BS EN 442-2:2014

BSI Standards Publication

Radiators and convectors

Part 2: Test methods and rating

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National foreword

This British Standard is the UK implementation of EN 442-2:2014. It supersedes BS EN 442-2:1997 which is withdrawn.

The UK participation in its preparation was entrusted to Technical Committee RHE/6, Air or space heaters or coolers without combustion.

A list of organizations represented on this committee can be obtained on request to its secretary.

This publication does not purport to include all the necessary provisions of a contract. Users are responsible for its correct application.

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Foreword

This document (EN 442-2:2014) 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of an identical text or by endorsement, at the latest by June 2015, and conflicting national standards shall be withdrawn at the latest by June 2015.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. CEN [and/or CENELEC] shall not be held responsible for identifying any or all such patent rights.

This document supersedes EN 442-2:1996.

This document has been prepared under a mandate given to CEN by the European Commission and the European Free Trade Association.

The most significant changes that have been made in this new edition of EN 442-2 are the following ones:

— some new definitions have been added;

— the straight or curved towel or bathroom radiator have been included;

— different surface treatments have been included;

— a new normative Annex J "Calibration Procedure" has been added;

— a new normative Annex K "Pretreatment and paint testing method" has been added.

This European Standard comes from an output of the project SMT4 - CT97 - 2127 funded by the European Commission DGXII-RDT.

This European Standard, *Radiators and convectors*, consists of the following parts:

— *Part 1: Technical specifications and requirements*;

— *Part 2: Test methods and rating* [the present document].

According to the CEN-CENELEC Internal Regulations, the national standards organizations of the following countries are bound to implement this European Standard: Austria, Belgium, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, Former Yugoslav Republic of Macedonia, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, Switzerland, Turkey and the United Kingdom.

Introduction

This European Standard results from the recognition that the heating appliances falling into the field of application hereinafter stated are traded on the basis of their thermal output.

To evaluate and compare different appliances it is therefore necessary to refer to a single stipulated value, hereinafter called the standard rated thermal output.

In addition, for low temperature systems a standard low temperature thermal output is given.

The standard thermal outputs (standard rated thermal output and standard low temperature thermal output) are defined value taken from the characteristic equation.

The pre-requisites of the standard thermal outputs, as defined by this European Standard, are the following:

— to be representative of the actual output of the appliance in different operating conditions;

— to be reproducible within the tolerances defined by this European Standard, taking into account the state of measuring techniques;

— to be representative of the thermal outputs, obtainable under the same test conditions, of any identical sample taken out of the current production (within the tolerances defined by this European Standard taking into account the state of measuring techniques and methods of manufacture).

1 Scope

This European Standard defines procedures for determining the standard thermal outputs and other characteristics of radiators and convectors installed in a permanent manner in construction works, fed with water or steam at temperatures below 120 °C, supplied by a remote energy source.

This European Standard specifies the laboratory arrangements and testing methods to be adopted, the admissible tolerances, the criteria for selecting the samples to be tested and for verifying the conformity of the current production with the samples tested at the initial test.

This European Standard also defines the additional common data that the manufacturer shall provide with the product in order to ensure the correct application of the products.

This European Standard does not apply to fan assisted radiators, fan assisted convectors and trench convectors and to independent heating appliances.

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 10088-1, *Stainless steels — Part 1: List of stainless steels*

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

ISO 16269-7, *Statistical interpretation of data — Part 7: Median — Estimation and confidence intervals*

3 Terms, definitions, symbols and units

3.1 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

3.1.1
heating appliance
device having the purpose of transferring heat in order to provide specific temperature conditions inside buildings

3.1.2
independent heating appliance
self-contained heating appliance which does not need to be connected to a remote energy source (e.g. a boiler) as it contains its own energy source (e.g. gas fired appliances, electric appliances, air to air heat pump appliances)

3.1.3
radiator
heating appliance produced with different materials (e.g. steel, aluminium, cast-iron) and with different designs (e.g. plate type, column type, tube type, finned tube type), which emits heat by free convection and radiation

3.1.4
sectional heating appliances (mainly applied to radiators)
heating appliance manufactured in sections of identical design and traded in this form which can be joined together into modular assemblies so that the desired output can be obtained

3.1.5
free convection heating appliance
heating appliance which does not contain a fan or similar device to activate the air flow over heat emitter

3.1.6
convector
heating appliance which emits heat almost entirely by free convection

Note 1 to entry: A convector comprising at least a heat emitter and a casing which provides an unheated convective chimney of defined height.

3.1.7
skirting convector
convector of limited height running along the base of an interior wall

3.1.8
height of the unheated convective chimney
vertical distance between the lowest edge of the convector and the bottom of the air outlet section

Note 1 to entry: It applies to convectors only, being a main factor influencing their thermal output.

3.1.9
wet heating surface; primary heating surface
portion of the heat emitting surface which is always in contact with the primary fluid (water or steam)

3.1.10
dry heating surface; secondary heating surface
portion of the heat emitting surface which is in contact with air only (e.g. fins projecting from the wet surface)

3.1.11
family of heating appliances
group of heating appliances of similar design and construction and of identical material, positions of primary fluid connections and other related variables that particularly affect the conditions of flow of the primary fluid within the heating appliance

3.1.12
type of radiators/convectors
group of heating appliances of similar design whose cross-section remains unchanged while the height or length varies or which have a systematic variation of only one characteristic dimension of the dry heating surfaces providing that this does not affect the water side (e.g. the height of convector fins on panel radiator)

Note 1 to entry: For the calculation in conformity to Annex D, at least three models are required.

3.1.13
model
heating appliance of defined height, length and depth within a type

3.1.14
range of heights
difference between the maximum and minimum height of the models in a type

3.1.15
module of heating appliances
reference length of the useful portion of a heating appliance

Note 1 to entry: The module coincides with:

— the section, in the case of sectional heating appliances;

— a length of 1 m, in the case of non-sectional heating appliances;

— a finned length of 1 m, in the case of finned tube convectors.

3.1.16
sample
representative heating appliance used for the determination of one or more of the performance characteristics

3.1.17
inlet water temperature
bulk temperature of the water entering the heating appliance

3.1.18
outlet water temperature
bulk temperature of the water leaving the heating appliance

3.1.19
temperature drop
difference between inlet and outlet water temperature

3.1.20
mean water temperature
arithmetical mean of inlet and outlet water temperature

3.1.21
reference air temperature
air temperature measured on the vertical line at the centre of the test booth, 0,75 m above the floor level

3.1.22
excess temperature
difference between mean water temperature and reference air temperature

3.1.23
standard excess temperature
excess temperature of 50 K as determined in the standard conditions

Note 1 to entry: Inlet water temperature of 75 °C, outlet water temperature of 65 °C and reference air temperature of 20 °C.

3.1.24
standard excess low temperature
excess temperature of 30 K at standard flow rate

3.1.25
air pressure
air pressure measured at the test place

3.1.26
standard air pressure
101,325 kPa (1,013 25 bar)

3.1.27
water flow rate
amount of water flowing through the heating appliance per unit of time

3.1.28
standard water flow rate
water flow rate relating to standard test conditions

3.1.29
standard rated thermal output
thermal output of a heating appliance defined at 50 K excess temperature

3.1.30
standard low temperature thermal output
thermal output of a heating appliance defined at 30 K excess temperature

3.1.31
characteristic equation
power function with a specific characteristic exponent that gives the thermal output as a function of the excess temperature at constant water flow rate

3.1.32
standard characteristic equation
characteristic equation which is valid for standard water flow rate and from which the standard thermal output can be found for the standard excess temperature of 50 K

3.1.33
regression equation of a type
equation which gives the standard thermal outputs and the characteristic exponent of all the models within a type as a function of one characteristic dimension

Note 1 to entry: The regression equation for the determination of thermal outputs is a power function, in which the characteristic exponent is a linear function of the characteristic dimension.

3.1.34
standard thermal output of the module
standard thermal output of a model divided either by the number of sections or by the length in metres

3.1.35
test pressure
relative pressure to which the heating appliance is submitted during the manufacturing process (i.e. factory test pressure)

3.1.36
maximum operating pressure
MOP
maximum relative pressure of the system to which the heating appliance may be submitted as chosen by manufacturer

Note 1 to entry: The maximum operating pressure is expressed in [kPa].

3.1.37
maximum operating temperature
maximum inlet water temperature allowed by the manufacturer

3.1.38
test installation
combination of:

— test booth and other related parts, and

— measuring instruments and related equipment

3.1.39
test system
combination of:

— test installation, and

— master radiators

3.1.40
test systems circuit
group of test systems convened to comply with the specifications and procedures of this European Standard and to a periodical comparison of test results

3.1.41
repeatability of a test installation
capability of one test installation to provide test results on one given set of master radiator within the tolerance specified by this European Standard

Note 1 to entry: See 5.2.4.

3.1.42
reproducibility of a test installation
capability of different test installations to provide test results on one given set of master radiators within the tolerance specified by this European Standard

Note 1 to entry: See 5.2.4.

3.1.43
pressure drop
difference of pressure between water inlet and water outlet of the heating appliance

3.1.44
standard pressure drop
drop in pressure between inlet and outlet of the appliance heat emitter on the primary fluid side, when the appliance is fed at the standard water flow rate

3.1.45
supplementary test
test for the purpose of establishing the effect of minor technical modifications on the thermal output of radiators that have already been tested

3.1.46
radiated heat output factor
Sk
assumed ratio between the radiation heat output and the overall heat output of the radiator, which is only valid for air pressure correction purposes

3.1.47
exponent np
exponent for the air pressure correction of the measured heat output of the radiator

3.1.48
emissivity
ratio of energy radiated by a particular material to energy radiated by a black body at the same temperature

3.1.49
master radiator
sample used for the calibration of test installations

Note 1 to entry: Master radiators are used to determine repeatability and reproducibility of the results of the test installations (see 5.2.3).

3.2 Symbols and units of measurement

Table 1 — Symbols, quantity and units of measurement

Quantity	Symbol	Unit
Thermal output	Φ	W
Standard thermal output	Φ_S	W
Modular thermal output	Φ_L	W
Reference value of a master radiator	Φ_0	W
Reference value of a primary set of master radiators for interlaboratory comparisons	Φ_M	W
Electrical method heat losses	Φ_V	W
Electric power	P_{el}	W
Thermodynamic temperature	T	K
Temperature	t	°C
Inlet water temperature	t_1	°C
Outlet water temperature	t_2	°C
Temperature drop	t_1-t_2	K
Mean water temperature	t_m	°C
Reference room air temperature	t_r	°C
Excess temperature	ΔT	K
Specific heat capacity	c_p	J/kg·K
Specific enthalpy	h	J/kg
Inlet water enthalpy	h_1	J/kg
Outlet water enthalpy	h_2	J/kg
Water flow rate	q_m	kg/s
Standard water flow rate	q_{ms}	kg/s
Pressure	p	kPa
Maximum operating pressure/resistance to pressure	p_{max}	kPa
Pressure drop	Δp	kPa
Repeatability tolerance	S_0	-
Reproducibility tolerance	S_m	-
Overall height of the heating appliance	H	m
Range of heights	H_r	m
Overall length of the heating appliance	L	m
Length of a section	L_S	m
Number of sections	N_S	-
Thermal resistance	R	m^2·K/W
Time interval	τ	s
Radiated heat output factor	Sk	-
Emissivity	ε	-

4 Selection of heating appliances to be tested

4.1 Classification

4.1.1 Heating appliances shall be grouped into families and types according to the definition in this European Standard. A family can include different types.

