.

5.2.3 Air leakage of underfloor plenum

The rated air leakage of the underfloor plenum in different operating conditions (characteristic curve) should be evaluated experimentally. Air leakage of the underfloor plenum is largely influenced by the construction of the raised floor, especially the locations where columns and diffusers are jointed with the raised floor.

5.2.4 Acoustic performance

Noise can occur when too much airflow is supplied inside the fan-powered diffusers or FCUs. Domestic acoustic regulations can be considered to limit the corresponding noise level.

5.3 Comfort consideration

Occupants are affected by velocity of the air, the vertical air temperature distribution caused by the space air stratification and the discharge temperature coming out of the diffusers. Although ISO 7730 and ASHRAE Standard 55 [1] prescribe 3 °C as the limit for the vertical air temperature difference between head and ankle levels, acceptable stratification can be up to 7 °C depending on the operative temperature of the occupied space.[2] Vertical temperature distribution for thermal comfort shall be considered. Discharge air temperature from the diffusers below 16 °C can cause a cold draft for the occupants and thus the discharge air temperature shall be maintained so that it does not go below 16 °C.

5.4 Maintenance of conformity

Operation and maintenance of the UFAD system shall be performed to meet conformity with conventional HVAC systems. The maintenance check for joints and insulation of a raised floor, space air stratification, thermal decay, air leakage of the underfloor plenum, space air temperature distribution and acoustic performance shall be conducted on a regular basis to ensure that the products maintain conformity with the requirements in Table 4. The initial attestation of conformity shall be valid until any change is made to the design of the model or any change is made to the manufacturing process having an influence on the thermal output.

Table 4 — Maintenance checklist

Category	Contents	Checklist
System specification and installation	— System specification a) Raised floor panel b) Underfloor diffusers c) Dimensional tolerances	— Check the joints with column or diffusers — Measure thermal resistance of raised floor — Check the dust on the diffusers — Measure dimensions of the underfloor plenum
Technical performance	— Space air stratification — Thermal decay — Air leakage of underfloor plenum — Acoustic performance	— Measure rated space air stratification — Measure rated thermal decay — Measure rated air leakage of underfloor plenum — Measure noise level

Annex A
(informative)

Descriptions of different approaches in underfloor plenum designs

A.1 General

This annex describes the following different approaches in designing underfloor plenums:

— pressurized plenum;

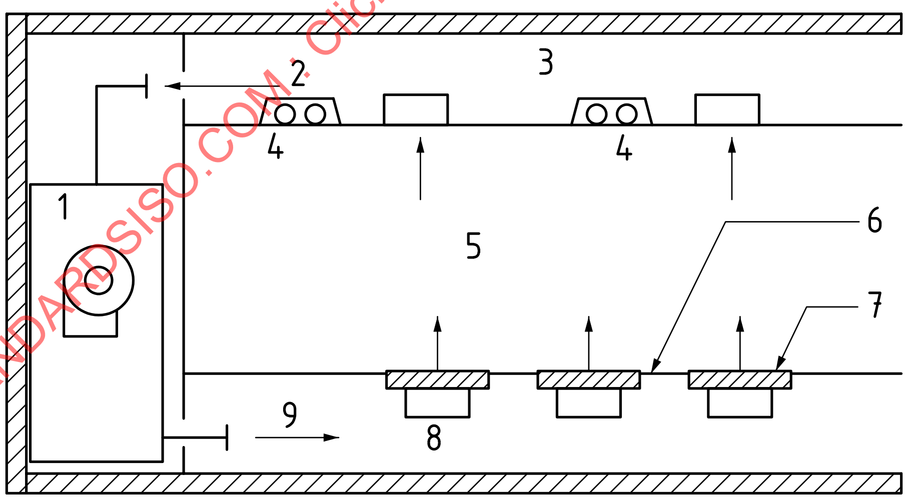
— neutral plenum;

— ducted plenum;

— combined feature of pressurized and neutral plenums.

A.2 Pressurized plenum

In pressurized plenums illustrated in Figure A.1, the zone AHU or central AHU blows conditioned air into the underfloor plenum to maintain positive pressure in the underfloor plenum relative to the occupied space. In this approach, passive diffusers are placed in the occupied spaces and no local fans in the underfloor air diffusers are needed. Due to the maintained pressure in the underfloor plenum, conditioned air can be provided into the occupied space from the underfloor plenum without the operation of local fans in the underfloor air diffusers. However, unintentional air leakage in the underfloor plenum can negatively affect the airflow pattern and the thermal performance of the entire system. An additional issue can be that the pressure causing the airflow into the occupied space through underfloor air diffusers may not be sufficient to handle the thermal load in the perimeter zones where the thermal load fluctuates dynamically.



