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BSI Standards Publication

Free hanging heating and cooling surfaces for water with a temperature below 120°C

Part 4: Pre-fabricated ceiling mounted radiant panels — Test method for cooling capacity

bsi.

National foreword

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Free hanging heating and cooling surfaces for water with a temperature below 120°C - Part 4: Pre-fabricated ceiling mounted radiant panels - Test method for cooling capacity

Panneaux rayonnants de chauffage et de rafraîchissement alimentés avec une eau à une température inférieure à 120 °C - Partie 4: Méthode d'essai pour la détermination de la puissance de rafraîchissement des panneaux rayonnants préfabriqués

An der Decke frei abgehängte Heiz- und Kühlflächen für Wasser mit einer Temperatur unter 120 °C - Teil 4: Vorgefertigte Deckenstrahlplatten zur Raumheizung - Prüfverfahren für die Kühlleistung

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European foreword

This document (EN 14037-4:2016) has been prepared by Technical Committee CEN/TC 130 “Space heating appliances without integral heat sources”, the secretariat of which is held by UNI.

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by March 2017, and conflicting national standards shall be withdrawn at the latest by March 2017.

The European Standard EN 14037, *Free hanging heating and cooling surfaces for water with a temperature below 120°C*, consists of the following parts:

— *Part 1: Prefabricated ceiling mounted radiant panels for space heating - Technical specifications and requirements;*

— *Part 2: Prefabricated ceiling mounted radiant panels for space heating - Test method for thermal output;*

— *Part 3: Prefabricated ceiling mounted radiant panels for space heating - Rating method and evaluation of radiant thermal output;*

— *Part 4: Prefabricated ceiling mounted radiant panels for space heating - Test method for cooling capacity;*

— *Part 5: Open or closed heated ceiling surfaces - Test method for thermal output.*

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Introduction

This European Standard results from the recognition, that heated and chilled ceiling radiant panels falling into the field of application hereinafter stated are traded on the basis of their thermal output. For evaluating and comparing different heated and chilled ceiling surfaces it is therefore necessary to refer to a heating stipulated value.

As installations with ceiling mounted radiant panels can also be used in practice for space cooling, it is necessary to have a test method for evaluating the cooling capacity. Installations with different free hanging heating and cooling surfaces need, for the use of space heating a test method for evaluating the heating output. The test method differs from the method for ceiling mounted radiant panels.

1 Scope

This European Standard defines the technical specifications and requirements for the definition of the cooling capacity of pre-fabricated ceiling mounted radiant panels according to the specifications of EN 14037-1:2016, 3.3.1. The test according to this standard requires the measurement of the thermal output according to EN 14037-2:2016 of the model.

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

EN 14037-1:2016, *Pre-fabricated ceiling mounted radiant panels for space heating - Technical specifications and requirements*

EN 14037-2:2016, *Pre-fabricated ceiling mounted radiant panels for space heating - Test method for thermal output*

EN ISO/IEC 17025:2005, *General requirements for the competence of testing and calibration laboratories (ISO/IEC 17025:2005)*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in EN 14037-1:2016 and the following apply.

3.1
water temperature rise
temperature difference between the outlet and inlet water temperature of the cooling appliance

3.2
standard temperature difference for the cooling capacity of ceiling mounted radiant panels
reference room temperature 32°C and mean water temperature 17 °C, determined temperature difference 15 K

3.3
nominal temperature difference
determined temperature difference 8 K between room temperature and mean water temperature

3.4
indirect cooling surface (dry surface)
portion of the cooling surface of the panel which is in contact with air only (e.g. radiant sheet between the tubes)

3.5
direct cooling surface (wet surface)
portion of the cooling surface of the panel which is in contact with the water

3.6
standard cooling capacity
cooling capacity at standard temperature difference and standard air pressure

3.7
nominal cooling capacity
cooling capacity at nominal temperature difference 8 K

3.8
characteristic equation
equation that gives the thermal cooling capacity as a function of the temperature difference at constant water flow rate

3.9
modular cooling capacity
cooling capacity of one module calculated from the cooling capacity of the active length of a ceiling mounted radi ant panel

3.10
standard modular cooling capacity
cooling capacity of one module at standard conditions

3.11
nominal modular cooling capacity
cooling capacity of one module at nominal temperature difference

4 Symbols and units

For the purposes of this document, the symbols and units given in EN 14037-1:2016 and the following apply.