4.1.2 For the purposes of determining catalogue outputs, a family shall be divided into a number of separate types (in a family of radiators there may, for example, be single or double panels, with or without convector surfaces, using the same basic components).

4.1.3 The output of each model shall not be greater than 3 500 W and the minimum thermal output of the selected model shall be not less than 200 W at standard excess temperature.

On request of the manufacturer lower thermal output could be tested and the deviation from the previous requirements shall be registered in the test report.

4.2 Selection of models to be tested for determining the thermal outputs of a type

4.2.1 Selection of models to be tested when the variable characteristic dimension is the overall height and the cross-section of the variable part is constant

4.2.1.1 When a type includes only models of height 300 mm and greater, the models to be tested within that type shall be selected in accordance with 4.2.1.2, 4.2.1.3, 4.2.1.4 and 4.2.1.5.

If the type also includes heights below 300 mm the minimum height below 300 mm shall be tested in addition to the above models.

For a type in which all heights are below 300 mm, only the minimum and the maximum height shall be tested.

4.2.1.2 The minimum number of models to be tested within a type is determined by the range of heights as shown in Table 2.

Table 2 — Minimum number of models to be tested

Range of heights (m) $H_r = H_{max} - H_{min}$	Number of models to be tested
≤ 1 m	3
> 1 m	4

4.2.1.3 The minimum length of finned coil of the models to be tested shall be 1 m or the closest to 1 m. For skirting convectors only the finned coil length shall be the closest to 3 m. In the case of sectional radiators, having height $H \leq 1$ m, the minimum number of sections shall be 10 or the minimum length 0,8 m. For sectional radiator having height greater than 1 m the minimum length shall be 0,45 m.

For towel radiators see 4.2.2.

4.2.1.4 In the case of $H_r \leq 1$ m, the models to be tested shall be three; the minimum and maximum height of the range and an intermediate height so that H_{int} is equal, to or the closest value greater than:

$$H_{int} = H_{max} - \tfrac{1}{2} \times H_r$$

where

H_{max} is the maximum height of the type.

4.2.1.5 In the case of 1 m < H_r ≤ 2,5 m, the models to be tested shall be four; the minimum and maximum height of the range and two intermediate heights so that H_{int1} and H_{int2} are the closest values respectively to:

$$H_{int1} = H_{max} - \frac{1}{3} \times H_r$$

and

$$H_{int2} = H_{max} - \frac{2}{3} \times H_r$$

4.2.2 Selection of models to be tested when the variable characteristic dimension for the type is other than the overall height

4.2.2.1 General principle

The minimum number of models to be tested is three, having the same overall height and respectively, the minimum, intermediate and maximum value of the relevant characteristic dimension (see 4.2.1.4).

The measured values shall be used to determine the characteristic equation of the type.

For the equation to be valid, all the measured thermal outputs shall fall within ± 2 % of the prediction of the equation.

If any value falls outside this range, the type shall be divided and new equations derived for each subset of the results.

4.2.2.2 Selection of models to be tested when a type includes horizontal parallel flow models

This procedure applies to tubular radiator classified as “towel or bathroom radiators”, according to Figure G.3.

If a type includes horizontal parallel flow models, with different heights and lengths, the thermal outputs of models having L_{min} and L_{max} respectively shall be tested. If there are more than 3 heights, the thermal output for all heating appliances having L_{min} and L_{max} respectively shall be established using the respective characteristic equation. For each height, the thermal output for models having length included between L_{min} and L_{max} shall be linearly interpolated. The adopted procedure shall be noted in the test report.

4.2.2.3 Straight or curved towel or bathroom radiator

For “towels and bathroom radiators” having similar external size (height, length, external diameter of the tubes) and different shape of horizontal tube (straight or curved):

If it is proved by at least 2 tests that the difference between the thermal outputs of the model having straight tubes and the model having curved tubes, is within ± 4,0 %, then the catalogue data of the models having curved tubes can be assumed equal to the equivalent models having straight tubes.

If the difference exceeds ± 4,0 % the models are classified as different type and so tested for any specific geometry.

4.2.2.4 Towel and bathroom radiator water circulation

For “towel and bathroom radiator” having the same external size (height, length, depth and external diameter of the tube) but different internal circulation of the hot water, if it is proved by at least 2 tests that the difference between the thermal outputs of the models having different internal circulation is within ± 4,0 %, then the catalogue data of all the models can be assumed to be equal. If the difference exceeds ± 4,0 % the models are classified as different type and so tested for any specific internal water circulation.

4.2.2.5 Different surface treatments (chromed, polished, etc.)

Models having same external size (height, length, depth and external diameter of the tube) but different surface treatment (i.e. painted, chromed or mechanically polished), shall be tested as follows:

a) Models painted and chromed shall be tested according to 4.2;

b) For models having other surface treatments (e.g. satinated or polished) the minimum number of samples to be tested shall be defined as follow:

   1) for each other type, two models, having the minimum and the maximum heat output as measured on painted model, shall be tested only to determine the less favourable reduction coefficient;

   2) the thermal output of all the models, shall be calculated using the reduction coefficient determined according to Point 1).

4.2.2.6 Influence of water flow rate on thermal output

On request of manufacturers the influence of water flow rate on thermal output shall be verified.

In this case additional characteristics shall be tested, setting half and double standard mass flow.

4.3 Testing samples submission and identification

4.3.1 On initial application for the testing of a family of heating appliances, or of a type within a family, heating appliance samples and product drawings shall be submitted to the testing laboratory.

Product drawings shall be submitted by the manufacturer.

4.3.2 The product drawings shall:

— show all dimensions and features having an influence on the heat emission, including the detail of welds or other assembly methods used;

— state the type of material and the nominal material thicknesses of wet or dry surfaces, with the thickness tolerances, and type of paint;

— shall be identified by the drawing number and the date of revision.

4.3.3 Before proceeding with the thermal output testing, the laboratory shall identify the appliance against the drawing and shall note conformity of the sample with the drawing in respect of:

— dimensional tolerances given in Table 3;

— material thickness tolerances of convective surfaces, shown on the product drawings.

The laboratory shall also measure the mass and the water content of the sample models. The relevant values shall be reported in the test report.

The models for test shall be selected as specified in 4.2.

4.3.4 Samples of heating appliances already in production shall be taken from the production line or manufacturer's stock by the laboratory or its authorized representative.

Samples of prototype appliances shall be submitted by the manufacturer.

Table 3 — Dimensional tolerances

Dimensions in millimetres or %

	STEEL RADIATORS				CAST IRON (per section)	EXTRUDED ALUMINIUM (per section)	CAST ALUMINIUM (per section)	FINNED TUBE CONVECTORS	
Overall height[a] of heat exchanger	Panel Radiators	Tubular	Sectional	Lamellar					
H ≤ 250					± 3,0				
250 < H ≤ 500	+ 4 / - 2	+ 4 / - 2	± 2	+ 4 / - 2	± 3,5			Height of Casing (HC)	+ 4 / − 2
500 < H ≤ 600						± 2,5	± 2,5		
600 < H ≤ 900	+ 5 / - 2	+ 5 / - 2	± 2	+ 5 / - 2	± 4,0				+ 5 / − 2
900 < H	+ 6 / - 2	+ 6 / - 2	± 2	+ 6 / - 2					+ 6 / − 2
Overall depth of heat exchanger									
All measures	+ 4 / - 3	± 1,5	± 2		± 2	± 0,65	+ 0 / - 1	Depth of Casing (DC)	+ 4 / −3
D ≤ 100				± 2					
100 < D				± 3					
Curved models		± 5	± 5						

	STEEL RADIATORS				CAST IRON (per section)	EXTRUDED ALUMINIUM (per section)	CAST ALUMINIUM (per section)	FINNED TUBE CONVECTORS	
Overall Length of heat exchanger	Panel Radiators	Tubular	Sectional	Lamellar					
All measures		± 1,5 %	± 1,5 %	± 1,5 %	± 1,5 %	± 0,65	± 0,2		
L ≤ 1 000	± 5							Length of Casing (LC)	± 5
1 000 < L	± 0,5 %								± 0,5 %
Height of convector surfaces	+ 3 / - 1,5		+ 3 / - 1,5		+ 3 / - 1,5	+ 0,2 / - 0	+ 0,2 / - 0,8	Height of fins (HF)	± 1
Depth of convector surfaces	± 1,5		± 2		± 1,5	+ 0,2 / - 0	+ 0,2 / - 0,8	Depth of fins (DF)	±1,5
Distance between connection centre			± 0,5		± 0,5	+ 0 / - 1,2	+ 0,8 / - 1,2		± 2
Material thickness of convectors	± 0,06	±0,06						Material thickness of fins (TF)	± 0,05
								Number of fins (NF)	± 5 %
								Finned length	± 5 %
								Distance casing to fins (TA)	± 5
								Distance casing to fins (BA)	± 5

a For tubular radiators, height refers to the dimension across header sections regardless of orientation of wall mountings.

4.4 Supplementary test

Upon manufacturer's request minor technical modifications may be investigated.

The testing laboratory investigates the effect of the change on heat output.

If the supplementary test reveals a deviation within ± 4,0 % of the measured standard rated thermal output, the manufacturer may declare the old value of the standard thermal output.

If the difference exceeds ± 4,0 % the models are classified as a different type in accordance with 4.2.

The findings of the supplementary test shall be demonstrated as follows:

— in the case of an assessment based on a visual check: by a written confirmation with the reference to the new drawing submitted by the manufacturer;

— in the case of measurements: by a complete test report.

5 Equipment of laboratory and test methods

5.1 Principle

The aim of the test is to determine the standard thermal outputs of the heating appliance using its standard characteristic equation, which is to be obtained according to 5.4.5.

5.2 Apparatus

5.2.1 Test system

For the purposes of this European Standard, a test system shall consist of:

a) a test installation;

b) a set of three master radiators built according to 5.2.3.

For the purposes of this European Standard, test installations are classified as reference and approved.

