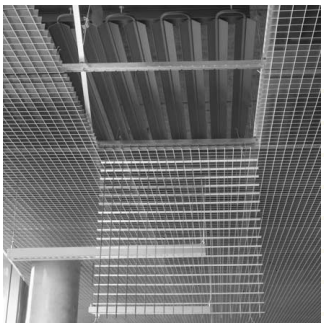
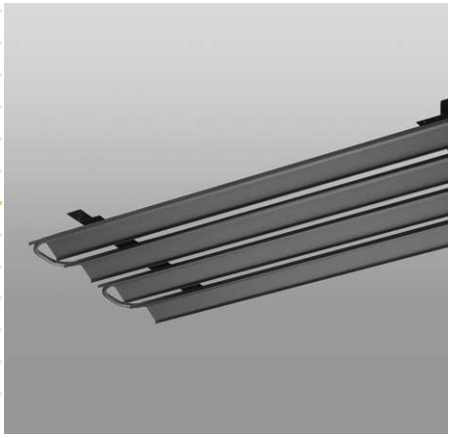
2

Cooling and heating systems

Static cooling ceiling system SKS-4/3





Technical Selection

DS 4094 E 05.2007/1

Krantz KOMPONENTEN®

Applied system solutions

Static cooling ceiling system SKS-4/3

Main features

- High specific cooling output:
  Standard cooling output 175 W/m^2 of cooling element without suspended ceiling (to DIN 4715)
  - Small percentage of covered area at medium cooling load affords large space for ceiling utilities
  - Supply temperatures > 16 °C lessen or prevent the condensation risk, which lowers the cost for measurement and control systems
  - Chilled water temperature differences > 2 K save on investment and operating costs
- Suitable for very high cooling outputs as required in TV studios and mechanical rooms, or for industrial applications
- Uses the retention capacity of the concrete ceiling
- Slight temperature differences in the occupied zone
- Combinable with any air distribution system
- The cooling elements are independent of the false ceiling, i.e.
  - design and installation of mechanical equipment and ceiling can largely occur separately
- Low installation height, thus
  - well suited for renovation and retrofitting
  - savings on building costs or building volume in new buildings
- The core of the system is copper serpentine piping, which means
  - no special requirements for chilled water quality
  - low system costs
  - long lifetime
  - assured quality
  - operating pressure up to 16 bars
- Good dynamic response
- No combustible components
- High-quality system manufactured to DIN EN ISO 9001 and from quality-controlled copper piping

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Static cooling ceiling system SKS-4/3

Preliminary remarks

The SKS static cooling ceiling system is made up of high-capacity elements that are suitable for installation above open suspended ceilings or for visible mounting. This system is primarily intended for cooling rooms of any type and for any use, but it can also be used for heating.

SKS-4/3 belongs to the well-known SKS system family, with the improved system design allowing for more efficient manufacturing processes. SKS-4/3 is intended for commercial applications – installation preferably above open suspended ceilings.

Construction design

The SKS cooling elements are made up of:

- copper serpentine piping in one piece, with connections for chilled water inflow and outflow,
- cooling fins, made from aluminium profile, into which the copper piping is pressed in a way to ensure effective and durable heat conduction,
- Z-shaped profiles, made from galvanized sheet metal, to which the single cooling fins are fastened and by which the complete cooling element will be suspended directly to the concrete ceiling.

The main dimensions of a cooling element are given in Fig. 1 (page 4) and further technical data is contained in the box below. The surface area of a cooling element should not exceed 5 m^2.
The piping for SKS-4/3 cooling elements is made exclusively from copper that is subject to permanent quality control.

As standard the cooling elements are either powder-coated or wet-painted in black; for visible mounting, however, all RAL colours as well as many other colours can be used.

Design data

The cooling output of SKS-4/3 has been determined in accordance with DIN 4715. If SKS-4/3 elements are free-hanging from a concrete ceiling, the standard cooling output amounts to 175 W/m^2 of cooling element (projected surface area). Graph A (page 6) shows the specific cooling output with such placement for the main range of operative room temperatures and mean water temperatures.

If SKS-4/3 elements are placed above a suspended ceiling, the latter affects the heat removal (radiation and convection) from the occupied zone if the free area is < 65%. With metal ceilings (rectangular or square tile ceilings, panel or strip ceilings, etc.) the cooling output has to be corrected in relation to both the free area according to Graph B (page 6) and the area covered by cooling elements according to Graph C (page 6). How to determine and correct these values can be read off the layout example on page 5.