Table 1 — Symbols and units

No.	Quantity	Symbol	Unit
1	Constant of the characteristic equation of the active length	K_{Cact}	W/ K $^{n_{act}}$ -
2	Exponent of the characteristic equation of the active surface	n_{Cact}	-
3	Heat transfer coefficient (air–insulation–wall)	u	W/(m^2 K)
4	Total heat flow in all enclosure walls	Φ_B	W
5	Standard modular cooling capacity	Φ_{CLs}	W/m
6	Nominal modular cooling capacity	Φ_{CLN}	W/m
7	Measured cooling capacity of a ceiling mounted radiant panel	Φ_{Cme}	W
8	Nominal cooling capacity of a ceiling mounted radiant panel	Φ_{CN}	W
9	Standard cooling capacity of a ceiling mounted radiant panel	Φ_{CS}	W
10	Total thermal output of simulators	Φ_S	W
11	Nominal temperature difference (8 K) of a ceiling mounted radiant panel when cooling	ΔT_{cn}	K
12	Standard temperature difference (15 K) of a ceiling mounted radiant panel when cooling	ΔT_{cs}	K

5 Testing of cooling capacity

5.1 Short description

The cooling capacity of the test sample shall be determined in its steady condition with measurements of the water flow and the temperature increase in the water. The cooling capacity shall be quoted as function of the temperature difference between the reference temperature and the average water temperature.

The test is carried out in a testing system according to EN 14037-2:2016 which consists of a closed booth with controlled temperatures of the inside surfaces plus master panel 1 (according to EN 14037-2:2016, Clause 6). All laboratories performing tests according to this standard shall participate in inter-laboratory comparison exercises (according to EN 14037-2:2016, Clause 6).

For covering the cooling capacity, the test booth will be heated with a number of electrical heated cooling load simulators which are positioned on the floor of the test booth. To get reproducible results, the simulators have to be arranged according to 5.2.

5.2 Test booth

The test is carried out in a test booth according to EN 14037-2:2016, Clause 5.

Differing from these definitions the surfaces, floor and ceiling of the test booth shall be insulated in the way that the average heat flow in those surfaces is lower than 0,40 W/m² during the test. This heat flow shall be determined by preliminary calibration tests of the booth or by calculations.

Differing from EN 14037-2:2016, 5.5, the reference temperature during the measurement shall be 32 °C ± 0,5K in steady condition for minimum 30 min.

The temperature(s) of inner surfaces of walls, floor and ceiling of the test booth (under the insulation) shall be controlled and be kept on a value, which is necessary to guarantee a max. temperature difference between these surfaces and the reference temperature of less than 1,0 K.

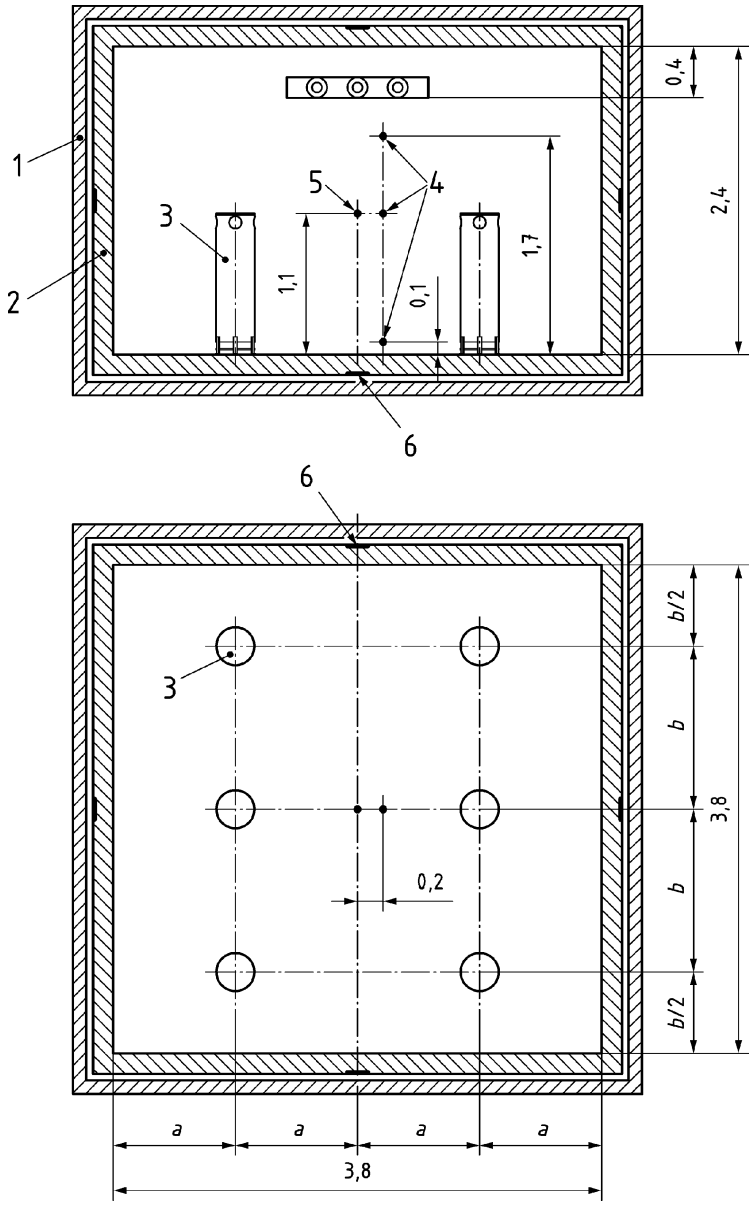
The radiant emissivity of the surface of the insulation has to be at least 0,9.