5.2.2 Reference test installation

5.2.2.1 General

The reference test installation shall contain the following equipment:

a) a closed unventilated booth comprising the test space within which the heating appliance under test is to be installed, equipped with water cooled surfaces to maintain specific thermal conditions independent of the external ambient, built according to 5.2.2.2;

b) apparatus for cooling the water circulating in the walls of the closed booth;

c) a primary heating circuit feeding the appliance under test, built in accordance with 5.4;

d) measuring and checking instruments complying with the requirements of 5.2.5 and 5.2.6.

5.2.2.2 Reference test booth

5.2.2.2.1 Test booth dimensions

The test booth shall have the following internal dimensions:

— length: (4 ± 0,02) m;

— width: (4 ± 0,02) m;

— height: (3 ± 0,02) m.

5.2.2.2.2 Test booth construction

The test booth shall be constructed with sandwich panels cooled by water (see Figure 1). The internal surface of the booth shall be smooth and made from flat sheets of steel. The sandwich panels (see Figure 1 and Figure 2) are made up of:

— a steel panel, water cooled;

— insulating foam injected between the steel panel and an external steel sheet, to form a single self-supporting body;

— an external steel sheet, 0,6 mm nominal thickness.

The steel water cooled panels (see Figure 3) are made up of two sheets welded together:

— one flat having 2 mm thickness;

— the other of 1 mm thickness having undulating shape to form waterways with a cross-section approximately 150 mm^2.

The thickness of the insulating foam layer shall be 80 mm. The minimum overall thermal resistance of each wall, floor and ceiling shall be 2,5 m^2 K/W. The wall behind the appliance under test is made by the same sandwich panels but it is disconnected from the cooling system (the steel panels are empty). The inside surfaces of the test booth shall be covered with a dull paint having an emissivity of at least 0,9. The panels are assembled so that the structure of the test booth is self-supporting, without thermal bridges (see Figure 4). The connections of the cooling panels to the circuit are made following a three-pipe circuit scheme (see Figure 5). The holes allowing water and electric connections with the outside of the test booth are provided with devices for air tightness.

5.2.2.2.3 Tightness of the test booth

The test booth construction shall be sufficiently tight to prevent uncontrolled air infiltration.

5.2.2.2.4 Cooling system

The water cooling system shall be designed in such a manner that at the highest admissible output of the testing appliance, the temperature difference occurring on the cooled internal surfaces of the test booth will not be more than ± 0,5 K compared with the average temperature of all cooled surfaces. In order to ensure this, each panel shall be supplied with a flow rate of at least 80 kg/h per m^2 of internal surface. This condition is a pre-requisite for operating the test booth.

During the tests the average temperature of the cooled internal surface shall be regulated so that the reference air temperature will be (20 ± 0,5) °C and will comply with steady-state conditions.

The surface average temperature is the mean of the inlet and outlet water temperatures of the relevant surface.

5.2.2.3 Measurements in the booth

5.2.2.3.1 Temperature measurements in the booth

Temperature measurements shall be made in the booth:

— to determine the reference room temperature;

— to monitor the thermal state of the test installation.

5.2.2.3.2 Air temperature measuring points

On the central vertical axis of the booth:

a) at the reference air temperature point 0,75 m from the floor,

b) at the following additional points:

1) 0,05 m from the floor,

2) 1,50 m from the floor,

3) 0,05 m from the ceiling.

Dimensions in millimetres

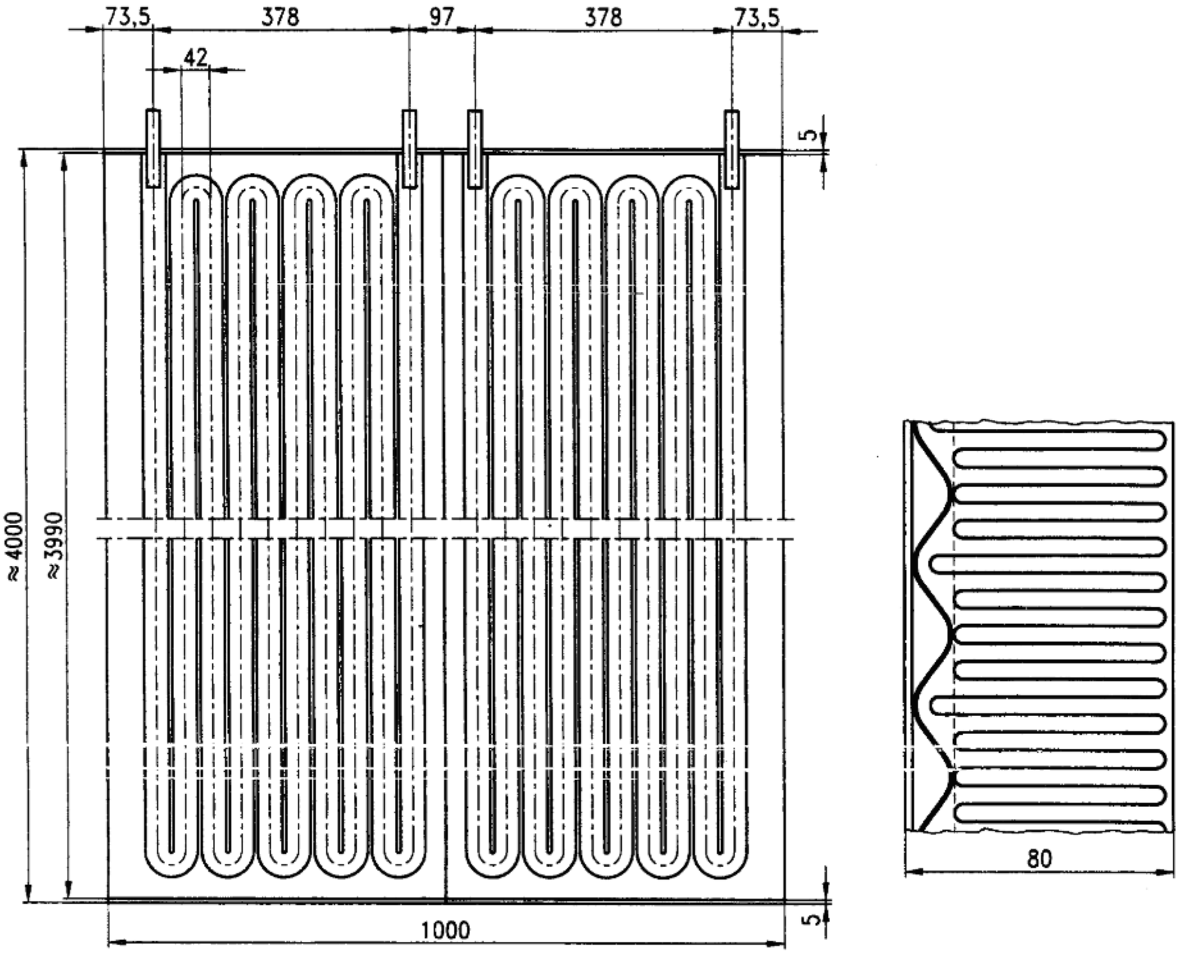


Figure 1 — Sandwich panel cooled by water

5.2.2.3.3 Temperatures of the internal surfaces

On the back beside wall apart from the central point, a point on the centre axis at 0,5 m from the floor.

The surface temperatures (excluding those of the wall behind the heating appliance) shall be maintained within a ± 0,3 K spread.

5.2.2.3.4 Other measurements

Air pressure.

5.2.3 Master radiators

5.2.3.1 General

The purposes of the master radiators are the following:

a) to verify that the reproducibility of test values among test installations is within the limits set by this European Standard;

b) to verify that reference and approved test installations give test results within the limits set by this European Standard;

c) to establish a common basis for all test installations in verifying that the repeatability of test values in each laboratory is within the limits set by this European Standard.

To verify the reproducibility among test installations built to the present European Standard, a single set of master radiators constructed and verified according to the present European Standard will be circulated among reference test installations to determine the respective Φ_0 and Φ_M values (see 5.2.4.3.3).

This single set of master radiators is named "primary set". Each laboratory shall equip itself with a set of master radiators constructed and verified to the present European Standard. This set, named "secondary set", shall be used to verify the repeatability of the test installation. The secondary set of one reference test booth, shall be used to verify the reproducibility of approved test installations.