The waterside pressure loss of the cooling elements in relation to water flow and dimensions is shown in Graph D (page 7). If several elements are connected in series, please consider the notes to this graph.

Cooling output and pressure loss can be determined (with limited accuracy) according to said layout example using the aforementioned graphs; this, however, applies for usual types of installation.

SKS-4/3 can also be used for heating purposes. As a rule, this makes sense only in case of visible installation or with suspended ceilings having a free area A_0 > 70%.

Rather high heating outputs (related to the active area) can be achieved since it is not necessary to limit the water supply temperature as is required in the cooling mode due to the dew point of indoor air.

To make it easier for you and for more safety, competent engineers at KRANTZ KOMPONENTEN can make the technical selection for you, using the relevant software.

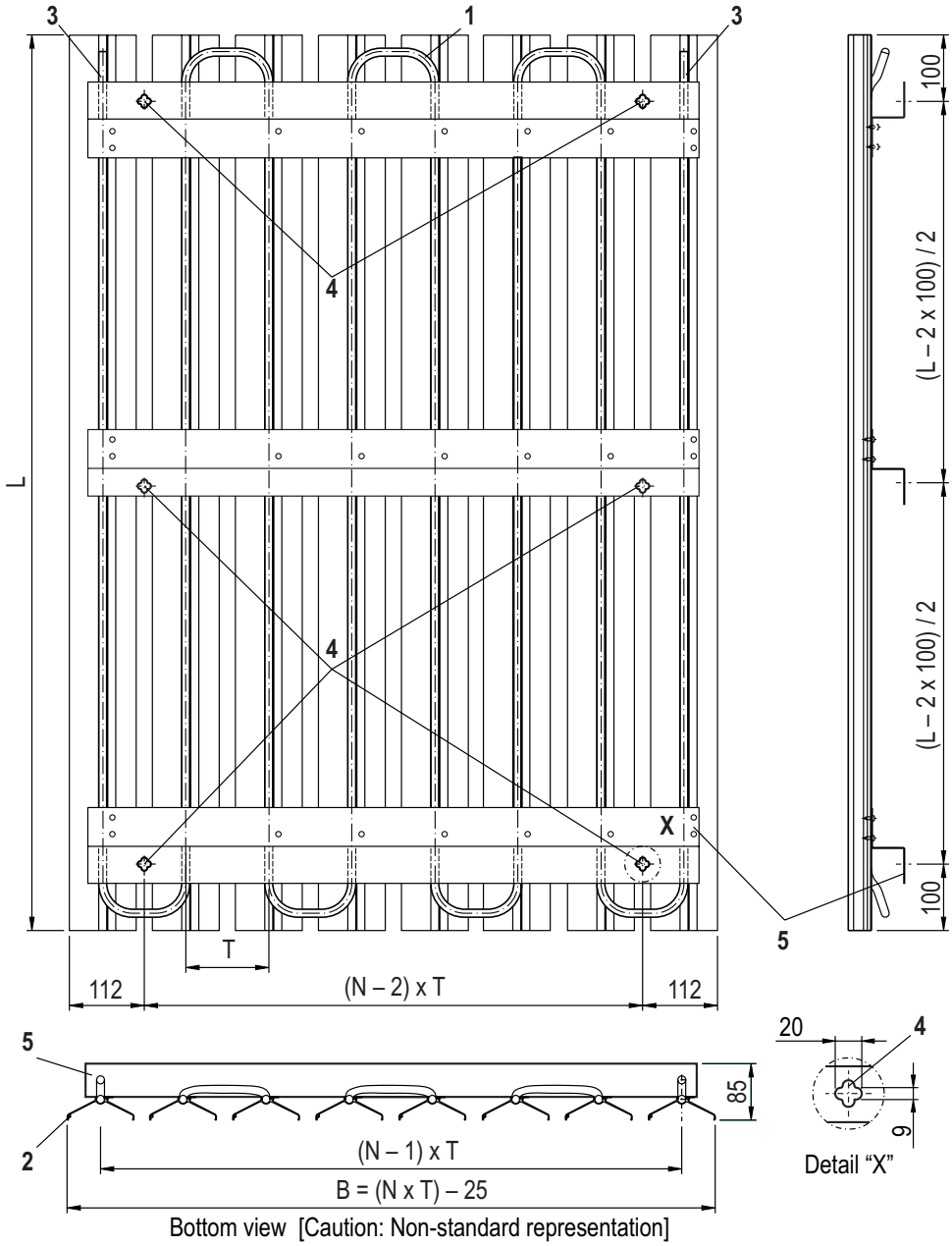
Main dimensions and materials

	Standard
Serpentine piping	copper pipe D = 12 mm x 0.5 mm, CU DHP R25, tested
Cooling fins	aluminium extruded profile
Fastening profiles	galvanized sheet metal
Connection ends	for push-in fittings or press-fitted connections: outside diameter 12 mm (standard) for solder connections: outside diameter 12 mm ± 0.1 mm
Pipe division	125 mm
Nominal length L	1000 mm ≤ L ≤ 4000 mm in steps of 100 mm [1)]
Nominal width B	350 mm ≤ B ≤ 1475 mm in steps of 125 mm [1)]
Nominal height	85 mm [1)]
Installation height	≥ 185 mm, i.e. min. 50 mm clearance above and below the element
Permissible operating pressure	6 bars [1)] (max. 16 bars)
Weight	approx. 7 – 9 kg/m^2 when filled with water

1) For other values, please consult us

Static cooling ceiling system SKS-4/3

Fig. 1: SKS-4/3 cooling element, main dimensions



Bottom view [Caution: Non-standard representation]

Number of cooling fins N	Actual width B
3	350
4	475
5	600
6	725
7	850
8	975
9	1100
10	1225
11	1350
12	1475

Key

1 Copper serpentine piping
