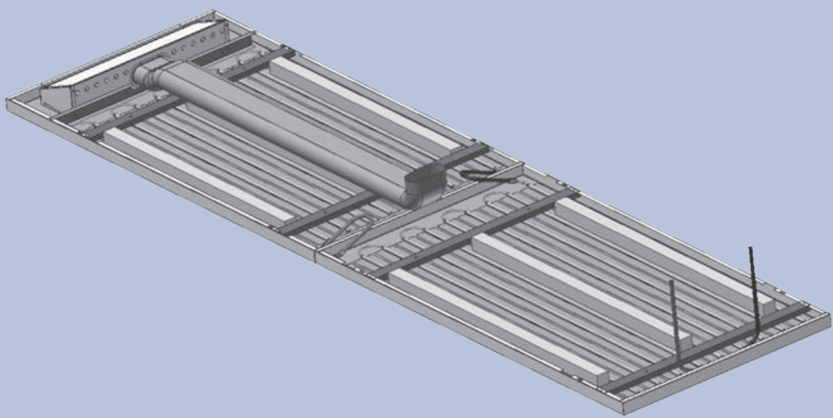


Krantz

Multifunction exposed ceiling AVACS

Cooling and heating systems

DS 4170 E 07.2016

Multifunction exposed ceiling AVACS

Preliminary remarks and construction design

Preliminary remarks

The multifunction exposed ceiling AVACS is designed for use with plane metal acoustic panels from various brands to make cooling or heating panels. The large-surface permanent contact between the cooling element and the ceiling panel is preferably done by bonding. AVACS stands for **A**ir **V**entilation **A**nd **C**ooling **S**ystem. The AVACS combines the following functions: cooling, heating, indoor air circulation and sound absorption, which are performed in compliance with thermal comfort criteria.

There are a number of configurations available, e.g.
- made up of one or several pieces
- rigid or pull-down design
- with or without supply air distribution
- optional with recirculated air; return air or without air fuction
- optionally fitted with inspection element for maintenance of control valves installed by the client.

AVACS come into use in offices, meeting rooms, foyers, exhibition rooms, libraries and such like, and serve to remove medium cooling loads.

Construction design and mode of operation

AVACS consists of:
- one or several perforated metal ceiling panels
- copper serpentine pipework (copper tube from a coil) with connection ends for water inflow and outflow
- aluminium heat conducting profiles for fixing the serpentine pipework and creating a large contact surface area to the panel
- steel crossbars for suspending the panel
- an induction unit
- an optional return air diffuser.

The AVACS can be optionally fitted with sound absorbers.

The main dimensions of a AVACS are given in Fig. 1. Further technical data is contained in Table 1.
AVACS can have various dimensions and designs, and be made of different materials; they are designed for specific parameters and meet different performance and sound absorption requirements. This is made possible by:
- the free choice of pipe length
- variable pipe spacing
- sound absorbers
- different types of connection to air ducts and water pipes.

For sound absorption, acoustic lining is bonded to the whole rear side of the perforated ceiling panel except the area of the induction unit. As the contact surface areas of a panel cover only part of the area available, the sound-absorbing effect is kept. The acoustic lining also provides unity of appearance of the ceiling panel from below. The induction unit, which generates a uniform and constant air stream above and below the cooling panel, is invisible from the room side.

The variable pipe spacing enables to purposely influence the cooling output and the sound-absorbing properties of the cooling panel. Owing to the good thermal conduction in sheet metal and/or aluminium sheet, the whole area of an active panel is effective for heat transport. As standard, the contact between the cooling element and the ceiling panel is done by bonding; an option with barium and ferrite magnetic strips for permanent contact is also available.

The induction unit is fixed to the panel on site using two sheet metal screws (or rivets). As standard it is fitted with an oval spigot for flex duct DN 125. The optional variant with circulating function a fan takes indoor air to the induction attachment.
The induction unit discharges about 70% of the supply air above and 30% below the AVACS, thus circulating a large volume of indoor air and ensuring a continuously comfortable thermal environment. The induction unit has been engineered such that the cooler supply air from outside does not drop as is the case with displacement air outlets, but rather flows almost horizontally along the underside of the AVACS as a result of the Coanda effect.

The pipework connections are preferably designed for push-in fittings; their shapes and positions are adapted to the required ceiling design and function, e.g. pull-down design lengthwise.
For the serpentine pipework we use only quality-controlled copper tube.

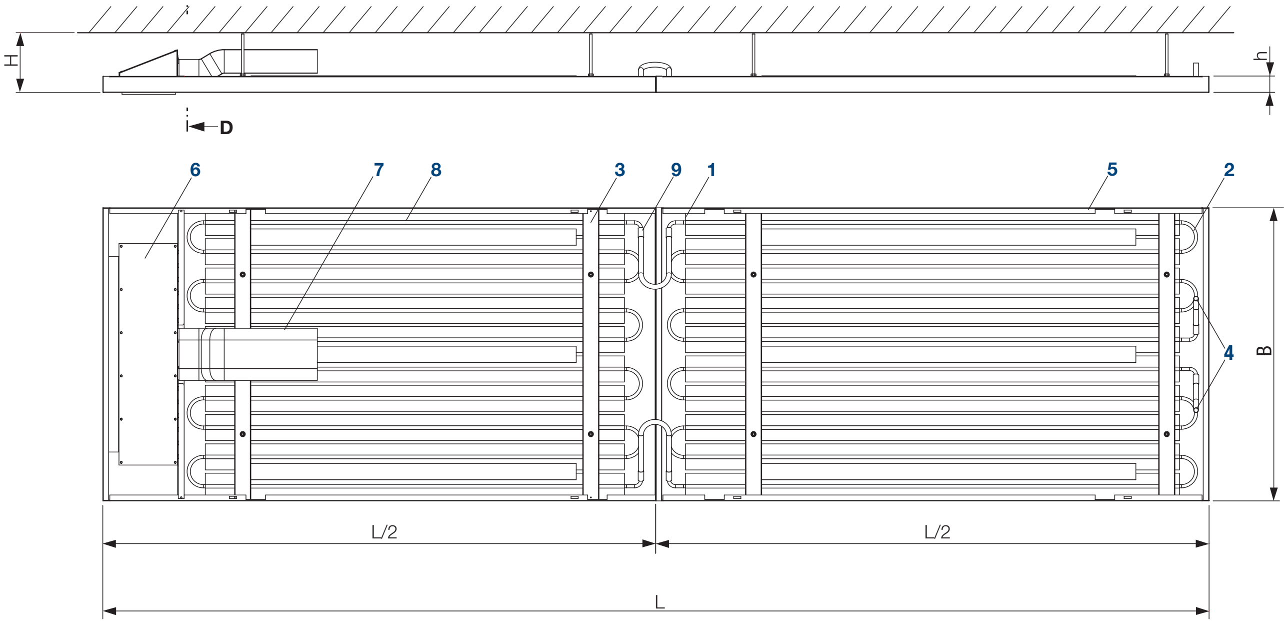
The AVACS can incorporate lights, air diffusers, loudspeakers and such like.