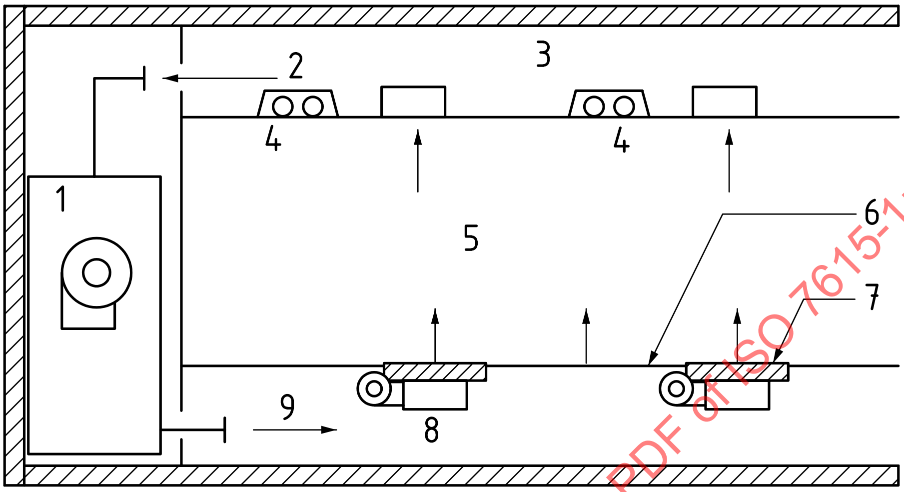
Key

1 air handling unit (AHU)
2 return air
3 return air plenum
4 lighting fixtures
5 occupied space
6 raised floor
7 passive diffusers
8 underfloor plenum
9 supply air

Figure A.1 — Pressurized plenum type

A.3 Neutral plenum

In the neutral plenums illustrated in Figure A.2, the zone AHU or central AHU blows conditioned air at low velocity into the underfloor plenum to maintain almost the same pressure as the occupied space. Local fans are embedded inside the underfloor air diffusers to provide enough supply air into the occupied space. As opposed to the pressurized plenum, neutral plenums do not suffer from the unintentional air leakage in the underfloor plenum due to the same pressure being maintained as the occupied space. Since the local fans are installed inside the underfloor air diffusers, enough supply airflows are provided in the perimeter zones having a dynamic thermal load profile.



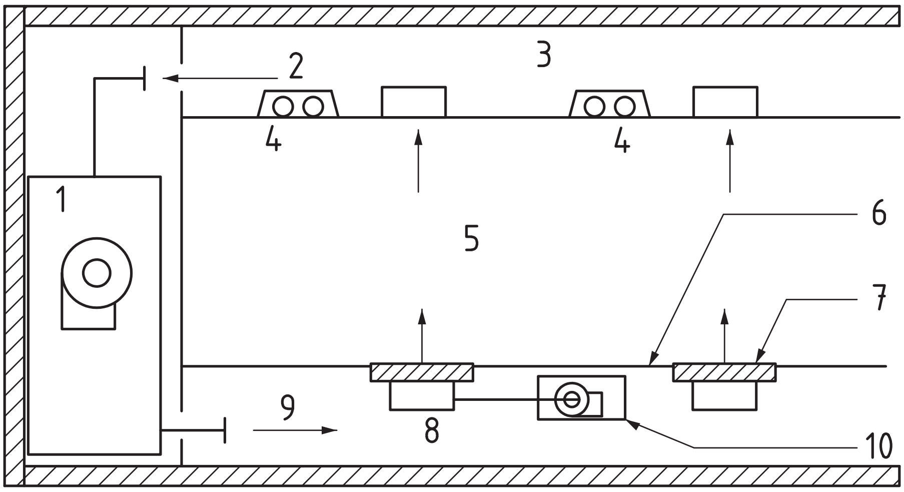
Key

1 air handling unit (AHU)
2 return air
3 return air plenum
4 lighting fixtures
5 occupied space
6 raised floor
7 fan powered unit
8 underfloor plenum
9 supply air

Figure A.2 — Natural plenum type

A.4 Combined plenum type

This approach is the combined feature of the pressurized and neutral plenum designs as illustrated in Figure A.3. In this approach, the zone AHU or central AHU blows conditioned air at high velocity into the underfloor plenum to maintain positive pressure in the underfloor plenum relative to the occupied space. Passive diffusers serve in interior zones having relatively stable load profile, while underfloor air diffusers integrated with local fans are placed in the perimeter zones where the thermal load changes depending on time and weather conditions.



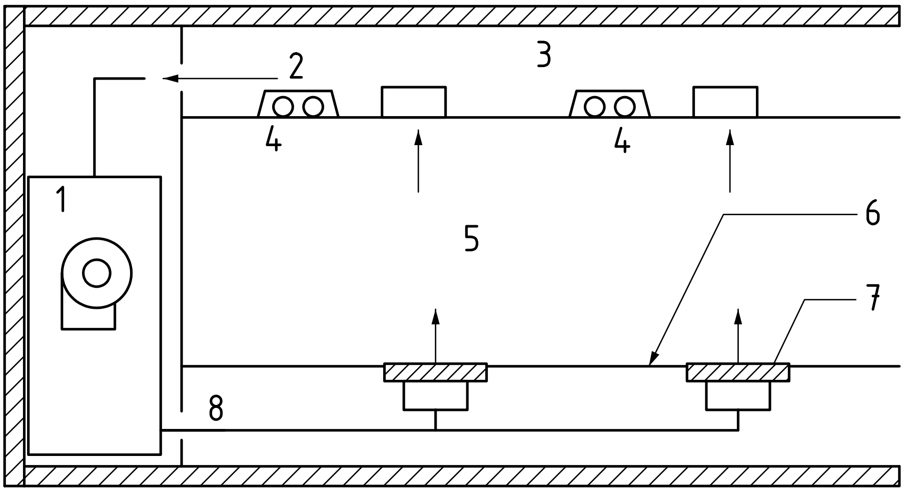
Key

1 air handling unit (AHU)
2 return air
3 return air plenum
4 lighting fixtures
5 occupied space
6 raised floor
7 passive diffusers
8 fan powered unit
9 supply air
10 fan air terminal

Figure A.3 — Combined plenum type

A.5 Ducted plenum

In the ducted plenums illustrated in Figure A.4, the zone AHU or central AHU blows conditioned air into the underfloor plenum through ductwork, similar to conventional ceiling-based air distribution systems. Underfloor air diffusers are connected to the ductwork to provide the conditioned air from the AHU into the occupied space. The underfloor plenum provides a cavity space for ductwork.