The test booth will be heated with 6 electrical heated cooling load simulators (see Figures 1 and 2), which are positioned on the floor of the test booth.

The output of each simulator shall not exceed 180 W and shall be continuously adjustable, e.g. with an adjustable transformer or a thyristor. Each simulator shall have an identical heat output and the same number of heaters.

The housing of the simulators consists of painted steel sheet. The emissivity of the inside and outside surface shall be at least 0,9. The active power of the simulators shall be measured with a measuring instrument of the accuracy class 1,0 % or better.

Dimensions in meters



Key

1 test booth

2 insulation

3 cooling load simulator

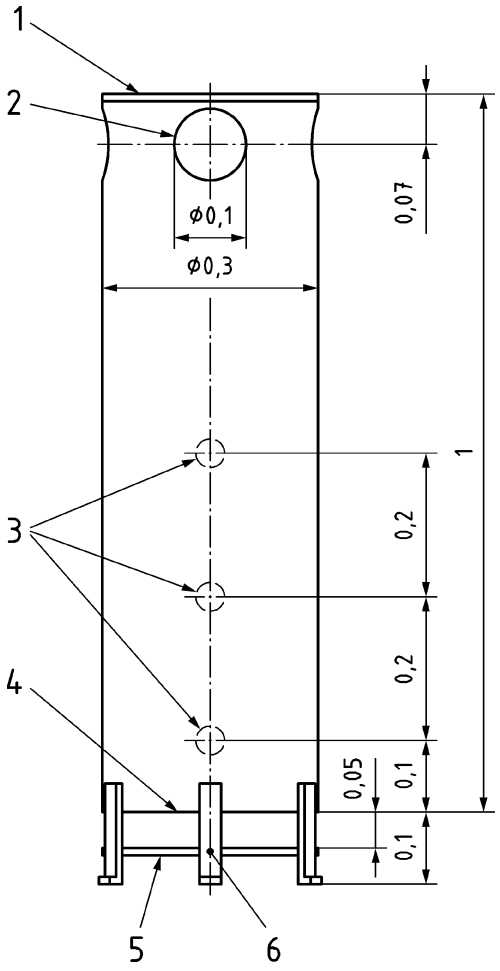
4 measuring point of air temperature

5 measuring point of globe temperature

6 measuring point of temperature under insulation

Figure 1 — Test booth with an installed radiant ceiling panel, the cooling load simulators and the measuring points for the temperatures

Dimensions in meters



Key

1 cover

2 4 holes, evenly distributed during the scale

3 electric heater with 60 W performance

4 no bottom

5 bottom

6 bases, distributed during the scale

Figure 2 — Cooling load simulators (dummy)

5.3 Test methods

The test method shall be carried out according to EN 14037-2:2016, Clause 7.

Instead of a heating unit a cooling unit will be installed in the measuring circuit.

The aim of the test is to establish the standard cooling capacity of a ceiling mounted radiant panel by determining the related values of cooling capacity and temperature difference. Neither of these quantities can be measured directly, but shall be calculated using the values of other measureable quantities, either directly or with additional information (calibration test, material properties table), by using mathematical relationships.

The maximum uncertainty in measuring the cooling capacity shall not exceed ± 25 W.

6 Carrying out the measurement

6.1 General

The natural convection inside the test booth shall not be affected by additional means.

6.2 Dimension and construction of the test samples

Dimension, construction and hydraulic of the test samples relate to the data in EN 14037-2:2016, 8.2. The minimum active surface of tested panel shall be in total 2,7 m^2. In case that one panel has less than 2,7 m^2 active surface, two or three equal panels shall be tested together. If one or two panels exceed 2,7 m^2, no additional panel shall be tested. If more than one panel is tested, they shall be hydraulically connected in series.