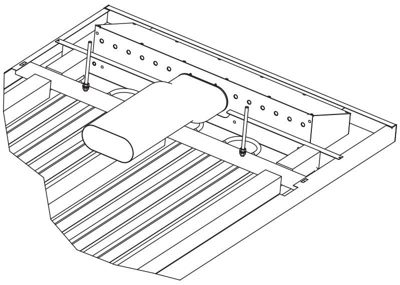
Fig. 3 shows the structure of a AVACS as installed. This sketch suggests that
- the induction unit is connected to a flex duct,
- the panels are fitted with push-in fittings and flexible hoses, and are grouped,
- the access to the ceiling plenum and the pipes, ducts and cable conduits, etc., inside the plenum is not hindered by the AVACS.

The versatility of the AVACS on the one hand and the high level of manufacture of metal panels to the German industrial standard TAIM on the other hand provide a good basis for the selection of panels from different manufacturers. By providing expert advice on technical selection and supplying the whole water system fitted within the panel area, Krantz provide reliability of the air-conditioning performance of the AVACS as well as a comprehensive air-handling solution.

Multifunction exposed ceiling AVACS

Dimensions





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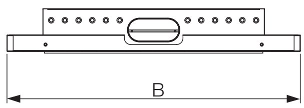


Key

1 Aluminium contact profile
2 Copper serpentine pipework
3 Fastening crossbar
4 Connections for water supply and return
5 Ceiling panel, perforated, covered with acoustic lining

6 Induction unit
7 Flex duct
8 Sound absorbers
9 Connection hoses

L = length of AVACS
B = width of AVACS
H_{min} = minimum suspension height
T = spacing of serpentine pipework

Fig. 1: AVACS with supply air function

Table 1: Main dimensions and materials

	Standard
Ceiling panel	sheet metal s = max. 0.8 mm, perforated, hole ø 2.5 mm, approx. 16% open area; powder coated
Serpentine pipework	copper tube 12 x 0.4 mm [1)]
Contact profile	aluminium profile, width b = 78 mm [1)], length matching serpentine pipework
Fastening crossbar	2.0 mm sheet metal
Connection ends	for push-in fittings ø 12 mm + 0.05 / – 0.10 mm [1)] Fittings: 90° bend, 180° bend } inclined at approx. 20 – 90° to the ceiling plane [1)]
Pipe spacing T	variable, matching the panel dimensions for optimum performance
Standard nominal length L	1 500 mm ≤ L ≤ 5 500 mm [1)]
Standard nominal width B	1 150 mm [1)]
Nominal height h	50 mm [1)]
Minimum suspension height H_{min}	150 mm
Allowable operating pressure	6 bars [1)] (up to 16 bars is possible)
Weight	approx. 8 kg/m^2 of panel area (when filled with water, depending on pipe spacing) plus 3.4 kg for induction unit
Total weight	depends on ceiling design and ceiling services, etc.