2 Cooling fin
3 Connection for chilled water
4 Fastening points
5 Rear fastening profile
L ≤ 3000 mm → 2 pieces
3000 mm < L ≤ 4000 mm → 3 pieces
B Actual width
L Actual length
N Number of cooling fins
T Pipe division (standard 125 mm)

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Static cooling ceiling system SKS-4/3

In normal cases, the range of applications is limited by the thermal comfort criteria (see also DIN 1946, Part 2 – Influence of radiation of the heated ceiling and cold air drop at the facade).

This is described in detail in our technical report „Heating and cooling with ceilings" (ref. TB 87/2002 e) which is available in our website.

For information on heating output and influences on thermal comfort in specific cases, please contact your local KRANTZ KOMPONENTEN agency or our head office at Aachen, department 'Cooling and Heating Systems'.

Layout example (cooling mode)

The following equations apply:

$\dot{q}$	=	$\dot{q}_0 \cdot k_D \cdot k_\beta$	(1)
		$\dot{q}_0$ from Graph A	as f (ϑ_R, ϑ_W)
		k_D from Graph B	as f (A_0)
		k_β from Graph C	as f (A_0, β)
A_{SKS}	=	$\dot{Q} / \dot{q}$	(2)
n	=	$A_{SKS} / A_{KE} = \dot{Q} / (\dot{q} \cdot A_{KE})$	(3)
$\dot{V}_W$	=	$(0.86 \cdot \dot{q} \cdot A_{KE}) / \Delta\vartheta_W$	(4)
β	=	$A_{SKS} / A_R = (A_{KE} \cdot n) / A_R$	(5)
Δp	=	$1.81 \cdot 10^{-5} \cdot N (L + 0.1) \cdot \dot{V}_W^2$	(6)
		Δp from Graph D as f ($\dot{V}_W$, equivalent pipe length)	

Method of calculation:

Requisite cooling output of cooling ceiling (about 60 W/m² of floor area)	$\dot{Q}$	=	1400 W
Room temperature	ϑ_R	=	26 °C
Chilled water supply temperature	ϑ_{VL}	=	16 °C
Chilled water temperature difference	$\Delta\vartheta_W$	=	2 K
Room ceiling surface area (floor area)	A_R	=	23 m²
Free area of false ceiling (related to ceiling surface area)	A_0	=	25%

1. From Graph A: $\dot{q}_0$ = 156 W/m²

2. From Graph B: k_D = 0.74 (mean value)

3. k_β results from Graph C:

As the covered area β is not yet known, it must be estimated!
Assumption: β = 50% → k_β = 1.06