Dimensions in millimetres

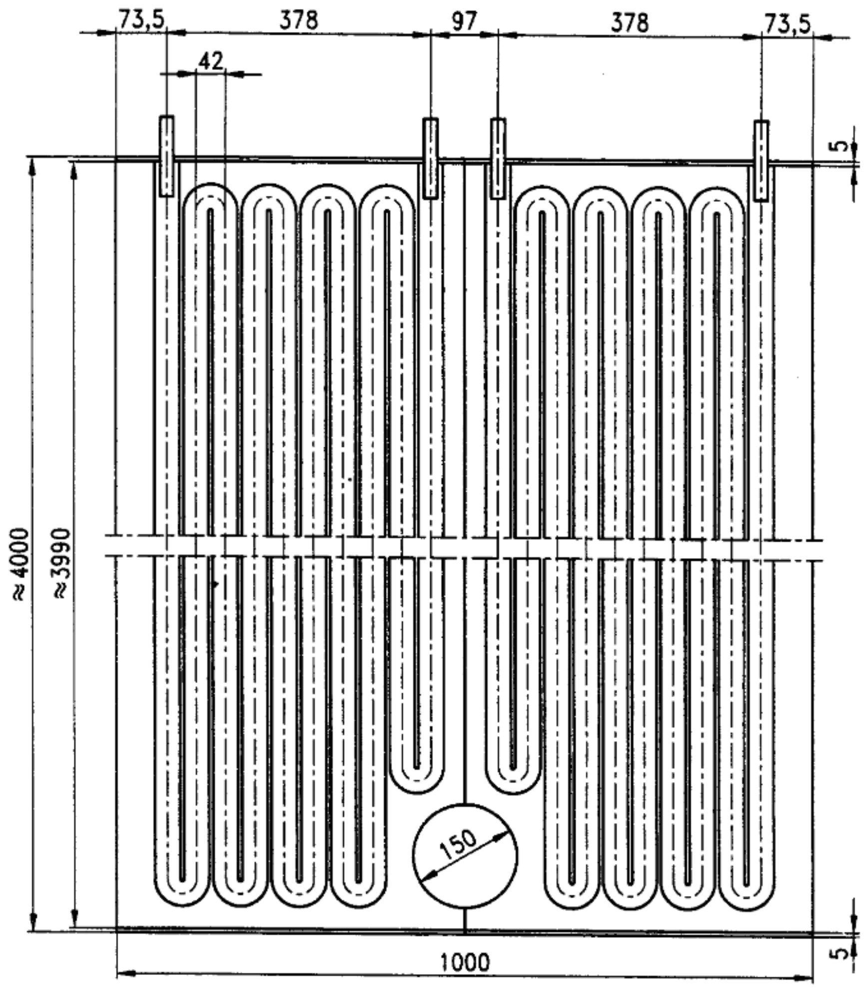


Figure 2 — Sandwich panel cooled by water with hole for external connections

Dimensions in millimetres

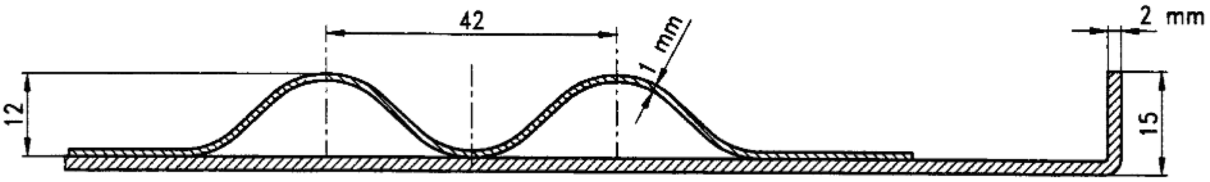
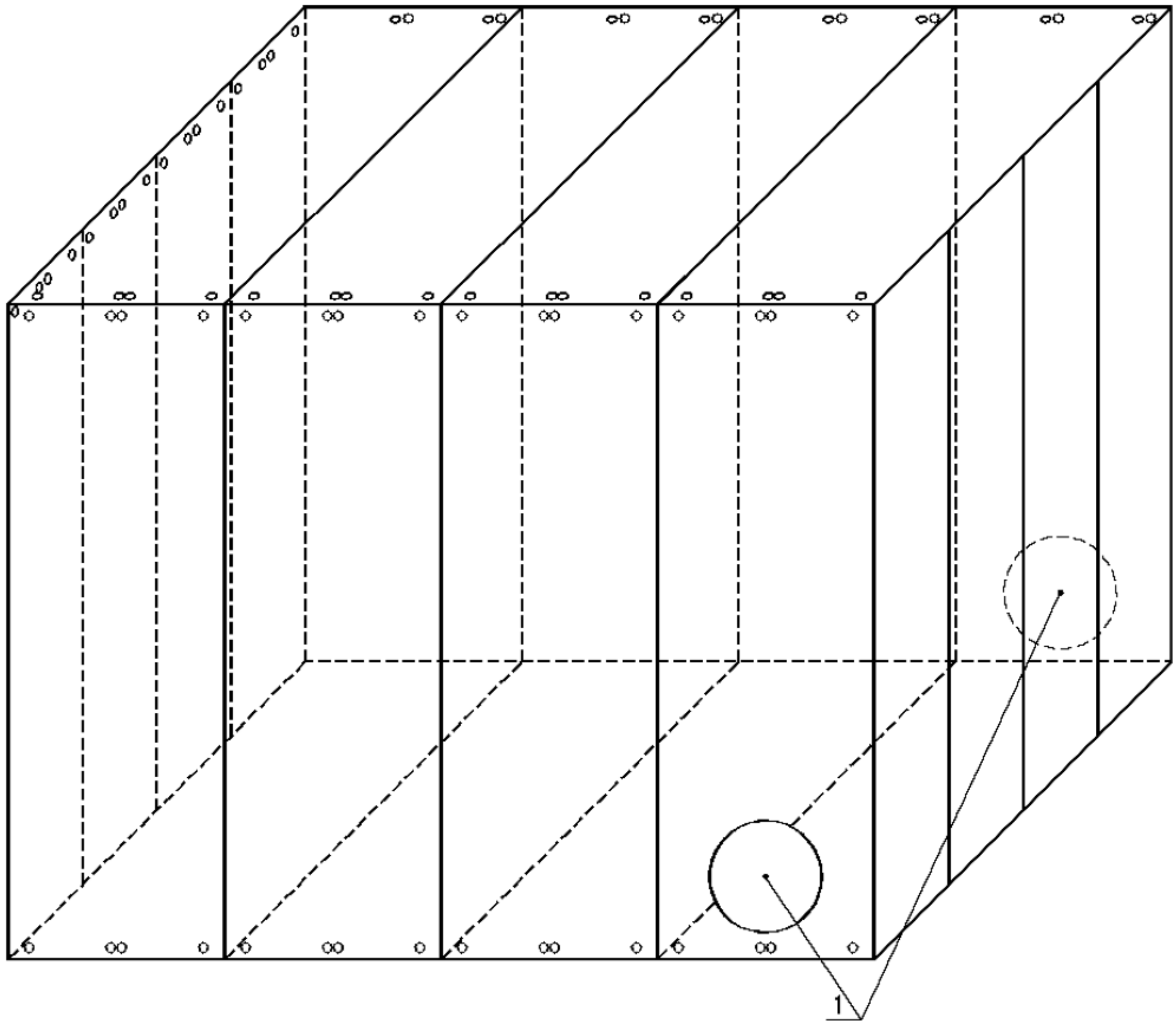


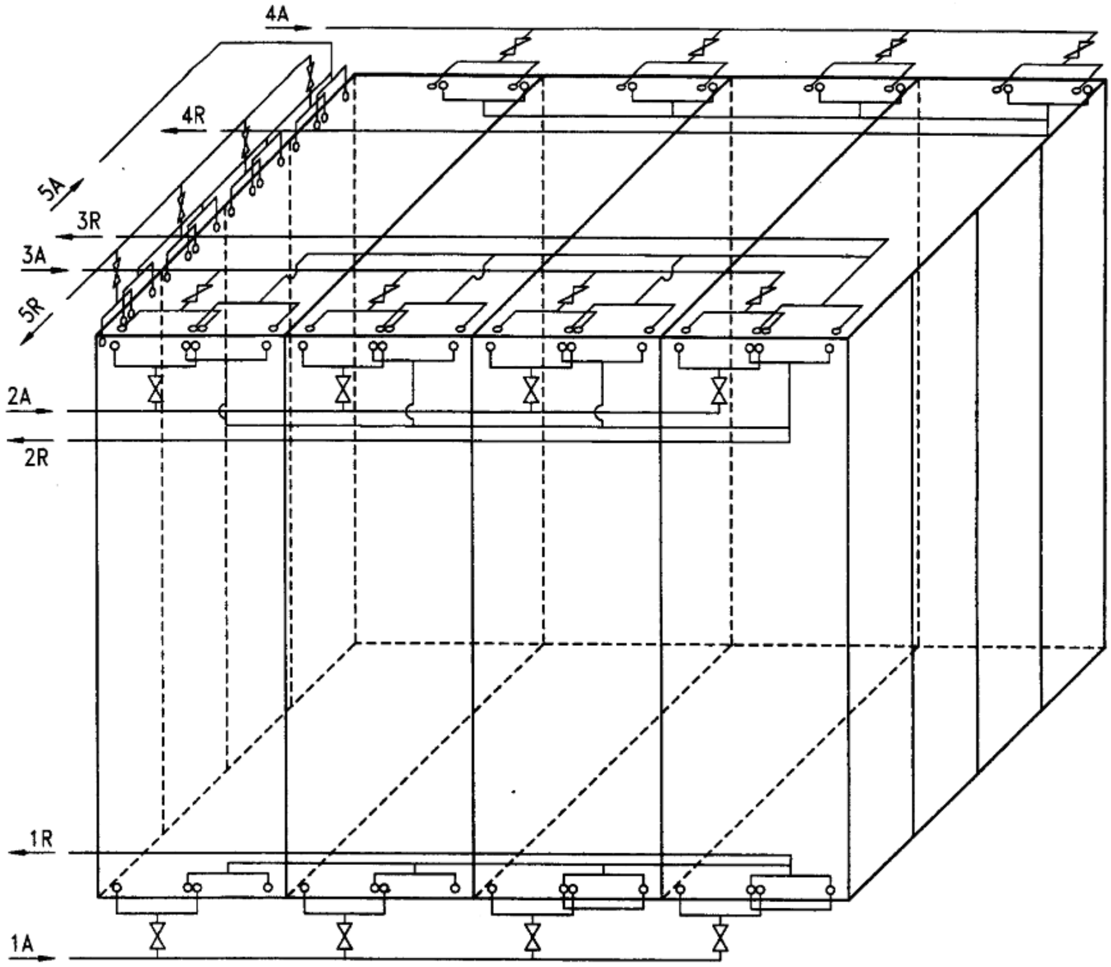
Figure 3 — Steel water cooled panel cross-section



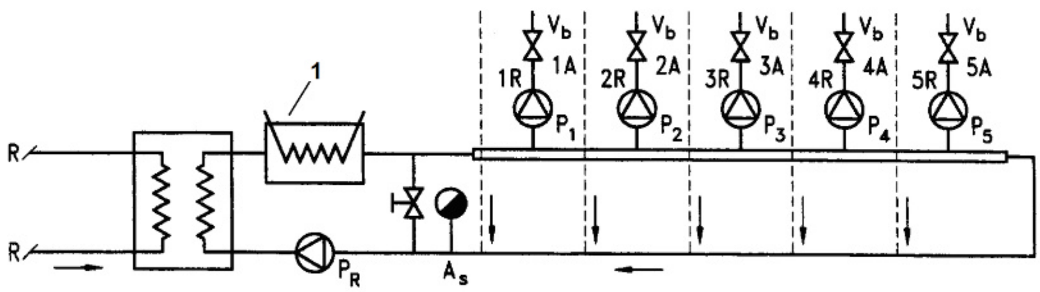
Key

1 air tight opening for electric and water connections

Figure 4 — Panel assembly



a) Water piping scheme



b) Main chilled water circuit (example)

Key

1 electric re-heater

R refrigerant circuit connection

A_s air separator

Figure 5 — Cooling circuits

5.2.3.2 Determination of Φ_0 and Φ_M values of master radiators (primary set)

Each reference test installation shall state a single Φ_0 reference value for each master radiator. This Φ_0 reference value may be derived from the results of more than one test.

A mean value shall be calculated from the reference values stated by the reference test installations, having discarded aberrant values. This shall be taken as the reference value Φ_M of each master radiator. The Φ_0 reference value, submitted by each reference test installation shall be within ± 1 % (S_m tolerance), of the reference value Φ_M for each master radiator.

5.2.3.3 Dimensions

The main dimensions of the three master radiators are given in Figure 6, Figure 7 and Figure 8.

5.2.3.4 Material

The master radiators shall be constructed from X5CrNiMo 17-12-2 (1.4401) EN 10088-1[1)] stainless steel.

5.2.3.5 Construction

Master radiators shall be constructed according to the relevant specifications contained in this European Standard.

5.2.3.6 Dimensional verification

Master radiators shall be dimensionally verified according to the procedure contained in this European Standard (see Annex A) and a complete report as requested by this European Standard shall be prepared and kept available for any further check.