[1)] Other types/values subject to enquiry

Multifunction exposed ceiling AVACS

Layout data

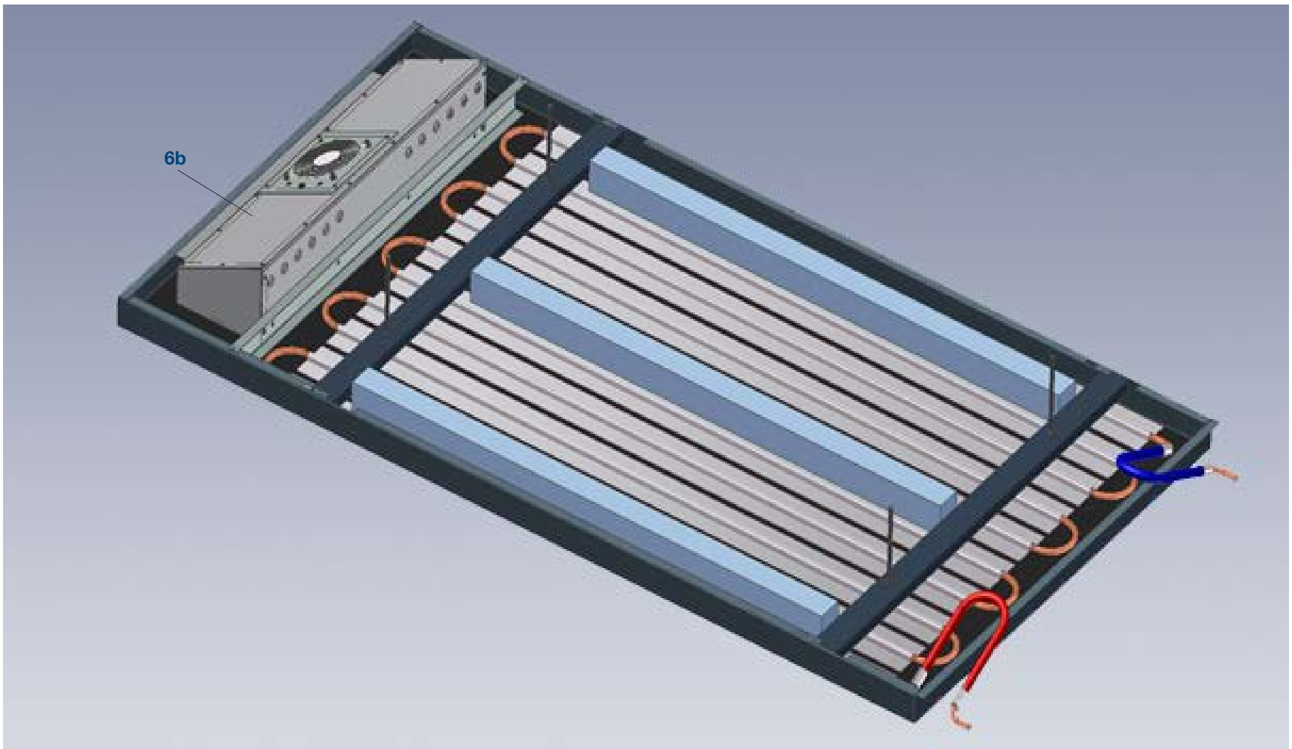
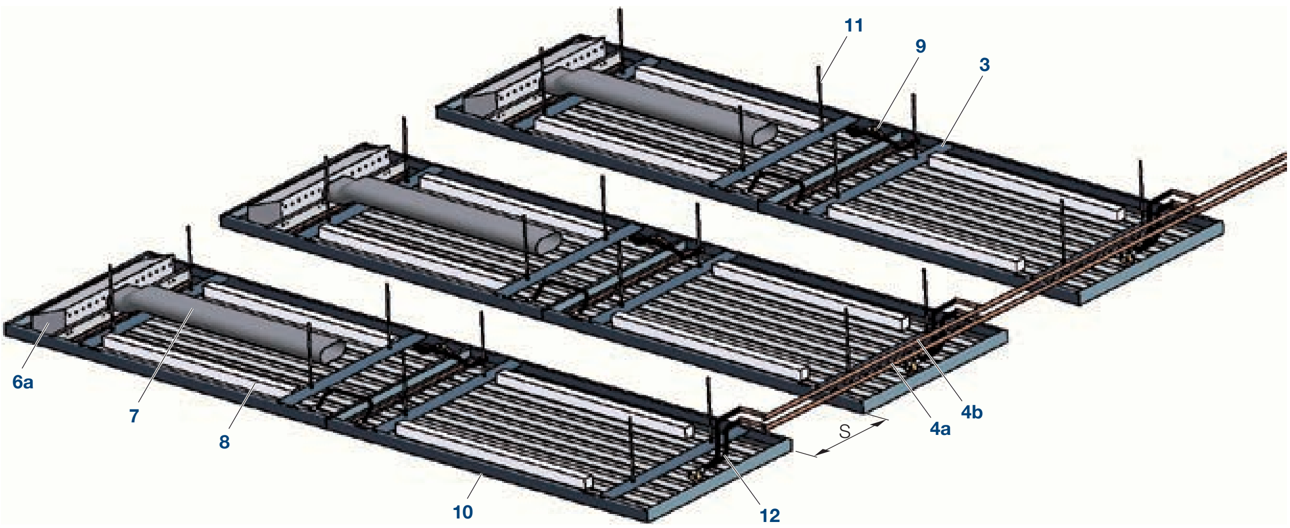


Fig. 2: AVACS with recirculated air function



Key

3 Crossbar for sail suspension
4a Chilled water supply pipe
4b Chilled water return pipe
6a Induction unit with supply air connection
6b Induction unit with recirculated air fan
7 Oval flex duct DN 125
8 Sound absorbers (optional)

9 Flexible hoses for connecting sail elements
10 Sail with copper serpentine pipework
11 Threaded rods
12 Flexible hoses for sail connection to water pipework

S = Spacing between 2 sails, minimum spacing S_{min} = 150 mm

Fig. 3: Example of arrangement of AVACS in a room

Layout data

The standard cooling output of the AVACS was determined to EN 14240 (Chilled ceilings – Testing and rating); it achieves values up to 165 W/m² (at 10 K).

The tests were carried out on the following AVACS design:

- Ceiling panel made of perforated sheet metal (s = 0.7 mm) with acoustic lining (mainly cellulose, ≤ 0.25 mm thick, 60 – 65 g/m²); perforation pattern: round straight perforations 2.5 – 5.5 / A_0 ~ 16%
- Suspension from ceiling: 150 mm with crossbars consisting of steel U-profiles
- Heat conducting profiles bonded to the ceiling panel using high-performance adhesive tape
- Sound absorbers on the rear side, 50 x 50 mm x nominal length of ceiling panel.

The AVACS used for layout and determination of cooling output was a 2-piece panel having an overall length of 3 400 mm and an overall width of 900 mm. The specific cooling output measured with reference to EN 14240 amounted to 125 W/m² at a temperature difference of 8 K and a supply air volume flow rate of 28 l/s [100 m³/h] above and below the AVACS (see Graph A). The reference surface area is always the active area of the AVACS (as per Fig. 1).