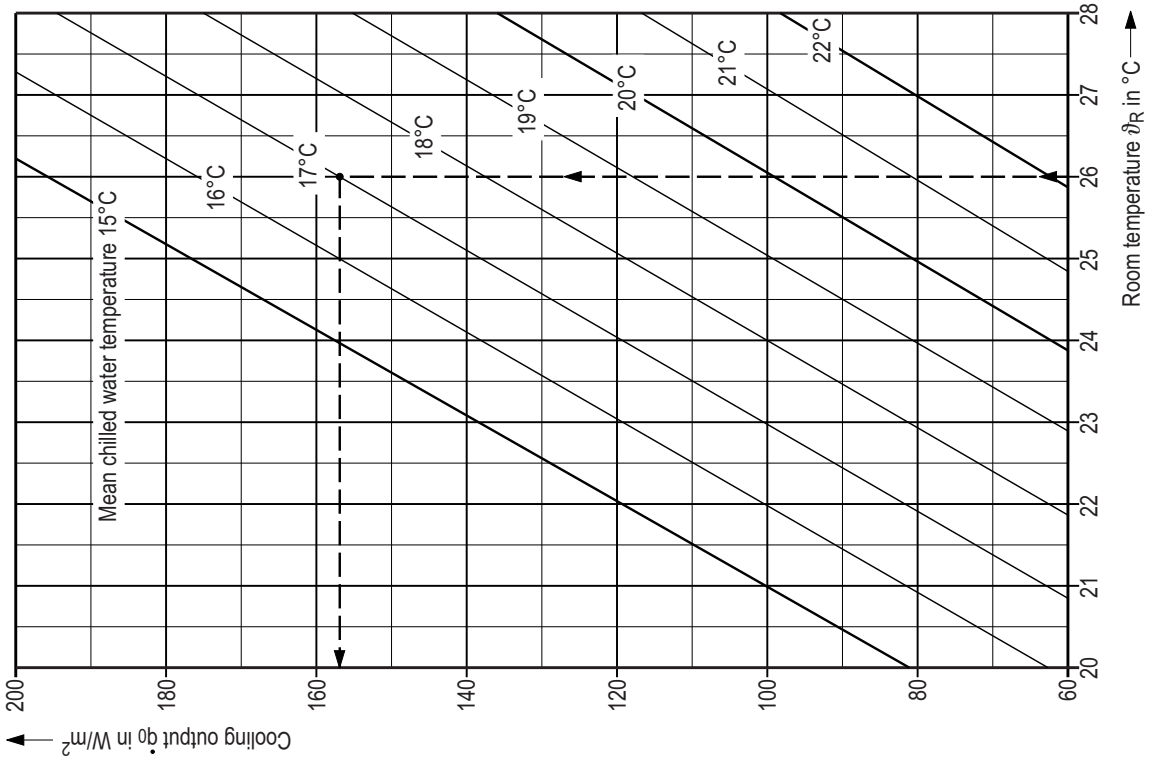
[continued on page 8]

Key

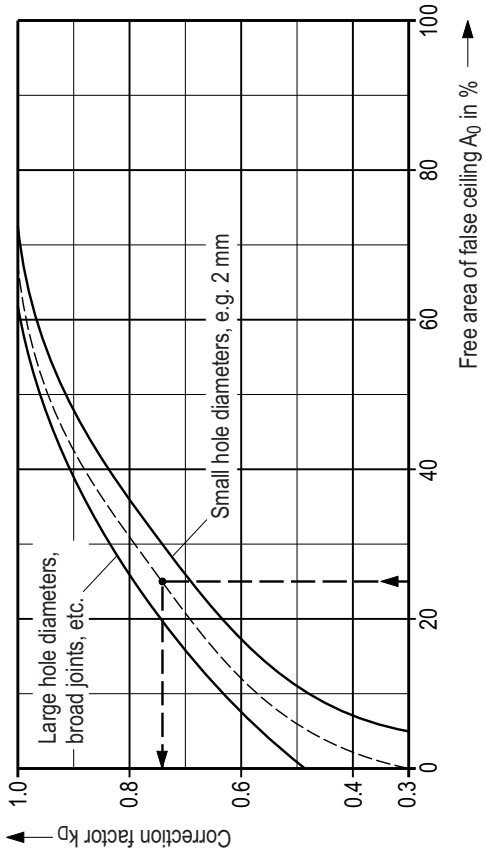
$\dot{Q}$	requisite cooling output of cooling ceiling in room, in W
$\dot{q}$	specific cooling output of cooling elements, in W/m² of cooling element (projected area)
$\dot{q}_0$	specific cooling output for A_0 = 100% and β = 64% to DIN 4715
ϑ_R	room temperature to DIN 1946, Part 2, in °C
ϑ_{VL}	chilled water supply temperature in °C
$\Delta\vartheta_W$	chilled water temperature difference in K
A_R	room ceiling surface area (floor area) in m²
A_0	free area of false ceiling (related to ceiling surface area) in %
A_{SKS}	requisite total surface area of SKS in m²
A_{KE}	surface area L x B of a cooling element in m²
n	number of cooling elements in surface area A_{SKS}, in units
β	covered area or ratio of total SKS surface area to room ceiling surface area, in %
k_D	correction factor for influence of A_0 on $\dot{q}$
k_β	correction factor for influence of covered area on $\dot{q}$
$\dot{V}_W$	chilled water flow rate per cooling element in l/h ($\dot{V}_W$ > 70 l/h)
Δp	pressure loss of a cooling element in kPa
N	number of cooling fins per cooling element, in units
B	actual width of cooling element in m
L	actual length of cooling element in m