Key

1 air handling unit (AHU)
2 return air
3 return air plenum
4 lighting fixtures
5 occupied space
6 raised floor
7 air distribution unit
8 supply duct

Figure A.4 — Ducted plenum type

Annex B
(informative)

Descriptions of different types of underfloor diffusers

B.1 General

The selection of underfloor air diffusers depends on the condition of pressure in the underfloor plenum, the zone thermal condition (interior/perimeter), and occupant requirements. In this annex, different types of diffusers commonly used in UFAD systems are described. The examples of products for each type are shown in Table B.1.

Table B.1 — Examples of underfloor diffusers

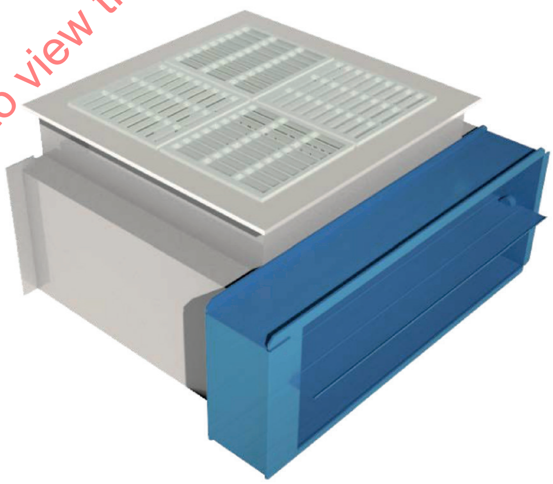
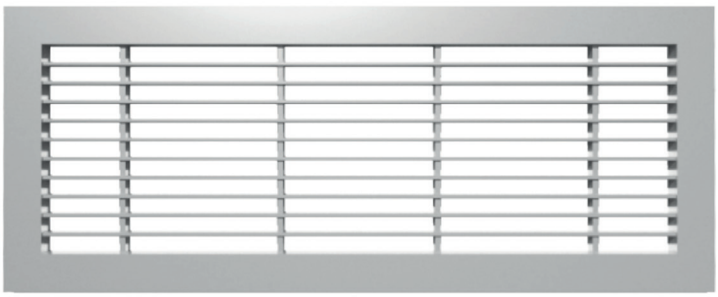
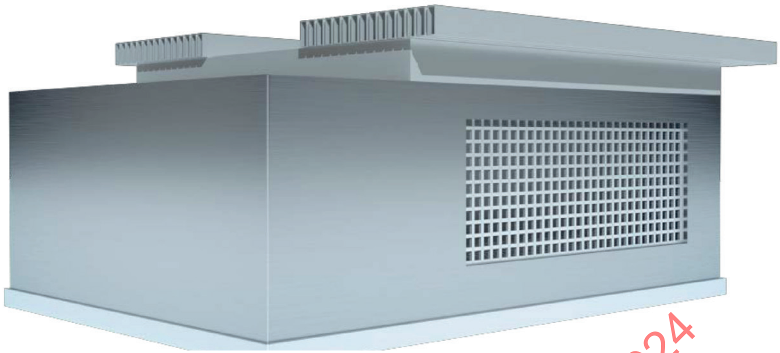
Types in this document	Example product
Passive swirl diffuser	
Displacement ventilation diffuser	
Variable-area VAV diffuser	
Linear bar grille	

Table B.1 *(continued)*

Types in this document	Example product
Fan powered VAV diffuser	
Air permeable carpet tile integrated with perforated access floor	

B.2 Passive swirl diffuser

Passive swirl diffusers have swirl deflection blades on the surface of the diffuser to generate a radial airflow pattern in order to induce intensive mixing of the zone air. The construction provides the minimum temperature difference and rapid temperature equalization for achieving stable zone thermal conditions. It has been popular in the interior zones for the pressurized UFAD approach because it generates high induction swirl to supply the air to the occupied space without using an auxiliary fan system. Although occupants do not usually control the airflow rate or volume, they can control the thermal environment by adjusting swirl blades, where applicable. The swirling can be horizontal or vertical. The horizontal air spread range and vertical projection height of each diffuser need to be considered according to the room thermal load and desirable airflow pattern.

B.3 Displacement ventilation diffuser

In the displacement ventilation diffuser, the air is discharged into the occupied space with flowing air parallel to the floor surface, which creates higher temperature stratification.

B.4 Variable-area VAV diffuser

Passive VAV diffusers have an internal damper in the core or box casing to adjust supply air volume to control discharge air velocity. The conditioned air is generally a jet-type flow through discharging from grilles on the diffuser. Occupants can control the direction of the supplied air by changing the direction of the diffuser grilles and the air volume by zone temperature or thermostats.