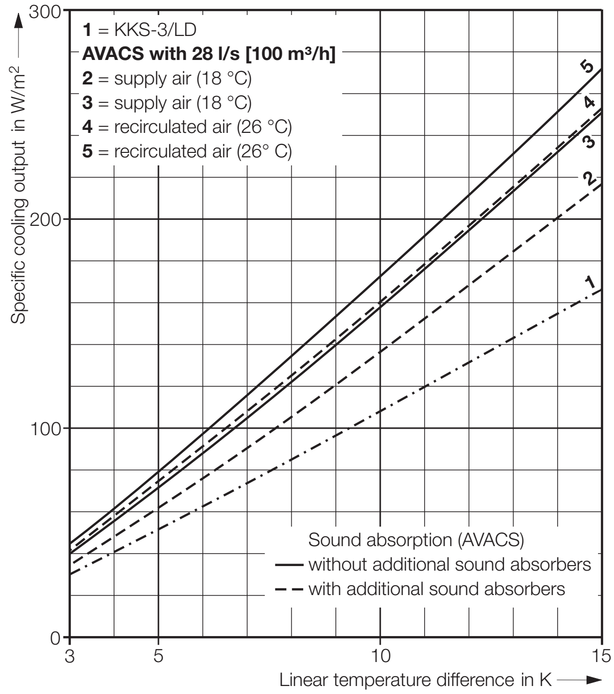
In reality several conditions that also influence the output differ from those in the test room to EN 14240, among others:

- the convective heat transfer at the panel surface when turbulent mixing ventilation is generated by ceiling diffusers,
- the exchange of radiant heat when room walls have higher surface temperatures, or
- the heat transfer on the rear side when insulation and ventilation above the panel are changed.

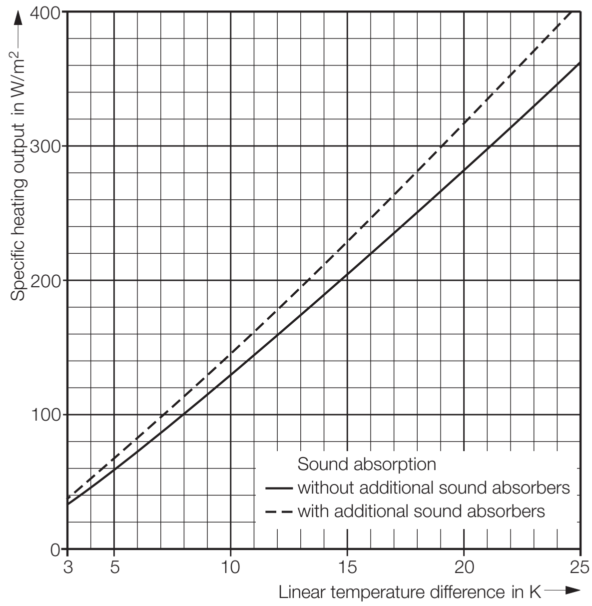
In practical usage these differences mainly result in increased output. Having carried out numerous laboratory tests we are able to assess such influences, yet exact statements can be made only after laboratory tests performed under conditions close to reality.

The maximum waterside pressure drop (30 kPa) of the cooling elements depends on their dimensions and the chilled water flow rate.

Cooling output and pressure drop can be determined using selection software (see example in Fig. 4). If you wish so, the selection of the AVACS can be carried out by our product specialists.
If you have special wishes regarding system design, materials or specific conditions of use, consult our specialists.



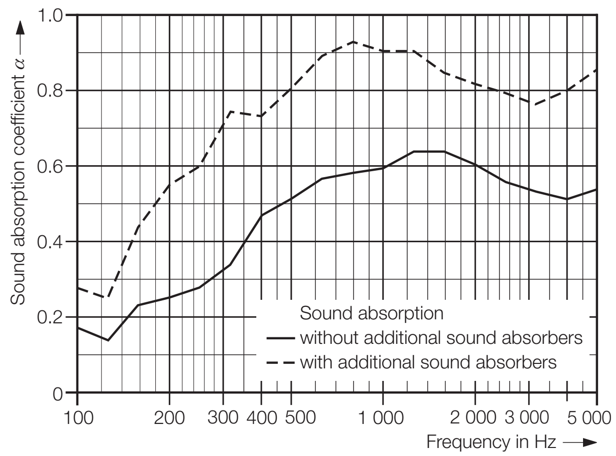
Graph A: Specific cooling output of AVACS to EN 14240



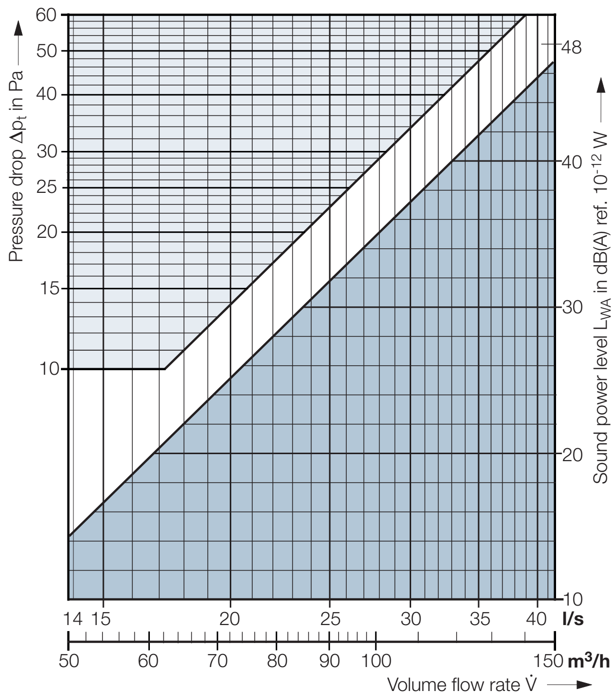
Graph B: Specific heating output of AVACS to EN 14037 (here with 28 l/s [100 m³/h] supply air; supply air temperature 20 °C)