6.3 Selection of the models to be tested for determining the cooling capacity of a type

For determining the cooling capacity of a type, the models with the minimum and maximum width are to be tested. The calculation of the cooling capacity of types in between is calculated by a linear interpolation.

6.4 Manufacturer documents for the test samples

The requirements on the manufacturer documents for the test samples relate to the data in EN 14037-2:2016, 8.4.

6.5 Arrangement of the sample in the test booth

The requirements on the arrangement of the sample in the test booth relate to the data in EN 14037-2:2016, 8.5. In case of two or three panels, distances between the panels shall be equal to the width of the panels. They shall be installed symmetrically to the centre axis of the test booth and parallel to the rows of the dummies.

In case of more panels installed, the connection pipe work shall be insulated as described in EN 14037-2:2016, 8.5.

6.6 Upper insulation of the test sample

The requirements on the upper insulation of the test sample relate to the data in EN 14037-2:2016, 8.6.

6.7 Connection of the test sample to the measuring circuit

The requirements on the connection of the test sample to the measuring circuit relate to the data in EN 14037-2:2016, 8.7.

6.8 Tests

The measuring of the standard cooling capacity is carried out with insulated connection components (according to test 1 in EN 14037-2:2016, 8.8). It is calculated by:

$$\Phi_{\mathrm{me}} = q_{\mathrm{m}}(h_2 - h_1) \qquad (1)$$

6.9 Mass flow

The water flow shall be regulated as in the thermal output test in EN 14037-2:2016 that a Reynolds value Re = 4 500 ± 500 results in the tubes of the ceiling mounted radiant panel at a water temperature of 50 °C.

6.10 Test temperature

The measurement shall be carried out at a reference temperature of 32 °C ± 0,5 K and a temperature difference of 15 K ± 0,5 K.

It shall be guaranteed that the surface temperature is higher than the dew point during the measurement.

6.11 Steady-state conditions

Steady-state conditions shall be maintained throughout the duration of the test, as far as both, the water and the ambient conditions in the test installation are concerned. Parameters shall be monitored at regular intervals. Steady-state conditions are deemed to exist when the standard deviations of all the readings (not less than 12 sets within 30 min) amount to less than half of the ranges specified below:

— water and air temperature ± 0,05 K

— water flow rate 1,0 %

The measuring results shall only be used if the thermal balance for test sample, simulators and heat transmission do not differ through the test space enclosures more than 5 % from the total cooling capacity of the test sample according to Formula (2):

$$|(\Phi_B + \Phi_S + \Phi_{me})| \leq 0{,}05\,\Phi_{me} \quad (2)$$

where

$$\Phi_B = \sum_{i=1}^{6} A_i \cdot U_i (t_{w,i} - t_{ref}) \quad (3)$$

6.12 Correction due to the air pressure

To take into account air pressures deviating from p_s = 101,325 kPa, the measured output Φ_{me} shall be corrected as follows:

$$\Phi_{Cme} = \Phi_{me}\left(0{,}5 + 0{,}5\left(\frac{p_s}{p}\right)^{0{,}4}\right) \quad (4)$$

6.13 Result of measurement – characteristic equation

The standard cooling capacity results from the corrected value of the output according to 6.12 as per the Formula:

$$\Phi_{CS} = \Phi_{Cme}\left(\frac{\Delta T_{CS}}{\Delta T_{me}}\right)^{n_{Cact}} \quad (5)$$

assuming a defined exponent of n_{Cact} = 1,1.

The standard cooling capacity with a temperature difference of 15 K can be recalculated to temperature differences other than the standard temperature difference analogical to the formula above.

6.14 Nominal cooling capacity

The nominal cooling capacity is calculated with the nominal temperature difference (8 K) from Formula (6).

$$\Phi_{CN} = \Phi_{CS}\left(\frac{\Delta T_{CN}}{\Delta T_{CS}}\right)^{n_{Cact}} \quad (6)$$

7 Test report

7.1 General

Person/organization performing the test shall prepare a test report based on the procedures and calculation contained in this European standard. The test report shall be in accordance with EN ISO/IEC 17025:2005, 5.10.2 and 5.10.3. The example of the test report is shown in Annex A.

NOTE Within the framework of CPR, System 3, this task would be performed by a laboratory.

The laboratory is only allowed to prepare a test report with reference to this standard, if the test sample fulfils the construction requirements of EN 14037-1:2016, 3.3.1 and a test report according to EN 14037-2:2016 is available.