Static cooling ceiling system SKS-4/3

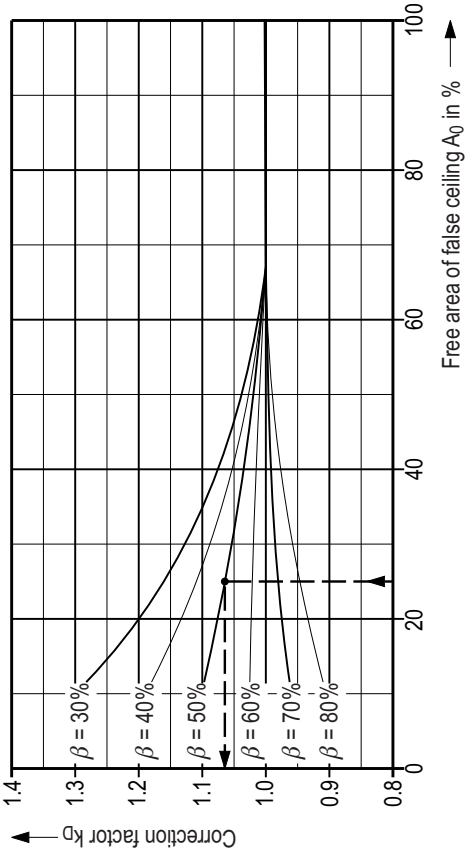
Graph A:
Specific cooling output of SKS-4/3 cooling elements forming a chilled sail (to DIN 4715-1)