Multifunction exposed ceiling AVACS

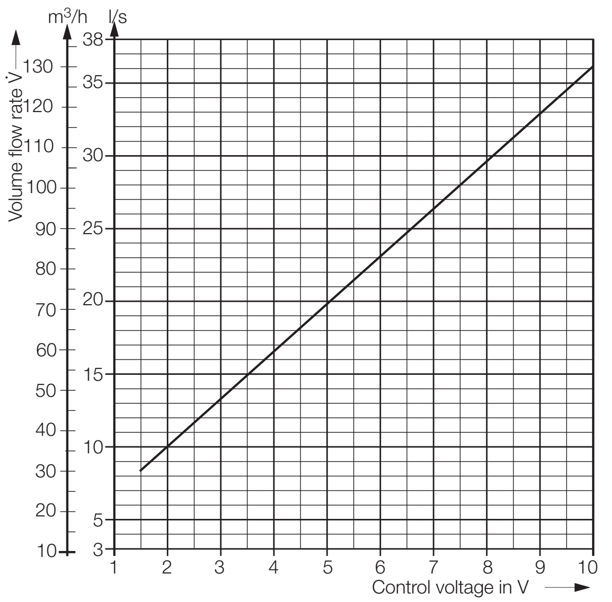
Layout data



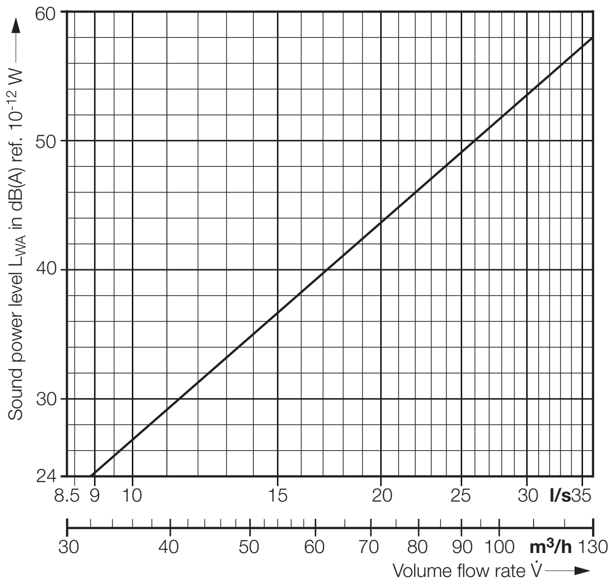
Graph C: Sound absorption measured on a AVACS fitted with acoustic lining, perforation pattern Rg 2516



Graph D: Sound power level and pressure drop dependent on the volume flow (supply air function)



Graph E: Volume flow dependent of the control voltage (AVACS with recirculated air function)



Graph F: Sound power level dependent on the volume flow (recirculated air function)

Table 2: Sound power level of AVACS with supply air function

Volume flow rate		Pressure drop	Sound power level L_{WA} in dB ref. 10^{-12} W								
			L_{WA}	Octave band centre frequency in Hz							
m³/h	l/s	Pa	dB(A)	63	125	250	500	1 K	2 K	4 K	8 K
50	14	7	#	18	22	22	20	—	—	—	—
75	21	17	26	27	31	29	27	20	12	—	—
100	28	29	35	33	37	35	32	30	24	16	—
125	35	46	41	38	42	39	36	38	34	27	—
150	42	66	47	43	46	43	40	44	41	36	—

Table 3: Sound power level of AVACS with recirculated air function

Volume flow rate		Sound power level L_{WA} in dB ref. 10^{-12} W								
		L_{WA}	Octave band centre frequency in Hz							
m³/h	l/s	dB(A)	63	125	250	500	1 K	2 K	4 K	8 K
50	14	35	26	25	33	31	29	25	14	—
60	17	39	30	29	38	35	34	30	18	—
70	19	43	34	33	41	39	37	33	22	—
80	22	46	37	36	45	42	41	36	25	—
90	25	49	40	39	47	45	44	39	28	—
100	28	52	43	41	50	48	46	42	30	—

Multifunction exposed ceiling AVACS

Layout example

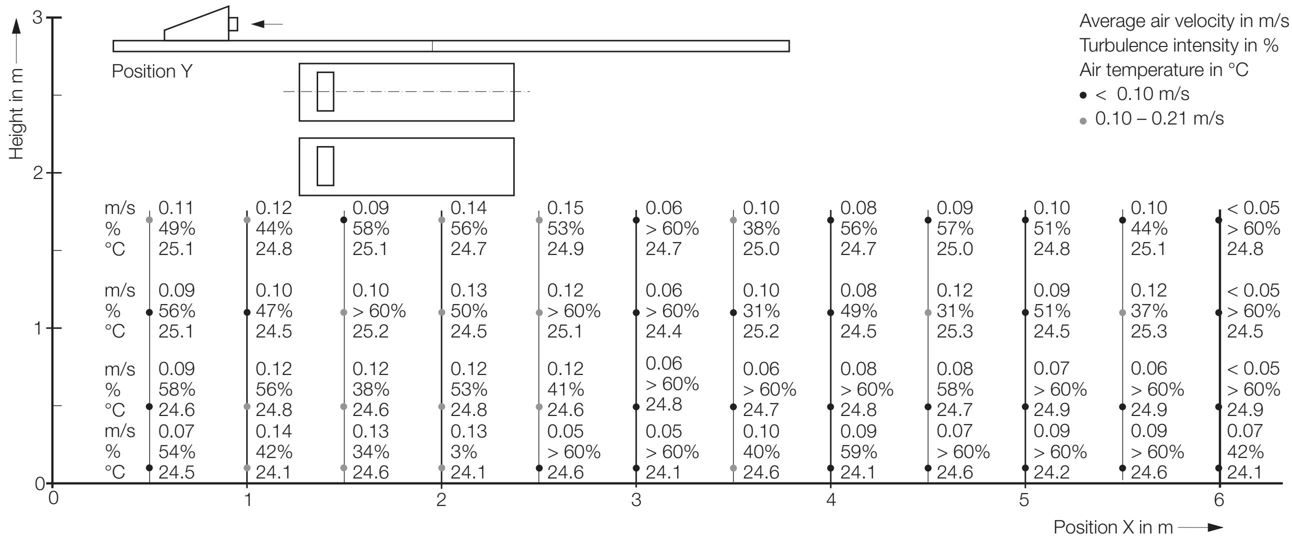


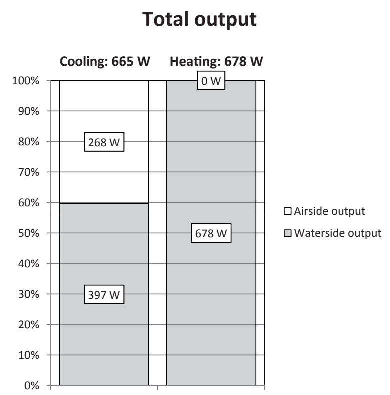
Fig. 4: Indoor air flow measurements

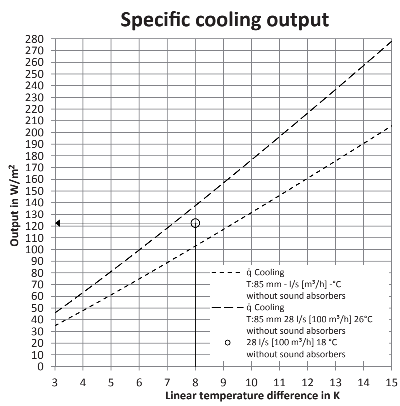
Layout example (cooling mode / heating mode)