5.2.4 Verification of test installation repeatability and reproducibility

5.2.4.1 General principles

This section deals with the verification of test installations built in accordance with this European Standard (reference test installations). It also describes the procedure for the subsequent approval of test installations built according to other designs (approved test installations).

All test installations shall be verified for:

— constructional conformity: any statement concerning thermal outputs shall be accompanied by a statement concerning the test conditions in which the stated outputs have been obtained;

— repeatability: within a tolerance S_0 accepted when testing one individual sample of the same master radiator in the same test installation at short or long time intervals;

— reproducibility: within a tolerance S_m accepted when testing one individual set of master radiators in different test installations.

1) This stainless steel is also called AISI 316.

Dimensions in millimetres

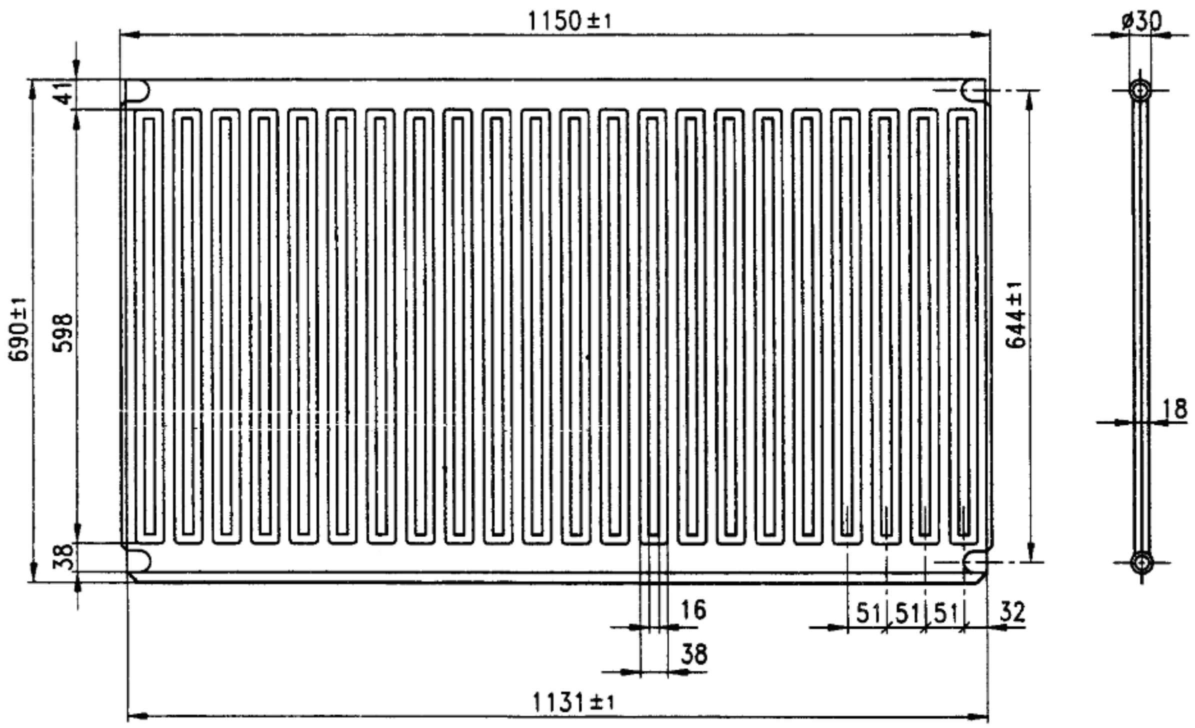
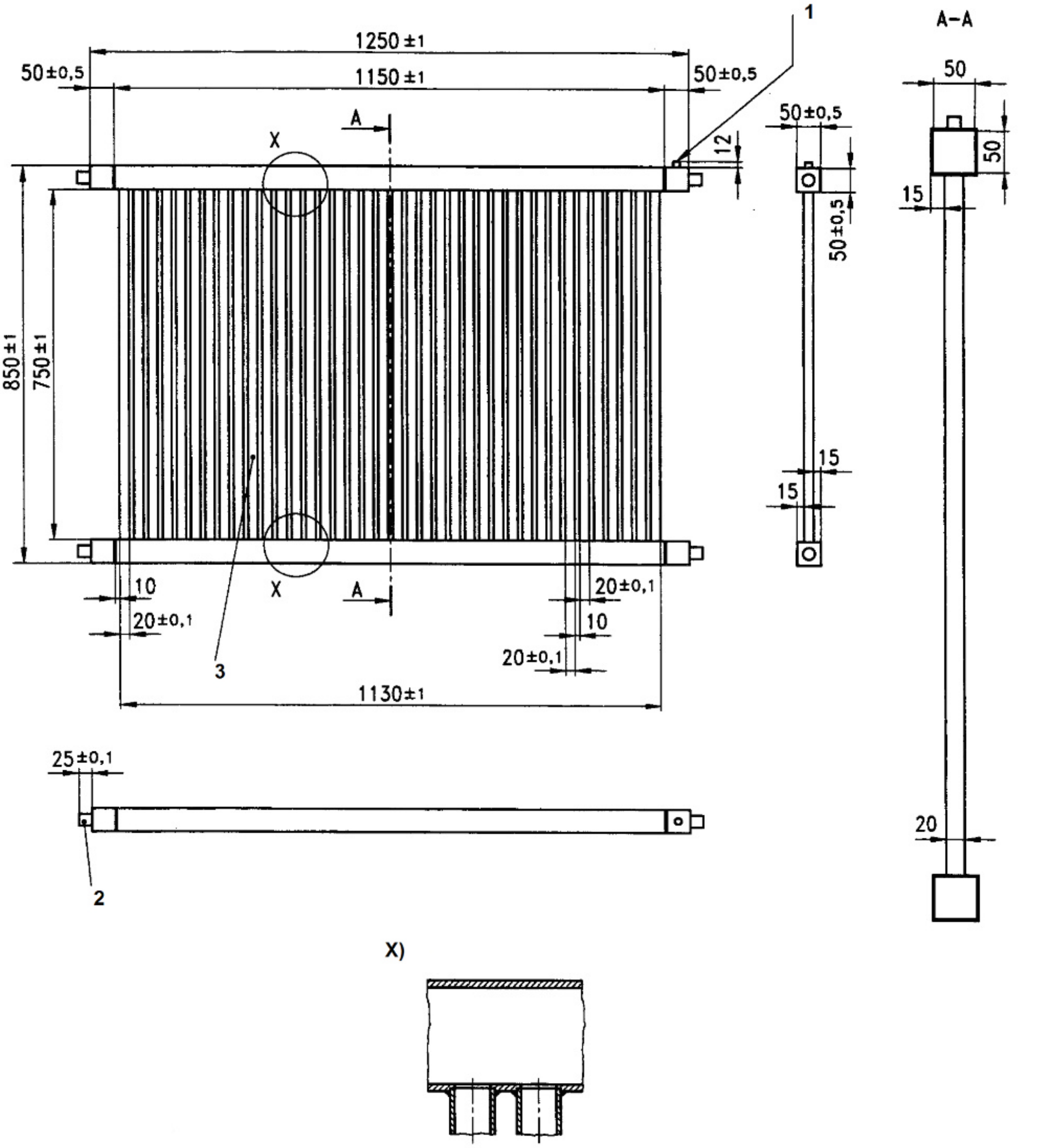


Figure 6 — Master radiator No. 1

Dimensions in millimetres



Key

1 pipe thread ISO 7/1 Rp 1/4

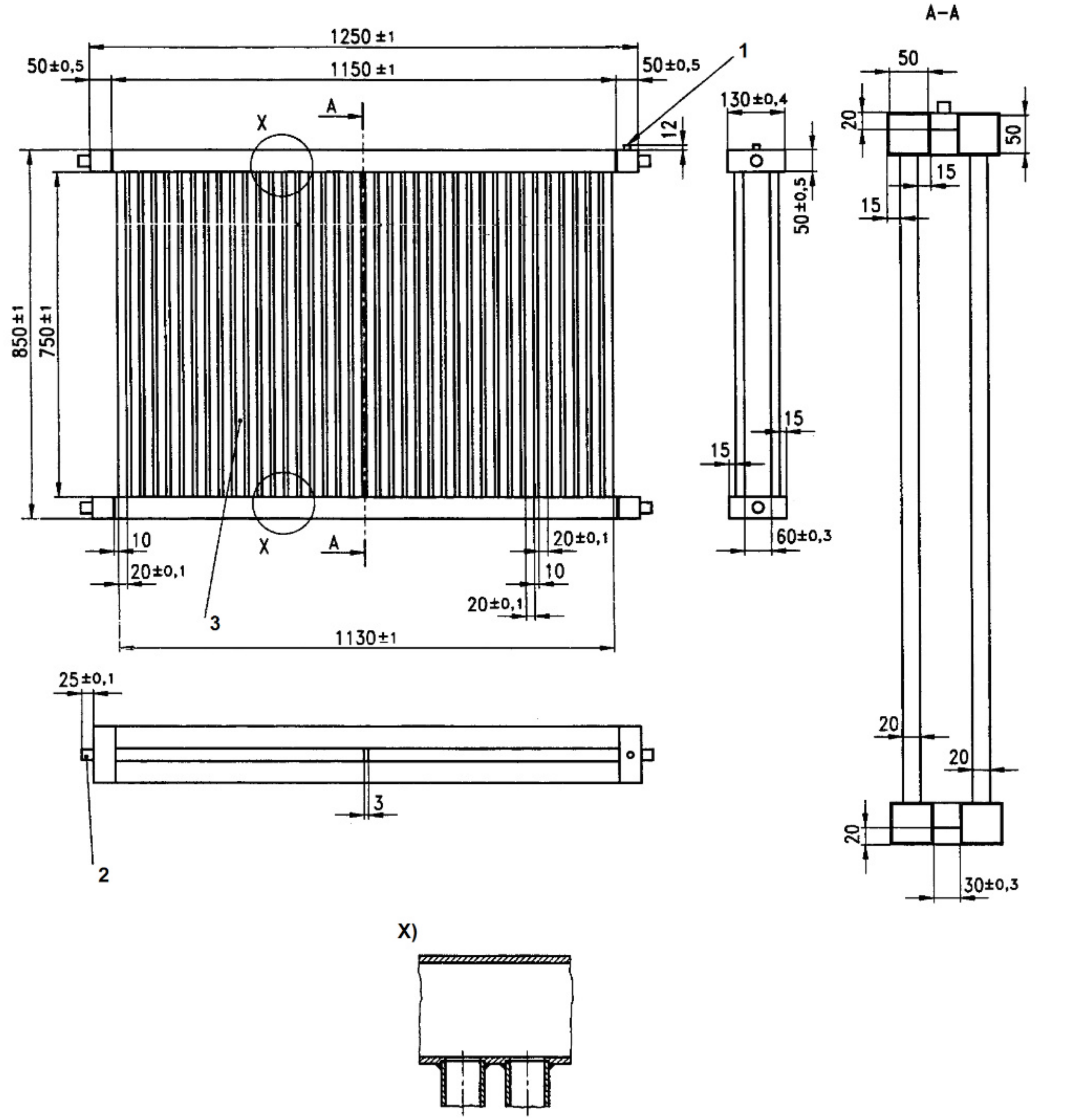
2 pipe thread ISO 7/1 Rp 3/4

3 38 pipes

X) detail of pipes welding

Figure 7 — Master radiator No. 2

Dimensions in millimetres



Key

1 pipe thread ISO 7/1 Rp 1/4

2 pipe thread ISO 7/1 Rp 3/4

3 38 pipes

X) detail of pipes welding

Figure 8 — Master radiator No. 3

Only test installations constructed in accordance with 5.2.2 may be nominated as reference test installations.