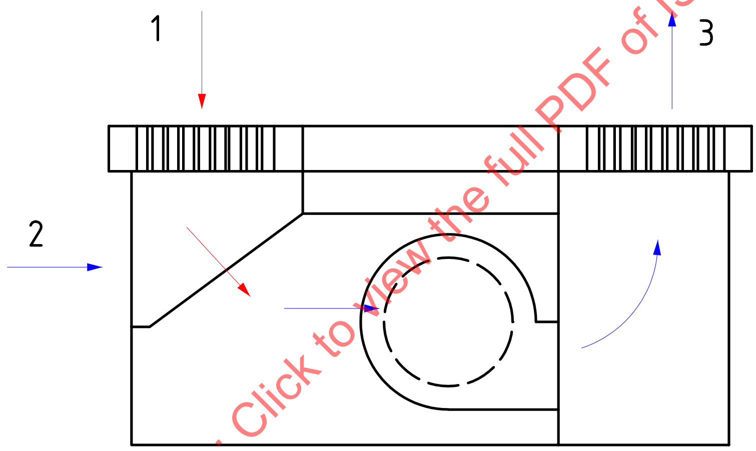
The typical passive swirl diffusers which are described in B.2 can be VAV diffusers with a thermally powered air damper or electronically motor driven air damper incorporating a building automation system. The supply air enters directly through the pressurized plenum or fan-powered duct. The damper in the trim of diffuser or the duct of the floor boot adjusts the opening to regulate the air volume.

B.5 Linear bar grille

Linear bar grilles with fixed openings, with louvres parallel to the longer dimension are popular for perimeter zones adjacent to exterior windows and walls. The diffuser has several slots with extruded aluminium grilles. Since air flow pattern is a planner jet, it is appropriate to control the thermal load in the perimeter zone near the building envelope. However, to prevent additional heat transfer from the building envelope into the underfloor plenum, the diffuser can be integrated with a floor ductwork or FCUs. Usually, it has air flow dampers which are designed to response to the building envelope load. Therefore, it is not suitable for the interior zone with the high occupancy and low thermal load variation.

B.6 Fan powered VAV diffuser

The underfloor fan powered VAV diffuser has inlet and outlet air volume control dampers integrated with the fan operation, as illustrated in Figure B.1. Room air is returned through the inlet and discharged into space, after being mixed with the outdoor air coming from the AHU for ventilation purposes. Depending on the heating/cooling/recirculation only mode, the damper position changes differently. In the heating or cooling mode, the damper is opened to allow the mixing between and returned room air and the underfloor air, while the damper is closed to prevent the underfloor air from being mixed before being supplied into the space in the recirculation only mode. Details of fan powered VAV with reheat operation are described in Annex C.



Key

1 recirculated air

2 plenum air

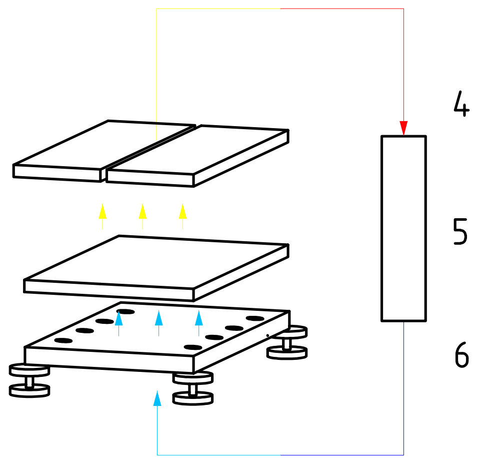
3 supply air

SOURCE: Reproduced with permission from Samhwa ACE Co. See Reference [5].

Figure B.1 — Fan Powered VAV Diffuser

B.7 Air permeable carpet tile integrated with perforated access floor

This system keeps the indoor environment clean and healthy by carrying heat and impure air upwards, out of breathing reach. The system feeds in a uniform flow of air up through the floor at a velocity too low to feel or to generate drafts. By distributing air from under the floor, the system allows flexible designs for office space layouts unrestricted by concerns about the diffuser position or its influence on air quality. The system enhances energy efficiency using solar power, well water and soil heat. Unlike conventional air distribution systems, the system is eco-friendly and requires no ductwork or PVC access floor panels.



Key

1 air-release slots in the ceiling
2 air permeable carpet tile
3 perforated access floor
4 ceiling plenum
5 AHU
6 underfloor plenum

SOURCE: Reproduced with permission from Technet Co. See Reference [7].

Figure B.2 — Concept of air permeable carpet tile integrated with perforated access floor

Air permeable carpet tile is laid over the perforated, fully accessible floor system. The system supplies fresh cool air or fresh heated air at a very low velocity up through the double floor, which is a space that also accommodates wiring and cabling. The rising air carries impurities and heat generated by people, appliances, and other sources, continuing upward all the way to air-release slots in the ceiling as illustrated in Figure B.2. This purifying process prevents the recirculation of airborne contaminants in the indoor environment.[6]

The thermal plume created by a heat source (e.g. occupants or electrical equipment), speeds the airflow around the source, thereby improving overall heat removal. Heat, smoke, odours, and other airborne contaminants are carried up to the ceiling in the thermal plume, out of breathing reach.[8] The examples of specification and dimension for a perforated access floor are shown in Table B.2.

Table B.2 — Example of specification and dimension for a perforated access floor

Material		Short fibre reinforced concrete
Dimension (mm)		500 × 500 × 28
Panel weight	kg/panel	12,5
	kg/m^2	50,0
Floor plenum height (mm)		100 to 500
Load-bearing capacity of panels		Deflection is within 5 mm, when a 300 kg concentration load (Φ 50 contact point) is applied
Floor load carrying capacity		3 000 N//m^2
SOURCE: Reproduced with permission from Technet Co. See Reference [7].		