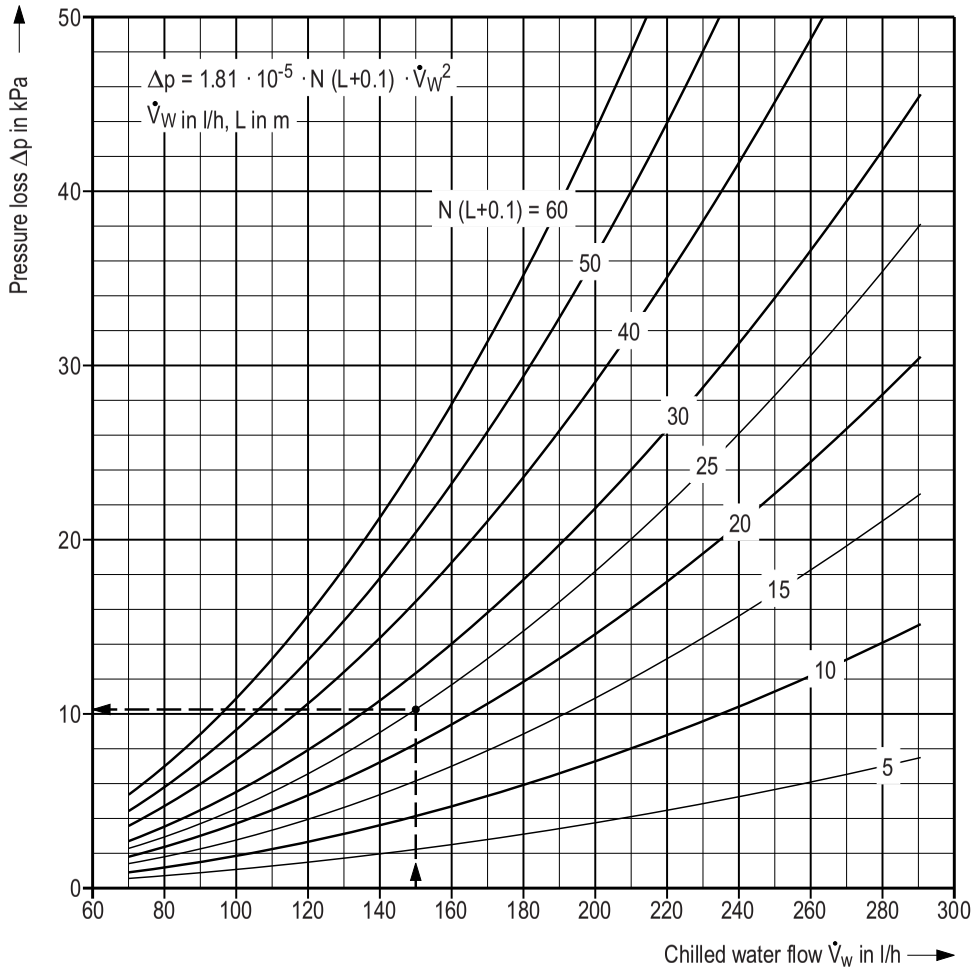
Graph B:
Influence of false ceiling



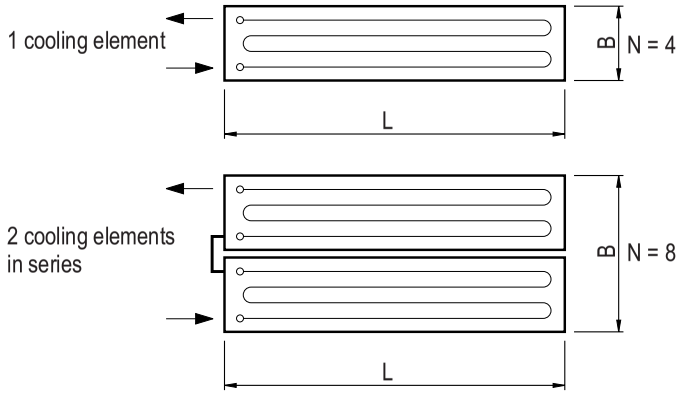
Graph C:
Influence of covered area β



Graph D:
Pressure loss of SKS-4/3 cooling elements



Notes to pressure loss graph



If cooling elements of equal length are connected in series, N and B refer to the sum of all N and all B.
If cooling elements of unequal length are connected in series, the equivalent pipe lengths of the single elements [N_i (L_i + 0.1)] must be added together.

Static cooling ceiling system SKS-4/3

4. From Equation (1):	$\dot{q}$ = 156 · 0.74 · 1.06 = 122 W/m²
5. From Equation (2):	A_{SKS} = 1400 / 122 = 11.5 m²
6. Check of covered area β:	
β = 11.5 / 23 = 50%, i.e. no correction necessary.	
7. From Equation (3) we obtain n:	
The number n of cooling elements depends on their size. Length and width are selected taking account of room dimensions, transport and installation options, pressure loss and further conditions mentioned in this brochure (see page 3). We recommend selecting 2.0 < L < 3.0 m and 1.0 < B < 1.5 m.	
Assumption:	L = 3.0 m, B = 0.975 m → A_{KE} = 2.9 m² n = 1400 / (122 · 2.9) = 11.5 / 2.9 = 3.9 rounded up n = 4 units $\dot{Q}$ = 4 · 2.9 · 122 = 1415 W ≈ 1400 W
8. From Equation (4):	$\dot{V}_W$ = (0.86 · 122 · 2.9) / 2 = 152.1 l/h
$\dot{V}_W$ > 70 l/h, i.e. no series connection required.	
9. From Graph D:	with N = ROUNDING OFF (B/125) = 8 8 · (3.0 + 0.1) = 24.8 m and $\dot{V}_W$ = 152.1 l/h → Δp = 10.5 kPa

SKS-4/3 cooling elements can be laid out for the most usual applications according to this example (see the following „Design specifications"). For more safety and to ensure correct layout, the cooling elements can be selected for you by the specialists of KRANTZ KOMPONENTEN, using the relevant software.

Design specifications (cooling mode)

This section deals with the job „Designing an SKS-4/3 cooling ceiling system" which is only one part of the overall architectural and technical design work for a building. General information on cooling ceiling design is contained in our technical brochures „Cooling ceiling technology" (K 181/e) and „Cooling ceiling system description" (DS 4076 e).

The chilled water supply temperature shall be selected above the dewpoint temperature of the indoor air. To prevent condensation, the chilled water supply pipes shall be fitted with dewpoint sensors, at least in rooms with the highest anticipated indoor air humidity. It is essential that the dewpoint sensors be sufficiently flushed by air at actual room conditions. Usually, this is not a problem because of the free area required in a suspended ceiling fitted with SKS-4/3 cooling elements.

The layout shall be carried out in line with the prevailing regulations and standards (in Germany mainly DIN 1946, Part 2), the local weather conditions as well as the actual conditions of the building (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_{VL}	= 16 °C
chilled water return temperature	ϑ_{RL}	= 18 °C,

i.e. an output-determining temperature difference of 9 K between operative room temperature and mean chilled water temperature.