Only reference test installations shall be used to determine the reference value Φ_M of master radiators. Approved test installations can operate provided that their repeatability and reproducibility, as well as their constructional conformity, has been verified with a reference test installation.

The reference value Φ_M for each master radiator is recorded in Annex H and the list of reference test installations is indicated in Annex I.

5.2.4.2 Test installation verifications

5.2.4.2.1 Reference test installations

— **Constructional conformity:**

The laboratory shall state the conformity to this European Standard.

— **Repeatability:**

The testing laboratory will use its own set of master radiators (secondary set) to determine the repeatability tolerance S_0 of the test installation.

Using these master radiators, heat output tests shall be carried out in accordance with 5.3 and 5.4.

The results of 10 consecutive tests shall be comprised within a 1 % spread (tolerance S_0).

— **Reproducibility:**

The reproducibility shall be verified using the primary set of master radiators. The test results (carried out in accordance with 5.3 and 5.4) shall be within ± 1 % (tolerance S_m) of the Φ_M value of each master radiator.

5.2.4.2.2 Approved test installation

The laboratory shall describe the complete specifications suitable for the identification of the test installation and the operating conditions (constructional conformity), stating that these specifications are those in which the repeatability and reproducibility verifications have met the tolerances set in this European Standard.

The statement shall be undersigned by the reference laboratory with which the reproducibility verifications have been made at the same time as repeatability and reproducibility verification.

— **Repeatability:**

The procedure given in 5.2.4.2.1 shall be followed.

The laboratory will use its own set of master radiators (secondary set).

— **Reproducibility:**

The reproducibility shall be verified using the secondary set of a reference test system. The verification statement shall be countersigned by the relevant reference test laboratory.

The test installation shall determine a single Φ_0 reference value for each master radiator. This Φ_0 reference value may be derived from the results of more than one test.

The Φ_0 reference value, submitted by the test installation, shall be within ± 1 % (tolerance S_m) of the repeatability test value for each master radiator (see 5.2.3.2) obtained in the reference test installation with which the verification has been made.

Test installation, conforming with the repeatability tolerance S_0 and reproducibility tolerance S_m may operate as approved test installation.

5.2.4.3 Periodic verification of test installations

5.2.4.3.1 General

Verification tests shall be carried out periodically to ensure continuing conformity of test installations. The periodic verification of test installation shall be carried out according to Annex J.

5.2.4.3.2 Constructional conformity

The test installation shall be periodically checked for constructional conformity.

5.2.4.3.3 Repeatability

Using its own set of master radiators (secondary set), the laboratory shall carry out an output test at least every 3 months The result shall fall within the 1 % spread (S_0 tolerance) obtained from the initial 10 consecutive tests.

5.2.4.3.4 Reproducibility

All test installations shall be periodically verified using the primary set of three master radiators of the reference test system with which the initial reproducibility verification was made, following the procedures described in 5.2.4.2.1 and 5.2.4.2.2.

5.2.5 Accuracy of measuring instruments and devices

5.2.5.1 General

In order to facilitate easy processing and a safe documentation of measurements data, all measurements may be recorded as electric values.

5.2.5.2 Mass

For the weighing method, a weighing machine with a maximum error of 2 g at 10 kg is to be used to measure the water collected in the measuring vessel.

5.2.5.3 Time

The time taken to collect the water is to be measured with a timer connected to a switching system and to the swivelled spout between the measuring vessel and to the collecting tank (max. error 0,015 s). The collection period shall be not less than 30 s.

5.2.5.4 Temperatures

For the temperature measurements the national standards and guidelines shall be followed.

The water temperatures are to be directly measured at the water connection points of the heating appliance under test.

The sensors may be mounted in a special device which shall be designed to ensure that the bulk temperature is recorded with sufficient accuracy.

The maximum uncertainty in determining the bulk temperature shall not be larger than 0,05 K and no more than 0,1 K for the temperature drop and the excess temperatures.

The air temperature measurement points are to be equipped with a radiation shield.

The total uncertainty is to be smaller than 0,1 K.

5.2.5.5 Electric output

The accuracy of measuring instruments shall be ± 0,1 % of the measured value. The voltage shall be stabilized to ± 0,1 %.

5.2.5.6 Air pressure

The accuracy in measuring the air pressure shall be ± 0,2 kPa (2 mbar).

5.2.6 Calibration of measuring instruments

The calibration of the measuring instruments, for the primary test variables, shall be traceable in conformity with EN ISO/IEC 17025.

5.3 Preparation for thermal output test

5.3.1 The heating appliance shall be installed in the following reference conditions:

a) the heating appliance shall be placed parallel to, and symmetrically about the centreline of the rear wall;

b) the gap between the rear of the nearest heat emitting surface of the heating appliance and the rear wall shall be (0,050 ± 0,002) m;

c) the gap between the floor and the bottom of the heating appliance shall be (0,110 ± 0,005) m;

d) the heating appliance on test shall be connected with the flow connection at the top of one end and the return connection at the bottom of the same end.

The flow connection for models according to 4.2.2.1 shall be bottom-bottom-opposite-end.

e) it shall be ensured that no air locks occur in the connecting pipes on the primary fluid circuit. This can be realized, for example, using the arrangement described in Annex B.

5.3.2 If the manufacturer's technical literature or standard fittings require installation differing from any of the above reference conditions, the heating appliance shall be installed according to the manufacturer's specification using, where relevant, the components normally supplied by the manufacturer.

5.3.3 In addition to the thermal output tests in the reference installation conditions defined in 5.3.1, other tests may be performed as specified by the manufacturer.

5.3.4 The laboratory shall state in the test report the installation conditions and the manufacturer shall report the same specifications in the technical literature.

5.4 Test methods

5.4.1 General

The thermal output can be determined in two ways:

— Weighing method: by the measuring of the water flow rate (see 3.1.27) through the heating appliance, and determining the enthalpy differential between inlet and outlet.

— Electrical method: by measuring the energy input to the water circuit.

— The quantities to be measured for determining the thermal output differ according to the method chosen.

5.4.2 Weighing method

The thermal output of the heating appliance under test is determined by measuring the water flow rate (weighing method) through the heating appliance and its enthalpy differential between inlet and outlet.

Using a test set-up such as illustrated in Figure 9, part of the water flows through the circulating pump (1) to the overflow (5), while the larger part is constantly circulated through the electric boiler (3) and the mixing device (4). The water used during the test flows down the overflow (5) through the radiator under test (7) and into the measuring vessel (14).

The water flow rate could be measured by other devices provided that they are verifiable by the weighing method and that they have at least the same accuracy.

5.4.3 Electric method

Water is circulated through an electric boiler (1) to the radiator under test (4), as for instance shown in Figure 10.

The thermal output of the radiator is determined from the electric power supplied to the electric boiler, after having deducted the heat loss Φ_V of the electric boiler and pipes, and taking into account the power of the pump (9).

The heat loss within the range of temperature differentials, to be observed, is determined using a short circuit test (a heat-insulated pipe with a known heat loss is mounted in place of the radiator).

It is recommended that the temperature measurement points (5) be located directly at the inlet and outlet connections of the electric boiler, in order to counter check the heat loss at the electric boiler.

5.4.4 Measurements and calculations

5.4.4.1 General

To establish the standard characteristic equation of a heating appliance it is necessary to determine the related values of thermal output and excess temperatures.

Neither of these quantities can be measured directly, but shall be calculated using the values of other quantities which can be measured, either directly or with additional information (calibration test, material properties table), and using mathematical relationships.

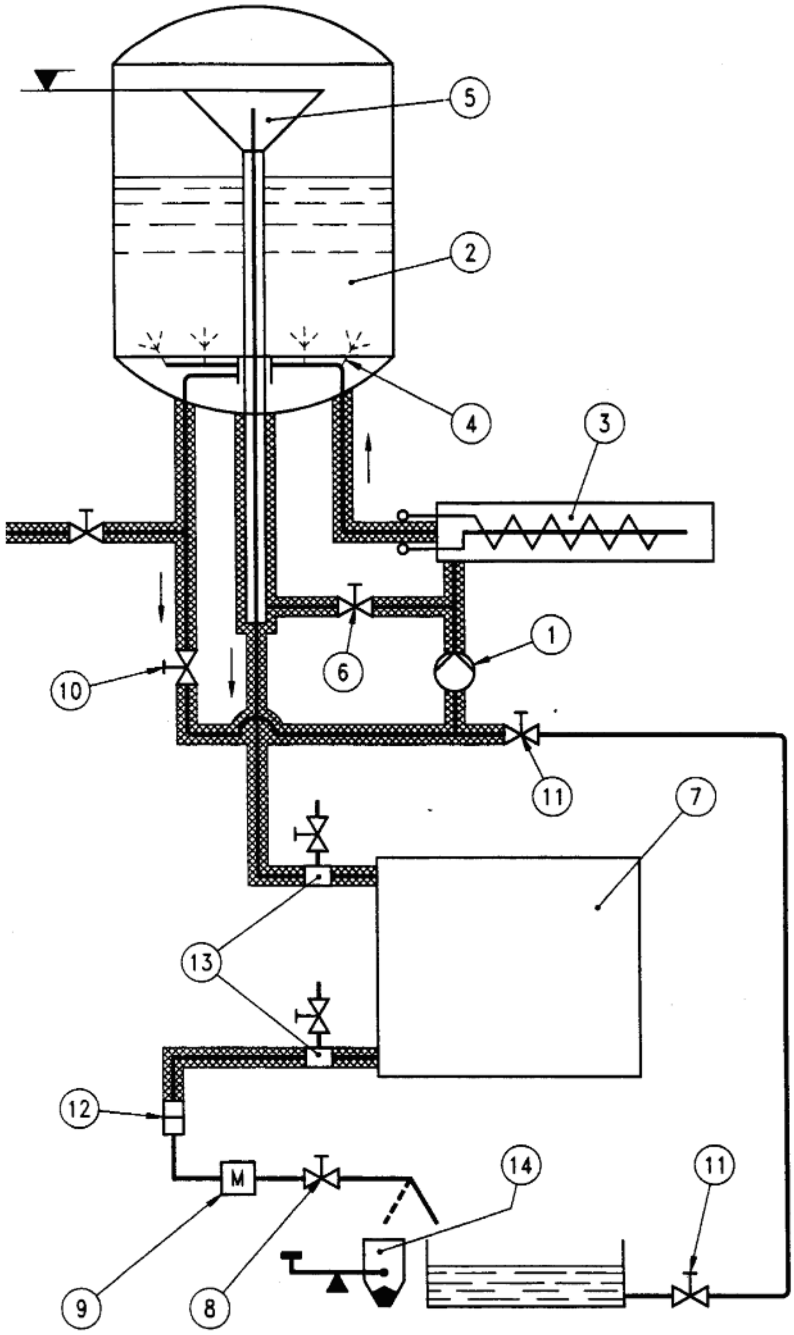
5.4.4.2 Weighing method

The thermal output Φ_{me} is calculated using the water flow rate q_m and the measured temperatures t_1 and t_2.