Annex C
(informative)

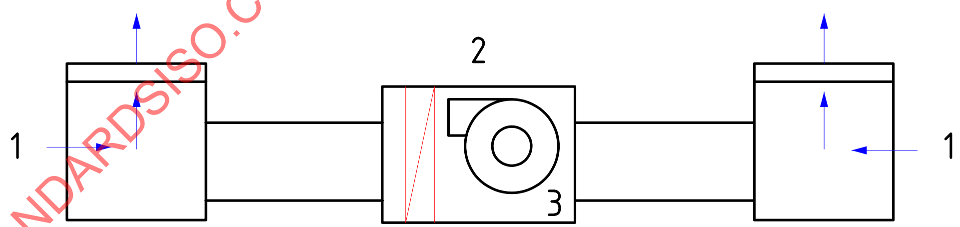
Descriptions of different types of perimeter terminal units in underfloor air distribution (UFAD) systems

C.1 General

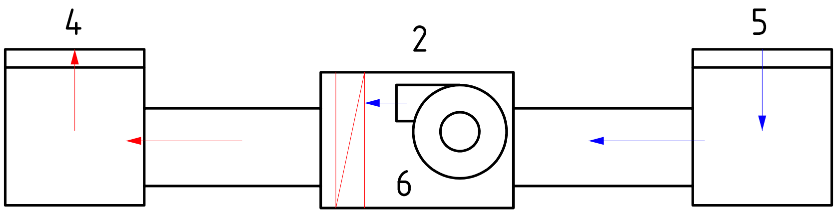
Common types of perimeter terminal units in UFAD systems are described in this Annex. In contrast to the interior zone, perimeter zones are typically more complex since these spaces have larger and more varying thermal loads depending on time and weather than the interior zone load and often require auxiliary heating. Variable-area VAV diffusers with constant speed heating fan coils are composed of a set of two diffusers and constant-speed fan which enables the induction of plenum air into the airflow as presented in Figure C.1. During the cooling, the fan is switched off and the volume of the air is modulated by the internal damper depending on the cooling load. During heating, the constant-speed fan is switched on so that return air can be pulled through one diffuser from the occupied space and the air can be supplied back into the occupied space after being heated up by the internal heating coil as illustrated in Figure C.1. Supplied conditioned air can be reduced to the minimum ventilation rate and the heating airflow is supplemented by induced plenum air. There are two types of heating fan terminals with diffusers: parallel or series, depending on the fan location.

With a parallel terminal unit, the fan is located outside of the primary airflow, i.e. the fan airflow is parallel. During cooling mode, the fan in the parallel unit is switched off. This requires the fan in the central AHU to be sized such that it can deliver the full design airflow to the room. During heating and dead band modes, the primary air from the central AHU is reduced to the minimum required ventilation rates, and the fan will be energized. Depending on the building control sequence, the speed of the fan and the amount of heat required is modulated to meet the heating needs of the space.

Series terminal units have the fan in series with the primary air. This requires the fan in the underfloor terminal unit to be operational when the AHU is on. The fan in the underfloor terminal unit is responsible for delivering the airflow to the space, eliminating this requirement from the AHU. The result is less pressure load on the AHU fan, which can lead to a smaller fan and less energy used.



a) Cooling mode



b) Heating mode

Key

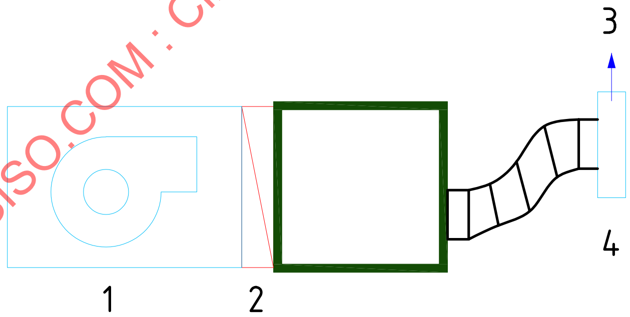
1 plenum air
2 fan terminal with heating coil
3 switched off
4 hot supply air
5 recirculated air from the occupied space
6 switched on

Figure C.1 — Variable-area VAV diffusers with constant speed heating fan coils

C.2 Variable speed fan coil unit (FCU)

An FCU, or VFCU, is a device that uses a coil and a variable-speed fan to heat or cool the occupied space as presented in Figure C.2. Air moves over the coil and the coil heats the air before returning it into the room during the heating mode. The supply airflow can be adjusted depending on the thermal load during the cooling mode. A VFD is a popular equipment to control the speed of the motor.

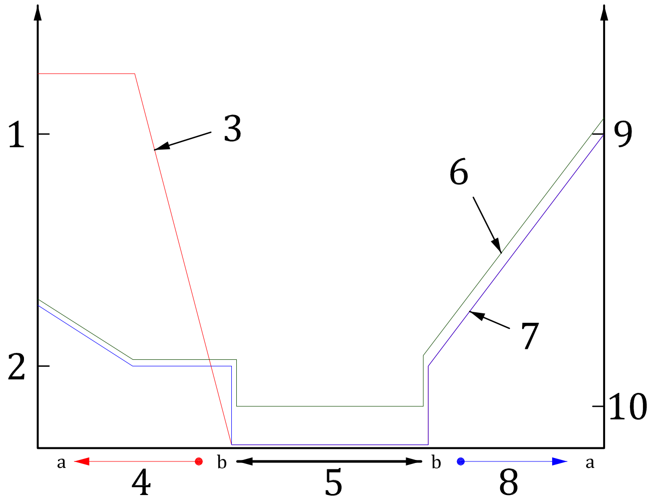
The control logic of variable speed FCU is illustrated in Figure C.3. During the cooling, the speed of the fan is adjusted to proportionally modulate the supply airflow into the occupied space depending on the load. During the dead-band, the fan is switched off, but the minimum air is supplied into the occupied space by the pressure in the underfloor plenum. Finally, there are two stages of operation during the heating. In the region with a relatively low heating load, the fan speed is fixed at the minimum and the discharge air temperature coming out of the diffuser is being controlled by operating the internal heating coil. In the region with a relatively high heating load, the discharge air temperature is fixed at the maximum set-point and the fan speed of the fan is adjusted to modulate the supply airflow into the occupied space.