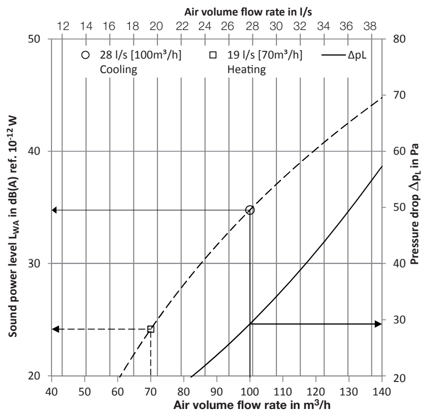
The achievable active area of a AVACS depends on the total panel area which must be geared to the room configuration. The specific cooling output is dependent on the active cooling area, the supply air volume flow rate and the waterside parameters. This can be seen in the following example (Fig. 5).

AVACS

Project:		
Input:		
Sail length:	3.2 m	
Sail width:	1.15 m	
Number of single elements:	2	
Sound absorbers:	none	
Design without induction unit:	no	
Length of connection hose:	1000 mm	
Layout:	Cooling + Heating	
Pipe spacing:	opt.	
Outside diameter of pipes:	12 mm	
	Cooling:	**Heating:**
Water supply temperature:	17	38 °C
Water return temperature:	19	32 °C
Room temperature:	26	20 °C
Supply air flow rate:	28 [100]	19 l/s [70 m³/h]
Supply air temperature:	18	20 °C
Pipe spacing:	95 mm	
Pipe connection:	180°	
Connection:	on one side	
Sail area:	3.68 m²	
Active area:	3.24 m²	
Numb er of pipe rows:	12	
(Heating mode isothermal)	**Cooling:**	**Heating:**
Mean water temperature:	18	35 °C
Temperature difference:	8	15 K
Waterside output:	397 W	678 W
Airside output:	268 W	0 W
Total output:	665 W	678 W
Specific output ($A_{akt.}$):	123 W/m²	209 W/m²
Sound power level:	35	24 dB(A)
Pressure drop, air:	30	15 Pa
(related to oval spigot 158 x 70 mm)		
Water flow rate:	171	97 l/h
Flow velocity:	0.48	0.27 m/s
Pressure drop, water:	18	7 kPa
	179	72 mbar







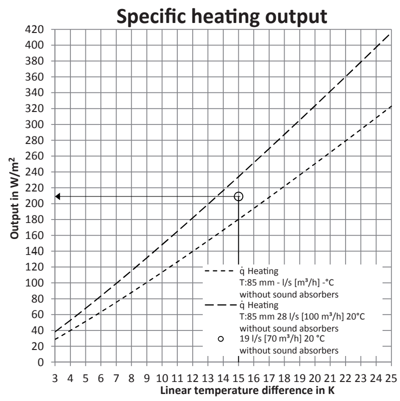


Fig. 5: Layout example

Design specifications (cooling mode)

This section deals with details of importance for the design of AVACS. The coordination required between the engineer and the architect for selecting the optimum solution for the ceiling, type of chilled ceiling system, kind of room ventilation, etc., is described in our publications ref. K 181 e ‘Cooling ceiling technology’ and DS 4076 e ‘Cooling ceiling system description’.

The design work on such chilled ceiling modules requires detailed consultation with the project’s architect, the lighting consultant and the acoustical consultant. The following questions must be answered from the beginning:

- What cooling output is to be delivered by the chilled ceiling?
- What services will be integrated into the ceiling and where?
- Is an adaptable floor plan required or not?
- To what extent is the ceiling area required for sound absorption?

This information is essential to determine the ceiling type and design and the possible active panel density. Besides room configuration as well as number and arrangement of ceiling services, level differences in the ceiling and mouldings also have a substantial influence on the achievable active panel density.

The ceiling type and material and the dimensions of the panels determine the design of the heat conducting profiles and the achievable specific cooling output. A number of variable details are required, but often they can be set by the architect or drywall contractor only during project implementation.

Most important are:

- length and width (L x B) of AVACS
- the ceiling system (way of fastening panels to ceiling suspension system) and associated details of ceiling panels
- the total cooling output required for the chilled ceiling per m^2 of ceiling area
- the ceiling layout, especially details of dimensions and location of ceiling services such as lights and air diffusers
- the sound-absorbing values required for the ceiling system
- data on texture of acoustic lining
- data on rear insulating material
- Is the chilled ceiling combined with a ventilation system? How is the supply air introduced into the room and how is the return air extracted?

The tender text on page 11 contains all data required for selecting AVACS and determining the cooling output.

The system layout is carried out in line with the prevailing regulations and standards (in Germany mainly DIN 1946-2), the local weather conditions as well as the actual building’s conditions (e.g. mechanical ventilation or openable windows).
Usual layout conditions in Germany are:
operative room temperature ϑ_r = 26 °C
chilled water supply temperature ϑ_{ws} = 17 °C
chilled water return temperature ϑ_{wr} = 19 °C,
i.e. an output-determining temperature difference of 8 K between operative room temperature and mean chilled water temperature.
Under optimum conditions, i.e. active panel density approx. 85% plus turbulent mixing ventilation from the ceiling, the cooling output can be up to 80 W/m^2 of floor area.