These temperatures are used to calculate the specific enthalpies as determined by the international steam tables at a reference water pressure of 120 kPa.

$$\Phi_{me} = q_m (h_1 - h_2)$$

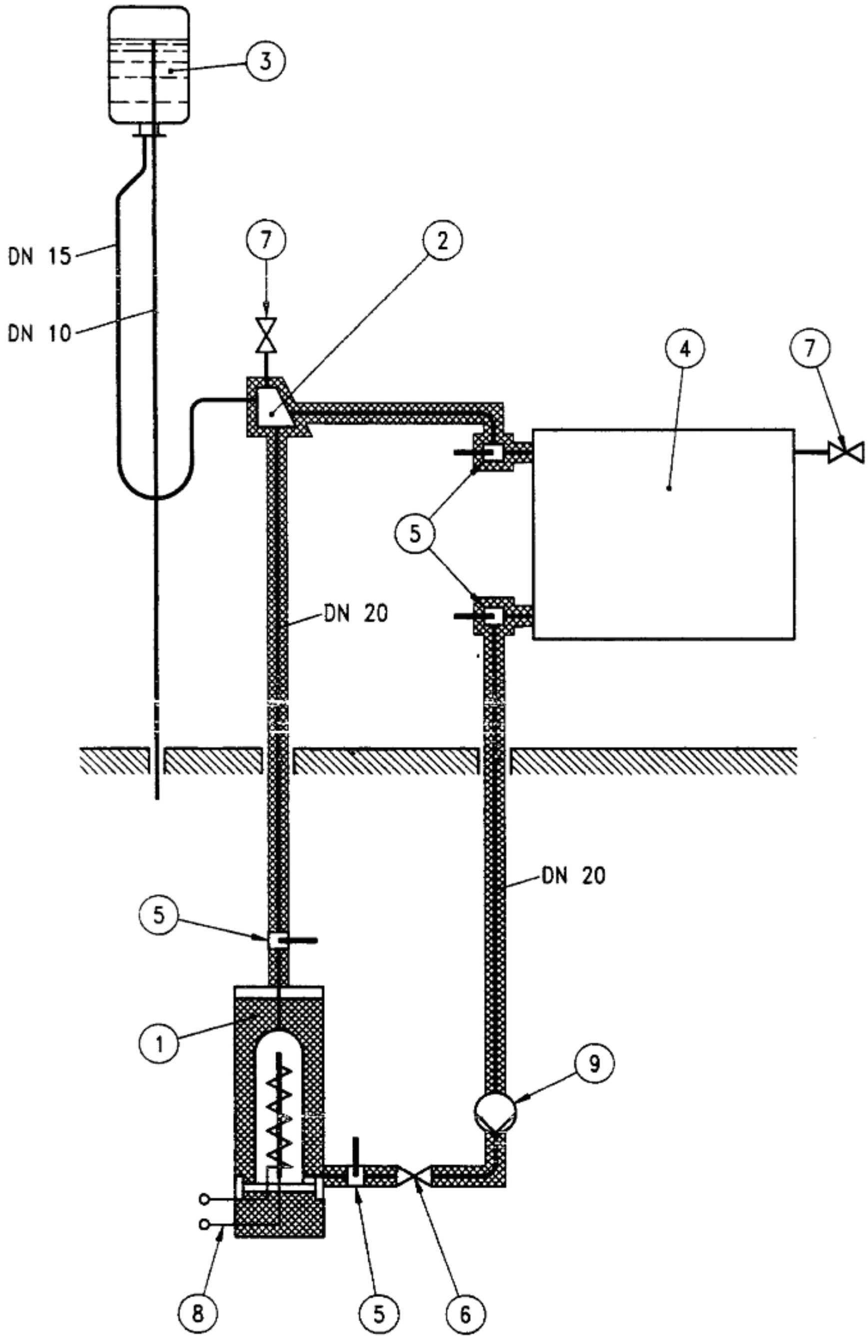
The water flow rate is calculated using the mass of the water m collected in the measuring vessel and the relevant time interval τ. $q_m = \frac{m}{\tau}$



Key

- 1 circuit pump
- 2 constant level supply tank
- 3 electric boiler
- 4 mixing device
- 5 overflow
- 6 valve
- 7 radiator
- 8 valve
- 9 heat exchanger
- 10 valve
- 11 valve
- 12 filter
- 13 water temperature measuring device
- 14 measuring vessel

Figure 9 — Weighing method: Test set-up



Key

1	electric boiler	6	valve
2	air purging bottle	7	air purging valve
3	expansion tank	8	connection to the constant voltage supply
4	radiator under test	9	pump
5	water temperature measuring point		

Figure 10 — Electric method: Test set-up

5.4.4.3 Electric method

The thermal output Φ_{me} is the difference between the electric power P_{el} to the heater, minus the heat losses Φ_V of the heater and the pipes:

$$\Phi_{me} = P_{el} - \Phi_V$$

The power of the pump is taken into consideration.

The water flow rate is calculated using the thermal output and the difference between the specific enthalpies.

$$q_m = \frac{\Phi_{me}}{(h_1 - h_2)}$$

5.4.4.4 Correction due to the air pressure

In consideration of atmospheric pressure deviating from p_0 = 101,3 kPa, the thermal output calculated by the relevant measured values Φ_{me} shall be corrected as follows:

$$\Phi = \Phi_{me} \left[S_k + (1 - S_k) f_p \right]$$

The correction factor f_p is to be calculated with the following equation:

$$f_p = \left(\frac{p_0}{p} \right)^{n_p}$$

in which p is the barometric pressure measured during the test, and the exponent n_p as well as the value of S_k are to be taken from Table 4.

NOTE Examples are given in Annex G.

5.4.5 Determination of the characteristic equation

5.4.5.1 The characteristic equation is to be determined on the basis of at least three points at constant water flow rate and at the following excess temperature:

ΔT = (30 ± 2,5) K

ΔT = (50 ± 2,5) K

ΔT = (60 ± 2,5) K

During the determination of the characteristic equation, the reference air temperature shall not change more than 1 K from one measurement to the next (in addition to the conditions for steady-state given in 5.4.5.2).

The water flow rate shall not fluctuate or differ more than 1 % from the adjusted value during the whole test.

To determine the standard characteristic equation, the water flow rate shall be adjusted to the standard water flow rate (q_{ms} ± 5 %).

5.4.5.2 Steady-state conditions

Steady-state conditions shall be maintained throughout the duration of the test, so far as both the primary fluid circuit and the ambient conditions in the test installation are concerned. Parameters are to be monitored at regular intervals by an automatic system. Steady-state conditions are deemed to exist when the standard deviations of all the readings (not less than 12 sets) taken at least in 30 min, are less than one half of the ranges specified below.

— water and air temperature *(see 3.1.19, 3.1.20, 3.1.23)* ± 0,1 K

— water flow rate ± 1 %

5.5 Presentation of results

5.5.1 Standard thermal output of a model

5.5.1.1 For heating appliances classified as radiators, the standard characteristic equation (Annex C) obtained from the test of a model is:

$$\Phi = K_{\mathrm{m}} \cdot \Delta T^{\mathrm{n}}$$

where

K_{m} is the constant of the model;

n is the exponent of the characteristic equation.

The coefficient "K_{m} " of each model is determined by the following relationship $K_{\mathrm{m}} = \Phi_{50} / 50^{\mathrm{n}}$.

Then the heat output at any ΔT is equal to:

$$\Phi = \Phi_{50} (\Delta T/50)^{\mathrm{n}}$$

$$\Phi_{30} = \Phi_{50} (30/50)^{\mathrm{n}}$$

5.5.1.2 For heating appliances classified as radiators and comprised in a type, according to 4.2.1.4 and 4.2.1.5, the thermal output is almost linear with length (i.e. exponent is close to unity) (see Annex D).

Thus $\Phi = \Phi_{\mathrm{L}} \cdot L$ and for heaters constructed from a number of identical vertical sections, $L = N_{\mathrm{S}} \cdot L_{\mathrm{S}}$.

The characteristic regression equation becomes:

$$\Phi_{\mathrm{L}} = K_{\mathrm{T}} \cdot H^{b} \cdot \Delta T^{(c_0 + c_1 \cdot H)}$$

where

K_{T} is the constant for the type;

b is the exponent of the characteristic dimension.

5.5.1.3 For heating appliances classified as radiators and comprised in a type according to 4.2, catalogue outputs for not tested models in the type are to be calculated from the characteristic regression equation of the type.

The exponent n for tested models is the value determined from the measurements.

For not tested models belonging to type:

— exponent "n" is determined by linear interpolation between two nearby values.

— water content and dry mass is determined by linear interpolation between two nearby values.

5.5.2 Determination of the catalogue outputs of a type made at variable water flow rate

The characteristic equation becomes:

$$\Phi_{\mathrm{L}} = K_{\mathrm{T}} \cdot H^{\mathrm{b}} \cdot q_{\mathrm{m}}^{\ \mathrm{c}} \cdot \Delta T^{(c_0 + c_1 \cdot H)}$$

where

q_{m} is the water flow rate.

6 Test report

The laboratory shall prepare a test report based on the procedures and calculations contained in this European Standard. The specimen of the test report is given in Annex E.

The following data shall be stated in the test report:

a) the standard characteristic equation of each tested model;

b) the standard thermal outputs (Φ_{30} , Φ_{50}) of each model;

c) any non-standard installation conditions which apply;

d) the pressure drop equation (i.e. pressure drop versus water flow rate), if requested by the manufacturer.