Key

1 fan
2 heating coil
3 supply air
4 linear diffuser

Figure C.2 — Variable speed fan coil unit (FCU) with reheat



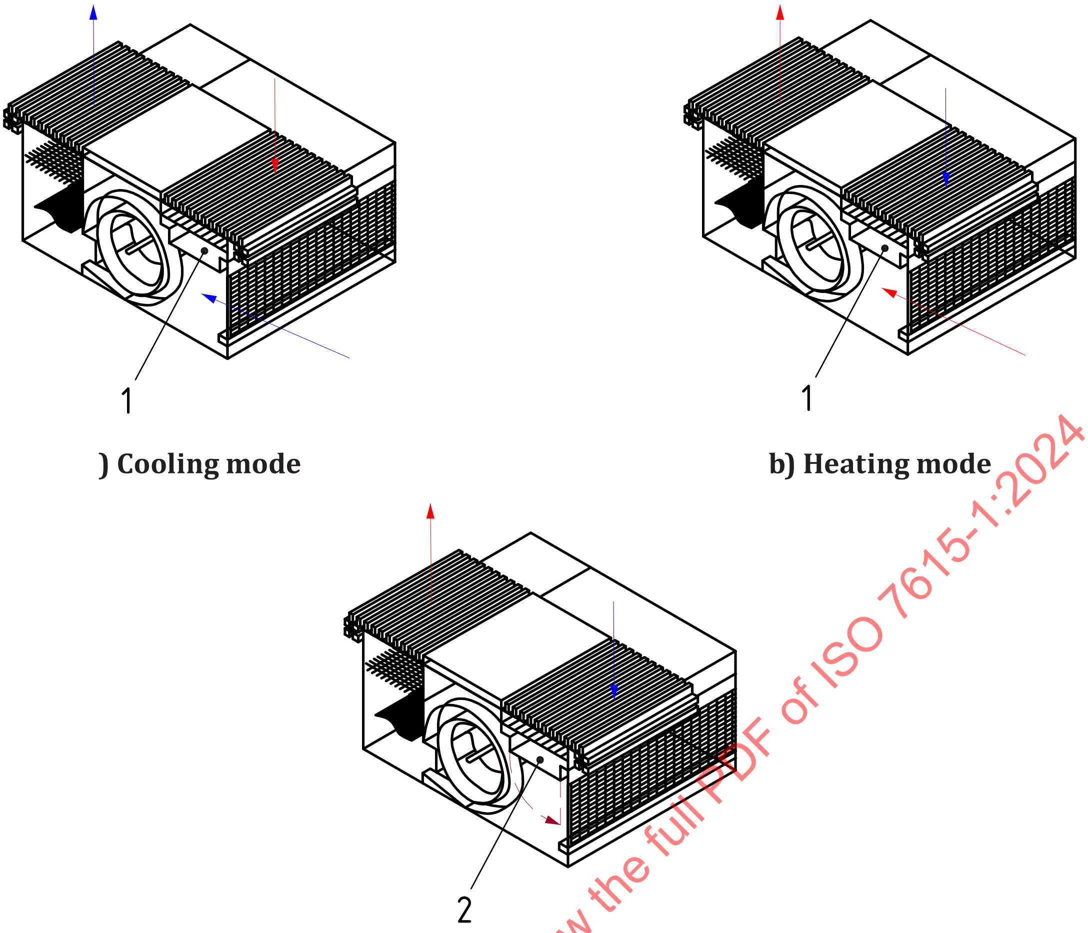
Key

1	design fan speed	6	Airflow
2	lowest possible fan speed	7	fan speed
3	discharge air temperature setpoint	8	cooling load
4	heating load	9	design airflow
5	deadband	10	minimum airflow (due to pressurized plenum)
a	High.	b	Low.

Figure C.3 — Control logic of variable speed fan coil unit (FCU)[4]

C.3 Fan powered variable air volume (VAV) with reheat

A VAV system can change the operational mode between either recirculating the space air or suppling plenum air to the space, or both. It has control dampers to switch the air flow. This can reheat the conditioned air if it is necessary, as illustrated in Figure C.4. The flow rate can be adjustable depending on the space thermal environment.



) Cooling mode

b) Heating mode

c) Recirculation mode

Key

1 damper open

2 damper closed

SOURCE: Reproduced with permission from Samhwa Co. See Reference [5].

Figure C.4 — Fan powered variable air volume (VAV) with reheat

C.4 Natural convection floor convectors

Natural convection floor convectors are based on the principle of natural air convection. They are designed for secondary room heating. They consist of the walkable floor casing and two-pipe coil as illustrated in Figure C.5. Their advantage is silent operation, since they do not use a fan, but the heating capacities are limited.