7.2 Data

The following data shall be stated in the test report:

a) name and address of the test institute;

b) location of the test (if different from the test institute);

c) name and address of the customer;

d) identification of the test method used;

e) description of the test booth;

f) identification of the test samples including, trade mark, model number, dimensions;

g) date of testing;

h) test results:

1) test data (see Annex A) including e.g. water temperatures, air temperatures, globe temperature, water flow rate, corresponding Reynolds number at 17 °C;

2) the standard characteristic equation of the active length $\Phi_{CS} = f(\Delta T)$;

3) the standard cooling capacity Φ_{CS} and the nominal cooling capacity Φ_{CN} of the tested model; and

4) the standard modular cooling capacity Φ_{CLs} and the nominal modular cooling capacity Φ_{CLN} of the different models within the certain series of types.

The constant *K* and the exponent *n* should be represented with 3 decimal places, the standard output with one decimal place. Performance appointing temperatures (water, globe) have to be stated with 2 decimal places and all other temperatures with 1 decimal place.

Annex A
(informative)

Specimen of the test report for cooling capacity

The test report shall contain the following information:

test report no.:..... date: .....

institute:.....

corresponding test report according EN 14037–2:

test report no.:..... date: .....

institute:.....

A brief description of the test booth is attached: (inside dimensions, water circulating system in the walls, measuring devices for water flow and temperatures)

this report consists of .....pages and it can be reproduced only in its integral form.

customer:.....

customer address: .....

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test according to EN 14037–1, –2 and –4

data of the test sample: (active length, active surface, identification of the model, identification of the manufacturer, materials, dimensions, water circuit design, connecting components, dimensions of connections, design of surface, bonding between wet and dry surface, suspension, maximum operating pressure, maximum temperature, dry mass, water content)

.....

---

manufacturers trademark (identification): .....

Identification of the type: .....

The type comprises the following models (in case of a single model indicate the model only):

Model	**Width** mm	**Active length** mm	**Number of tubes**	**Drawing no.**	**Tested (Y/N)**

Signature of the Test Engineer ..... and the Laboratory Director .....

Standard cooling capacities of the models

Model	**Width** mm	**Active Length** mm	**Standard cooling capacity** W	**Nominal cooling capacity** W	**Standard modular cooling capacity** W/m	**Nominal modular cooling capacity** W/m

Results of test (for each tested model)

	symbols	unit	measured values
Date of test			
Air pressure	p	kPa	
Reference room temperature	t_{ref}	°C	
Inlet water temperature	t_1	°C	
Outlet water temperature	t_2	°C	
Water temperature rise	t_2- t_1	K	
Inlet water enthalpy	h_1	J/kg	
Outlet water enthalpy	h_2	J/kg	
Enthalpy difference	h_2- h_1	J/kg	
Mean water temperature	t_m	°C	
Temperature difference	ΔT	K	
Water flow rate	q_m	kg/s	
Measured output	Φ_{me}	W	
Output corrected for barometric pressure	Φ	W	

Characteristic equation of the tested model: $\Phi = K_m \cdot \Delta T^{nCact}$

where

K_m = ...

n_{Cact} = 1,1

Control temperatures

	unit	measured value
Air temperature 0,10 m above floor	°C	
Air temperature 1,10 m above floor	°C	
Air temperature 1,70 m above floor	°C	
Surface temperature wall 1	°C	
Surface temperature wall 2	°C	
Surface temperature wall 3	°C	
Surface temperature wall 4	°C	
Surface temperature wall 5 (floor)	°C	
Surface temperature wall 6 (ceiling)	°C	

Control of the dimensional tolerances of the sample

Dimension	unit	measuring			Mean	Nominal dimension (manufacturer)	Tolerance	Measured max. difference	Difference in limit
D_o	mm						±0,50 mm		
d_{tub}	mm						±2,0 %		
L_{tub}	mm						±3,00 mm		
L_{sh}	mm						±3,00 mm		
W_{rp}	mm						±6,00 mm		
s_{sh}	mm						±0,08 mm		
L_{le}	mm						±3,00 mm		

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[1] EN 14037-3:2016, *Free hanging heating and cooling surfaces for water with a temperature below 120°C - Part 3: Pre-fabricated ceiling mounted radiant panels for space heating - Rating method and evaluation of radiant thermal output*

[2] EN 14037-5:2016, *Free hanging heating and cooling surfaces for water with a temperature below 120°C - Part 5: Open or closed heated ceiling surfaces - Test method for thermal output*

[3] EN 14240, *Ventilation for buildings - Chilled ceilings - Testing and rating*

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