Still higher cooling loads can be removed using high-capacity cooling elements from our SKS product family.

The minimum chilled water flow rate should be no less than 45 l/h per chilled water circuit or group of elements. Otherwise an insufficient flow velocity within the copper serpentine pipework will impair the output.
In view of the usual size of the panels (< 1 m^2) the minimum water flow rate can be achieved only by connecting several panels in series. For further advantages, e.g. lower costs for chilled water pipework, it is usual to make groups with a pressure drop of 25 to 30 kPa.

The following relations are to be considered for the system design:

- width B of ceiling panels, pipe spacing T and the resultant number of pipe rows as well as position of connection ends
- arrangement of water supply and return pipes
- making groups with as equal pressure drop as possible
- allowing for desired features such as pull-down design and automatic air relief
- cost minimization, e.g. with optimum hose lengths, position, type and number of group connections at water supply and return.

Krantz provide the comprehensive system design and supply the AVACS with accessories

- flexible connection hoses
- modular supply and return pipes with connection possibility at the room boundary (without shutoff and control valves and fittings) to fit the ceiling layout, type and design as well as the cooling output in conjunction with the overall HVAC solution.

The chilled water supply temperature must be chosen above the dew point temperature of the room air. To prevent condensation (at least in rooms with the highest expected air humidity), dew point sensors shall be fitted to the water supply pipes or to the contact profile close to the supply connection. It is essential that the dew point sensors be sufficiently flushed by air at the prevailing indoor conditions.

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Multifunction exposed ceiling AVACS

Remarks on project implementation

AVACS can achieve a sound absorption class to EN ISO 11654 as follows:
α_w = 0.60 to 0.70, Class C, i.e. highly absorptive.
This mainly depends on the AVACS design and the sound-absorbing materials.

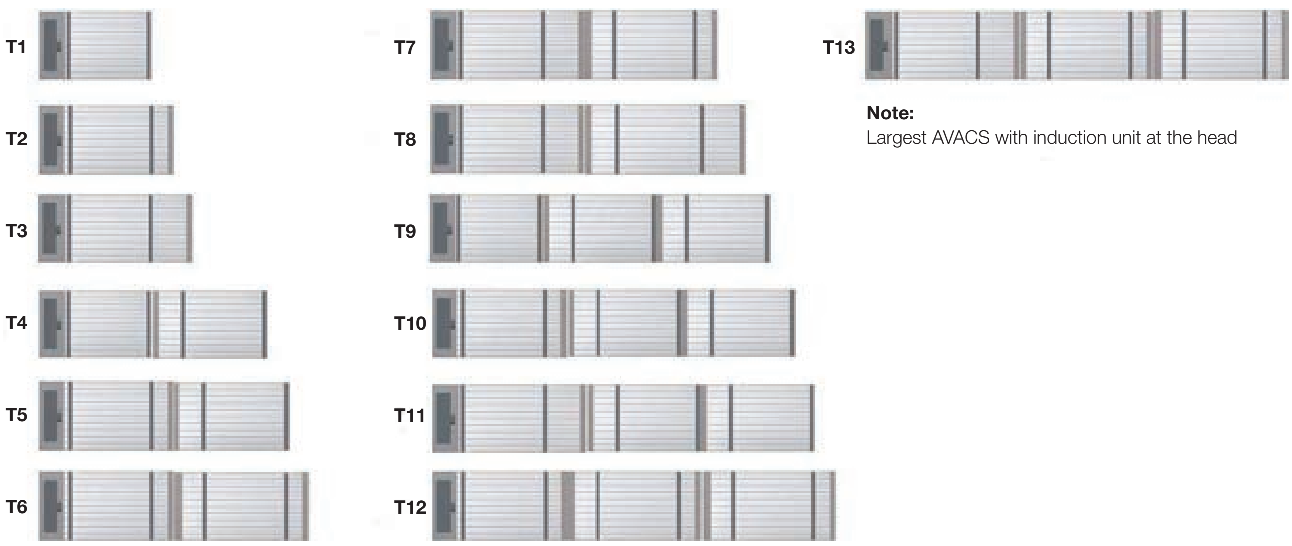
The general influence of chilled ceilings on thermal comfort – with or without mechanical ventilation – is described in detail in our brochure 'Cooling ceiling system description' (ref. DS 4076 e) and in other publications. These also contain information on the combination of our cooling ceiling systems with different air distribution systems. Such combination is advisable for most applications.

Chilled ceilings make for great satisfaction of room occupants because they provide:
- nearly constant temperatures over the room height
- low room air velocities
- comfortable heat removal by both radiation and convection
- noiseless operation, etc.

Remarks on project implementation

A prerequisite for project implementation is a detailed system design based on the ceiling layouts approved by the architect. These include the following information:
- Number and arrangement of AVACS
- Cooling output to be removed / Heating output to be delivered
- Position and type of connection ends of serpentine pipework
- Waterside connections between AVACS as well as specifications, e.g. type of connection hoses
- Position of supply and return pipes, their connection points, and the grouping of serpentine pipework
- Flow rates and pressure drops at the connection points of supply and return pipes to the chilled water system.

To achieve different performance levels with as little panel area as possible, the AVACS is made available in 13 standard design options. It is thus possible to get panel lengths up to 5.5 m and cooling outputs up to 970 W (at 8 K). The AVACS dimensions available are shown in Fig. 5.



Type / Element length	T1	T2	T3	T4	T5	T6	T7	T8	T9	T10	T11	T12	T13
1 500	1			2	1				3	2	2		
1 750		1			1	2	1			1		3	2
2 000			1				1	2			1		1
Total length	1 500	1 750	2 000	3 000	3 250	3 500	3 750	4 000	4 500	4 750	5 000	5 250	5 500

Fig. 6: Standardized sizes

Information on installation

The installation of the suspended cooling panels is carried out by the drywall contractor who has to include the different AVACS components in his installation procedure.