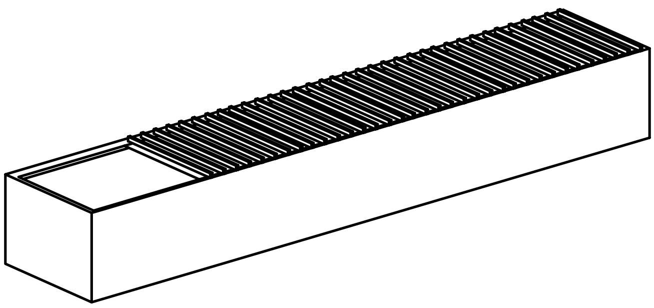


Figure C.5 — Natural convection floor convectors

C.5 Floor convector with fan (underfloor fan-coil unit)

Floor convectors use a fan for obtaining forced air convection, therefore enabling heating and cooling of the air with higher capacities compared to natural convection floor convectors. They consist of the walkable floor casing, 2-pipe or 4-pipe coil and a fan, as illustrated in Figure C.6.

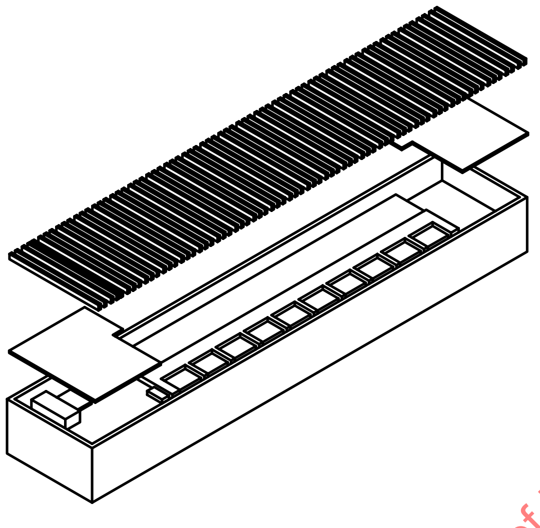
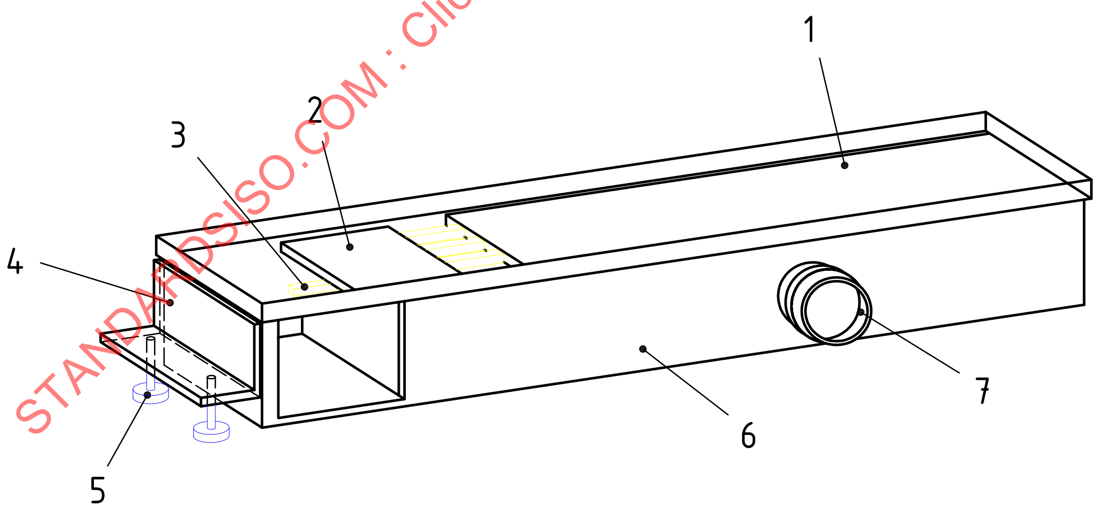


Figure C.6 — Floor convector with fan (underfloor fan-coil unit)

C.6 Underfloor induction unit

Underfloor induction units illustrated in Figure C.7 provide centrally conditioned primary air (fresh air) to the room that is discharged through the nozzles. Due to this process, the secondary (room) air is induced and passed through the 2-pipe or 4-pipe heat exchanger. The primary and secondary air are then mixed and supplied to the room. Since there is no fan used for air circulation, there is no electrical consumption or fan induced noise, however it requires primary air preparation and introducing via nozzles in the unit.