The cooling output being high, the requisite covered area is generally 30 – 60% only. This affords large space for ceiling utilities. It is preferable to suspend the cooling elements and the related chilled water pipework – mainly from copper – directly to the concrete ceiling, above lights, air diffusers, sprinkler heads, etc., so as to ensure full accessibility to all ceiling utilities and to allow for subsequent changes or supplements to the system.

Tables A and B show the cooling outputs that can be achieved at the aforementioned layout conditions, in relation to the free area of the suspended ceiling and the area covered by SKS-4/3 cooling elements.

Table A: Cooling output in W/m² of cooling element

Free area	Covered area β in %		
A_0 in %	30	45	60
20	130	119	111
25	135	126	119
40	147	143	139
> 65	157	157	157

Table B: Cooling output in W/m² of ceiling surface area

Free area	Covered area β in %		
A_0 in %	30	45	60
20	39	54	67
25	41	57	71
40	44	64	83
> 65	47	71	94

These tables show that above-average cooling outputs can already be achieved at a medium percentage of covered area, in conjunction with a sufficiently open ceiling or visible installation of SKS-4/3 elements.
For comparison, the cooling outputs achievable at an output-determining temperature difference of 7 K are shown in Tables C and D.

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Static cooling ceiling system SKS-4/3

Table C: Cooling output in W/m² of cooling element

Free area	Covered area β in %		
A_0 in %	30	45	60
20	100	92	85
25	104	97	91
40	119	110	107
> 65	120	120	120

Table D: Cooling output in W/m² of ceiling surface area

Free area	Covered area β in %		
A_0 in %	30	45	60
20	30	41	51
25	31	44	55
40	36	50	64
> 65	36	54	72

The high output of SKS-4/3 cooling elements can thus be used to advantage for

- achieving above-average cooling outputs in rooms with high heat loads,
- significantly reducing the active cooling surface area,
- reducing the chilled water flow rate via higher chilled water temperature differences $\Delta\vartheta_W$ > 2 K,
- operation with chilled water supply temperature ϑ_{VL} > 16 °C.

The minimum chilled water flow rate per cooling element amounts to 70 l/h. If this value is not reached, one of the following measures should be taken:

- to enlarge the elements concerned,
- to connect several elements in series, or
- to allow a smaller chilled water temperature difference for these elements (i.e. lower return temperature).

Otherwise, a too low flow velocity within the cooling element will impair its output (see output curve in Graph A, page 6).

The waterside pressure loss of a cooling element is determined by its specific cooling output, its size (length x width) and the selected chilled water temperature difference. As a rule, it should be ≤ 20–30 kPa but, on the other hand, it should be significantly higher than the piping resistance of its water path within the control loop so as to ensure a steady water distribution in line with the layout.

In practice, connections according to the Tichelmann principle have proved effective.

To a large extent, the suspended ceiling can be designed and installed independently of the SKS-4/3 cooling elements.

Only the following must be specified:

- the material (as a rule sheet metal or aluminium sheet),
- the free area, but not the exact hole or joint pattern,
- the position of the cooling elements within the suspension height of ≥ 185 mm (at least: nominal height + 50 mm above and below the element).

If the element width is < 1.20 m, there should not be any problem with the detailed coordination required later as the standard for the spacing of suspension points in metal ceilings is 1.20 m. For elements with length and width > 1.20 m, one may expect extra cost for the suspended ceiling structure, e.g. for girders.

If the suspended ceiling is subject to sound-absorbing requirements, these can be simply met using the same procedure as for SKS-4/1 elements (see brochure DS 4072/e 05-01, page 9, Fig.1). All known sound-absorbing materials can be used for this purpose.

Yet it is not possible to use acoustic mats or similar material on perforated ceiling tiles in conjunction with SKS-4/3 cooling elements.

The general influence of SKS-4/3 cooling ceilings on thermal comfort – with or without mechanical ventilation – is described in detail in our brochure „Cooling ceiling system description" (DS 4076 e) as well as in other publications.

Cooling ceilings make for great satisfaction of room occupants thanks to the following features:

- nearly constant temperatures over the entire room height,
- low indoor air velocities,
- heat removal by radiation and convection favourable in terms of physiology,
- no noise, etc.

In commercial applications, for keeping to the indoor air velocities specified by DIN 1946, Part 2, we recommend limiting the specific cooling output to $\dot{q}$ < 160 W/m² of cooling element.

It is quite possible, and even recommended for most applications, to combine SKS-4/3 cooling elements with various air distribution systems. In such case, the directions contained in the aforementioned brochure „Cooling ceiling system description" are to be taken into account.