The installation of the water supply and return pipes is to be carried out at the same time as or directly after the installation of the ceiling suspension system, e.g. gypsum board ceiling, by the pipe fitter. The leakage test on these piping sections is to be made prior to mounting the cooling panels.

Fig. 7: For panel suspension, the fastening crossbars are suspended from the ceiling using threaded rods and their position is adjusted in height and alignment

Then the AVACS are positioned against the crossbars and fixed with screws so that they cannot shift but can be unfixed.

Fig. 8: Installed AVACS

Our installation instructions describe in full detail how to properly install our multifunction exposed ceiling. It is essential that these instructions be complied with.

For ceiling inspection, systems with cooling panels in pull-down design are advantageous. We can optionally provide an inspection element to enable to get to the control valves and sensors provided by the client (for servicing purposes); then no pull-down design is required for the panel.

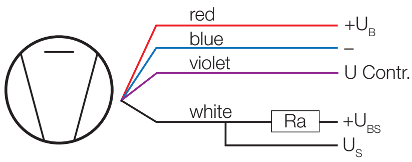
Using infrared thermography it is possible to prove that the AVACS installed are complete and ready for use.

To prevent condensation, the operation of condensate probes and control systems along with the associated fittings will be checked following the manufacturers' specifications.

Electrical connection of the recirculating air fan see fig. 9.

Electrical connection of the recirculating air fan

Power supply of the recirculated air fan: 24 V DC±15%
The rotational speed can be set via a 0 – 10 V DC signal.
The motor of the fan starts at their minimum rotation speed at a signal setting of 1.5 V an increases this steady to 10 V.



Wire color	Function
red	+24 V
blue	GND
violet	CTRL
white	TACHO (OC)

Fig 9: Electrical connection of the recirculating air fan

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Multifunction exposed ceiling AVACS

Features and tender text

Main features

- Energy transfer by convection and radiation, resulting in high thermal comfort
- Standard cooling output to EN 14240: up to 165 W/m^2 (at 10 K)
- Only slight temperature differences in the occupied zone
- Suitable for refurbishment on offices and exhibition spaces
- Combinable with concealed air distribution systems
- Supply air or recirculated air volume flow rates can range from 14 to 28 l/s [50 to 100 m^3/h]
- Very high output in relation to the active panel area (area-output ratio) thanks to built-in induction unit
- Very high thermal comfort thanks to air distribution below the AVACS
- Induction unit not visible from below
- The induction unit may obviate the need for additional ventilation for the room
- Optimum exchange between fresh and stale air if both an induction unit and a return air diffuser are available
- Ventilation with conditioned supply air being discharged uniformly and horizontally
- Also suitable for heating
- Different types of finish are possible; ceiling services can be integrated
- Good acoustic properties
- Low suspension height from ceiling (min. 150 mm), thus
  - well suited for refurbishment projects,
  - savings on construction costs and building volume on new-build projects
- The technical selection can be done by Krantz; this ensures safety, reliability, and a comprehensive system solution
- With installation methods in use in building services and drywall construction
  - ease of installation
  - short installation time
- The core of the system are the copper serpentine pipework and the induction unit; this means
  - no special requirements for chilled water quality
  - low system costs
  - long service life
  - assured quality
  - operating pressure up to 16 bars dependent on the execution
- Elements manufactured to ISO 9001, using quality-controlled copper tube
- Available without combustible components

Tender text

.... units
AVACS designed to build an attractive cooling/heating radiant ceiling system for removing sensible heat loads via radiation (approx. 40%) and convection (approx. 60%); ventilation with conditioned supply air discharged uniformly and horizontally, with high induction of indoor air. An air cushion at the discharge area minimizes dirt accumulation on the ceiling; air discharge direction from the facade towards the room;

consisting of:

- a panel suspension system made up of Sendzimir galvanized crossbars that are suspended from the concrete slab by means of threaded bolt (by others) and are adjustable in height; each panel is to be stabilized without additional visible screws
- perforated metal ceiling panels, hole diameter: 2.5 mm, approx. 16% open area, with powder coated face; quality according to TAIM requirements; with 90° return edge (h = 50 mm) on all sides; these are additionally returned inwards and reinforced in the corners.
  The visible border (unperforated) on all sides is about 10 mm.
- black acoustic lining bonded to the rear side of the ceiling panels
- a cooling/heating system made up of copper serpentine pipework ø 12 x 0.4 mm, which is embedded in large aluminium heat conducting profiles and bonded to the ceiling panels
- an induction unit with oval connection spigot suitable for flex duct DN 125, for air distribution along the AVACS, which is to be fixed (by others) to the metal ceiling panel with 2 sheet metal screws (Note: coordination with ventilation contractor is necessary)
- Optional Induktionsaufsatz mit Ventilator für den Umluftbetrieb, Nennspannung 24 V DC
- As an option, sound absorbers can be put on the rear side of the metal ceiling panels to improve the sound absorption coefficient; further, the AVACS can be optionally provided in pull-down design.

Technical data

Total cooling output per 2-piece panel dependent on the execution (referred to dimensions below):   W

Specific cooling output (waterside):	.... W/m^2
Chilled water supply temperature:	17 °C
Chilled water return temperature:	19 °C
Room temperature:	26 °C
Temperature difference:	8.0 K
Max. operating pressure:	6 bars
Water quality:	adequate mains water
Supply air temperature (bei Ausführung Zuluftfunktion):	18 °C
Air volume flow rate:	28 l/s [100 m^3/h]

Dimensions / Design:

Length of AVACS (see standards in Fig. 6):	.... mm
divided into	.... single lengths
1st partial length	.... mm
2nd partial length	.... mm
3rd partial length	.... mm
Width of AVACS:	1 150 mm
Suspension height:	≥ 150 mm

Connection type:
Pipe end for push-in fitting, OD = 12 mm (standard)
Connection side: one side
(depending on number of pipes and number of water connections per element)

Colour: similar to RAL 9010 (standard)

Make: Krantz
Typ: AVACS

Subject to technical alterations.

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