Key

1 floor grille

2 heat exchanger

3 water connection

4 casing

5 levelling feet

6 primary air plenum with integral nozzles

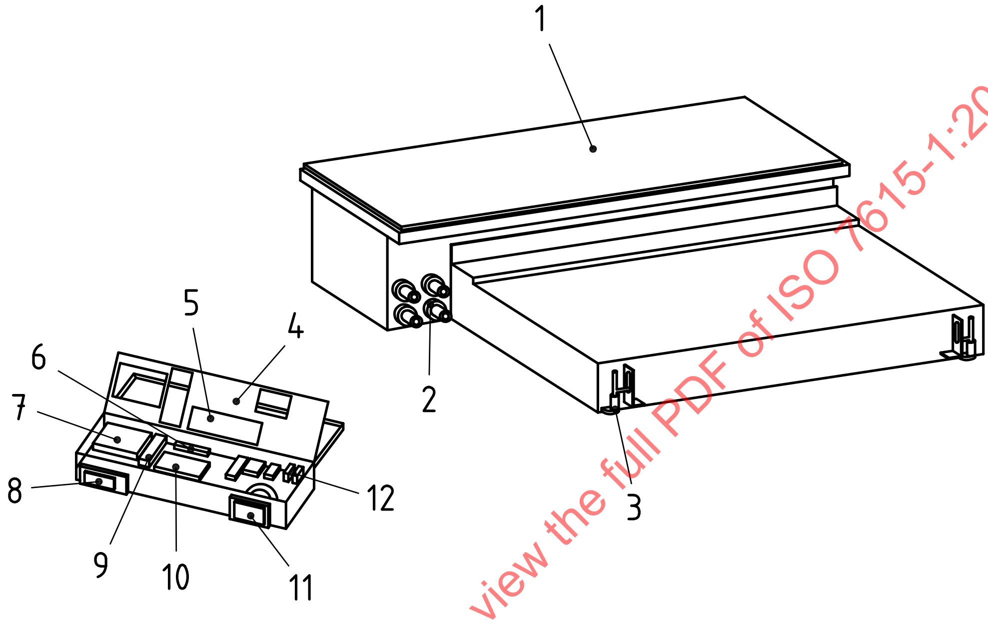
7 primary air spigot

SOURCE: Reproduced with permission from Trox ® Technik. See Reference [9].

Figure C.7 — Example of underfloor induction unit

C.7 Decentralised ventilation unit

The decentralised ventilation units illustrated in Figure C.8 are supply and extract units with a secondary air addition used for ventilation and heating/cooling. The fresh air is taken by fan, passed through the filter, heat recovery plate exchanger and through 2-pipe or 4-pipe heat exchanger for either heating or cooling, or both. The supply air is discharged to the room as an inducing displacement flow. Using the secondary air damper, the secondary (room) air can be added to the fresh air. The extract air is passed through the filter, recovery heat exchanger, and the extract air fan is discharged to the outside as exhaust air. For night purging, a motorised shut-off damper opens an alternative extract air duct such that the extract air is led to the extract air fan, thereby bypassing the plate heat exchanger. Demand-based ventilation and extract ventilation is possible by means of monitoring the room air quality.



Key

1	ventilation grille	7	fresh air filter
2	water connections	8	fresh air opening
3	levelling foot	9	extract air filter
4	inspection access panel	10	heat exchanger
5	supply air temperature sensor	11	exhaust air opening
6	internal wiring	12	control valves

SOURCE: Reproduced with permission from Trox ® Technik. See Reference [9].

Figure C.8 — Example of decentralised ventilation unit

Annex D
(informative)

Examples of underfloor air distribution (UFAD) system design

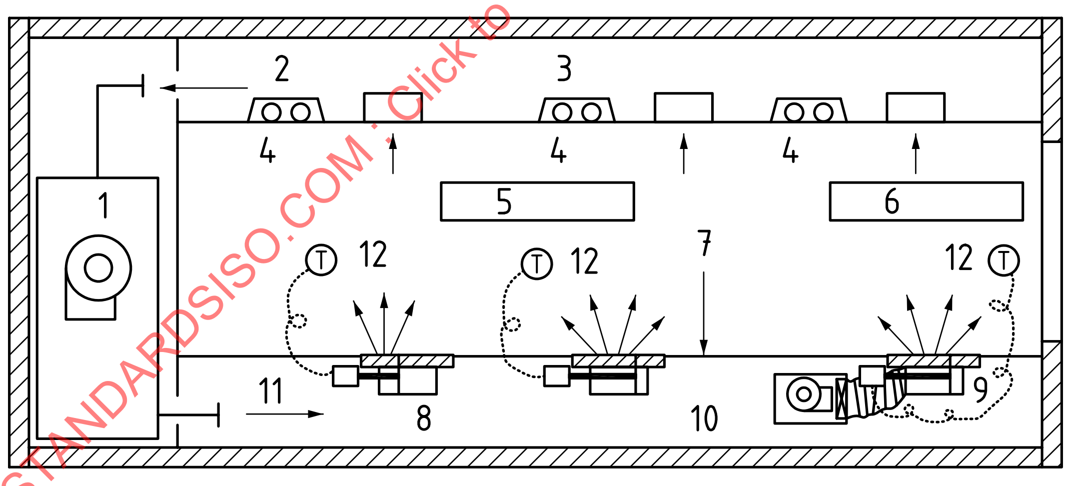
D.1 General

There are two commonly used UFAD system designs in practice. The first option is composed of the constantly pressurized plenum, the individually or group controlled VAV diffusers, and the perimeter cooling without fans or heating only with constant volume fan coils. The other option is composed of the passive swirl diffusers in the interior zones and the heating and cooling with variable-speed fan coils in the perimeter zones.

D.2 Constantly pressurized plenum design

D.2.1 General approach of constantly pressurized plenum design

The constantly pressurized plenum design controls the supply air pressure in the plenum nearly constantly, whereas VAV diffusers for the interior thermal zone, control the supply air volume, as illustrated in Figure D.1. The individual or group controlled VAV diffusers adjust the amount of air flow to the occupied space depending on the thermal load, as sensed by the zone controller and thermostat. For the perimeter zone, the fan is switched off and the volume of the air is modulated by the internal damper depending on the load during the cooling. During heating, the constant-speed fan is switched on so that return air can be pulled through one diffuser from the occupied space and the air can be supplied back into the occupied space after heated up by the internal heating coil.



Key

1	air handing unit
2	return air
3	return plenum
4	lighting fixture
5	interior zone
6	perimeter zone
7	raised floor
8	variable air volume (VAV) diffuser
9	constant air volume (CAV) fan box with heating coil
10	underfloor plenum
11	supply air
12	air temperature sensor

Figure D.1 — General application of constant pressurized plenum design