For design specifications for the heating mode, refer to our technical report 'TB 87/2002 e' or consult us.

Static cooling ceiling system SKS-4/3

Installation instructions

All dimensions referring to suspension and water connection are mentioned in Fig. 1 on page 4; further data, e.g. weight and nominal pressure, is mentioned on page 3.

The SKS-4/3 cooling elements are best suspended directly from the concrete ceiling using M8 threaded rods that require plugs suited to the material and structure of the concrete ceiling and authorized by building authorities.

Where required, sound-absorbing components will be added to prevent emissions from external noise sources in the room, e.g. pump or valve noise, building noise and the like.

With rather great suspension heights or dense and regular arrangement in groups, an intermediate structure made up of steel mounting profiles is useful in many cases (fewer suspension points in the ceiling, easy alignment, etc.).

It is not allowed to suspend or fasten other components or ceiling utilities to the cooling fins or Z-shaped profiles of the cooling elements.

As a rule – especially for a small percentage of covered area – the cooling elements should be distributed evenly throughout the room. With a higher percentage of covered area, arrangement in groups makes sense, also weighted to the cooling load. The elements can be mounted abutting lengthwise (without clearance) or abutting endwise in case of one-sided chilled water connection.

Above and below SKS-4/3 cooling elements there should be ≥ 50 mm clearance to ceiling utilities and to the concrete or suspended ceiling. Less clearance, especially to large-surface components beneath the cooling elements, is likely to impair the cooling output.

The water connection must be made in compliance with the general rules for water systems; in particular, it should be without tension and should not hinder the venting of the elements.

SKS-4/3 cooling elements are delivered stacked on wooden pallets (up to 20 elements on one pallet), wrapped in plastic film. We recommend using a fork-lift truck for unloading and transport on site. Upon request the packages will be prepared for unloading with a crane.

Intermediate storage is recommended in roofed-over, dry, non-dusty spaces. Elements taken out of the packages should be mounted immediately. Prior to the installation of the cooling elements, all trades should have completed any kind of work generating a lot of dust or whirling dust up.

For large-size cooling elements, the use of travelling winches is recommended to facilitate installation.

Operation and maintenance

To prevent condensation, we recommend using condensate controllers where appropriate.

The cooling elements and the chilled water pipes, fittings and connections shall be checked following the manufacturers' specifications.

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Static cooling ceiling system SKS-4/3

Tender text

Static cooling ceiling system SKS-4/3 consisting of single, compact, high-capacity cooling elements for easy ceiling installation, with:

- copper piping 12 x 0.5 mm featuring a smooth, neat and dry inside surface to DIN 1787, tolerances to DIN 8905, in serpentine design with connections for chilled water inflow and outflow as straight pipe ends,
- triangular cooling fins made from aluminium extruded profile, with chilled water pipes pushed into,
- rear fastening profiles for uniform levelling of cooling fins, serving as suspensions from the ceiling (number dependent on cooling element length)

All visible parts are powder-coated or wet-painted.

Connection type:

- Pipe end for push-in fitting, press-fitted or solder connection (standard D_a = 12 mm)

Colour:

- black (matt) similar to RAL 9005 (standard)
- other colour to RAL .....

Number of cooling elements: ..... units

Make: KRANTZ KOMPONENTEN

Type: SKS-4/3

Type code:

SKS-4/3 x /
- Length
- Width
- Installation type Z, S
- Connection type S, L

Length – 1000 mm ≤ Nominal length ≤ 4000 mm
in steps of 100 mm

Width – 350 mm ≤ Nominal width ≤ 1475 mm
in steps of 125 mm

Installation type

Z – concealed installation in false ceiling plenum

S – visible installation

Connection type

S – push-in fitting or press-fitted connection, outside diameter 12 mm

L – solder end, outside diameter 12 mm

Technical data

Cooling output per cooling element: .....W

Cooling water supply temperature: .....°C

Cooling water flow per cooling element: .....l/h

Room temperature: .....°C

Free area of suspended ceiling: .....%

Covered area (exclusive of piping): .....%

Pressure loss per cooling element: .....kPa

Max. operating pressure (standard): 700 kPa

Water quality: Mains water

- Standard dimensions:
  - Nominal length: 3000 mm
  - Nominal width: 975 mm
  - Nominal height: 85 mm
  - Pipe division: 125 mm
  - Connection: one-sided

- Special dimensions:
  - Nominal length: .....mm
  - Nominal width: .....mm
  - Nominal height: .....mm

– Subject to technical alteration –

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