The thermal output of the module shall be indicated with one decimal digit if its value is below 100 and rounded mathematically, while it is rounded mathematically to the whole number in the other cases.

The exponent of the function shall be indicated with four decimal digits.

The temperature shall be indicated with one decimal digit.

Table 4 — Radiated heat output factor "Sk" and exponent "n_p"

Radiator Type	Radiated heat output factor S_k	Exponent n_p Height of radiator H < 400 mm	Exponent n_p Height of radiator $H \geq$ 400 mm
Sectional vertical radiators (see Figure G.1)			
Depth b ≤ 110 mm	0,30	0,40	0,50
Depth b > 110 mm	0,25	0,45	0,65
Horizontal water flow radiators / towel radiators (see Figure G.3)			
Depth b ≤ 30 mm	0,27	0,36	0,40
Depth b > 30 mm	0,25	0,40	0,45
Sectional vertical radiators, front closed (see Figure G.2)	0,25	0,55	0,65
Multi column radiators (see Figure G.9)			
Depth b ≤ 110 mm	0,30	0,40	0,50
Depth b > 110 mm	0,25	0,45	0,65
Pleated steel radiator (see Figure G.4)	0,25	0,55	0,70
Pipe grill radiators (see Figure G.5)	0,20	0,65	0,75
Single panel radiators without convectors	0,50	0,40	0,50
Single panel radiators with 1 convector			
Pitch of the fins ≤ 25 mm	0,35	0,60	0,70
Pitch of the fins > 25 mm	0,35	0,55	0,60
Single panel radiators with 2 convectors			
Pitch of the fins ≤ 25 mm	0,25	0,65	0,75
Pitch of the fins > 25 mm	0,25	0,60	0,65
Double panel radiators without convectors	0,35	0,40	0,55
Double Panel radiators with 1 or 2 convectors between the panels (see Figure G.6)			
Pitch of the fins ≤ 25 mm	0,20	0,60	0,75
Pitch of the fins > 25 mm	0,20	0,55	0,70
Double panel radiators with 3 convectors or 2 convectors behind each panel			
Pitch of the fins ≤ 25 mm	0,15	0,60	0,75
Pitch of the fins > 25 mm	0,15	0,55	0,70
Triple panel and multi-panel radiators without convectors	0,20	0,40	0,55
Triple panel and multi-panel radiators with 1 convector			
Pitch of the fins ≤ 25 mm	0,15	0,55	0,70
Pitch of the fins > 25 mm	0,15	0,50	0,65
Triple panel and multi-panel radiators with more than 1 convector (see Figure G.7)			
Pitch of the fins ≤ 25 mm	0,10	0,65	0,90
Pitch of the fins > 25 mm	0,10	0,60	0,80

Convectors without case 2,5 < Pitch of the fins ≤ 4 mm Pitch of the fins > 4 mm	0,05 0,05	1,0 0,8
Convectors with case height < 400 mm 2,5 < Pitch of the fins ≤ 4 mm Pitch of the fins > 4 mm	 0,00 0,00	 0,90 0,75
Convectors with case height ≥ 400 mm 2,5 < Pitch of the fins ≤ 4 mm Pitch of the fins > 4 mm	 0,00 0,00	 0,60 0,55

For radiators with chromed and polished final finish S_k = 0 and n_p is the same of the corresponding painted radiators. For other surface treatments the factor S_k is calculated as:

$$\frac{\varepsilon}{0{,}92} \cdot S_{k,p}$$

where:

$S_{k,p}$ is the Sk factor for the corresponding painted radiator

ε is the emissivity of the surface

The exponent n_p is almost independent from the excess temperature ΔT.

In the above table, the values are based on a ΔT = 50 K and they can be used for any ΔT.

Annex A
(normative)

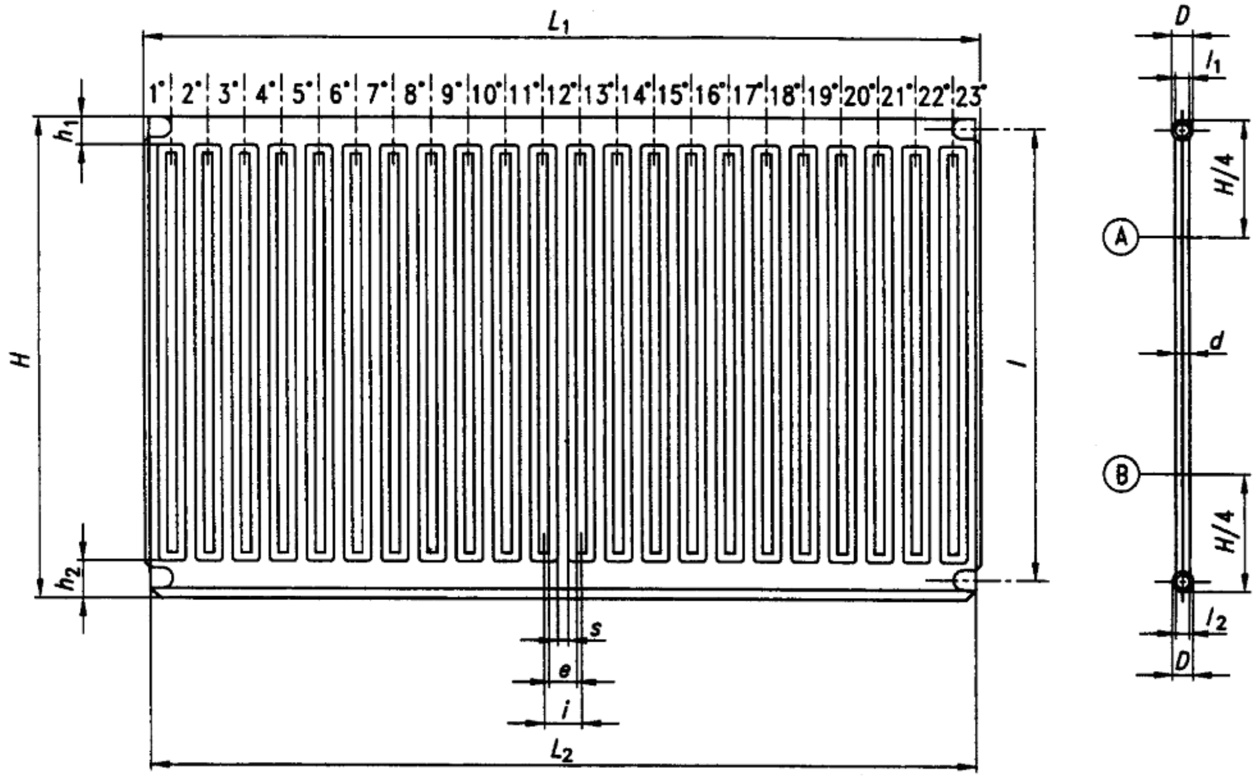
Master radiators dimensional verification

After having been painted, master radiators shall be dimensionally verified using the relevant form of this annex (see Figure A.1, Figure A.2 and Figure A.3).

The arithmetical mean value of each dimension shall be within the limits indicated in the form.

The measured weight and water content shall be reported in the form.

The filled-in form shall be made available by the laboratory for any further check.



Ns	H	s		e		i	
		sA	sB	eA	eB	iA	iB
1							
2							
3							
4							
5							
6							
7							
8							
9							
10							
11							
12							
13							
14							
15							
16							
17							
18							

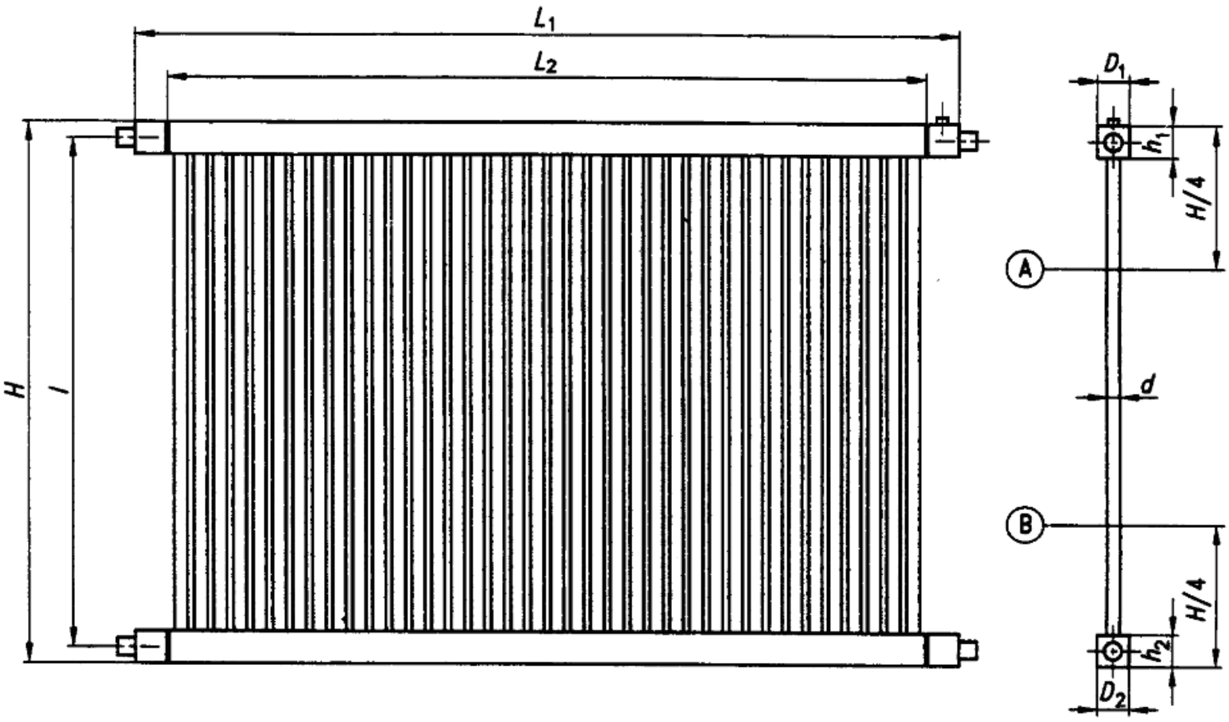
Other data (maximum and minimum accepted value of the relevant measure)
Length L_1 (1 149 mm to 1 151 mm) L_2 (1 130 mm to 1 132 mm)
Distance between axes *l* (643 mm to 645 mm)
Junction external diameter *D* (29,7 mm to 30,3 mm)

19								
20								
21								
22								
23								
Mean values	*H*	*s*		*e*		*i*		

Maximum and minimum accepted values of the relevant dimensions

H	$l_1 = l_2$	*s*	*e*	*i*	*d*	h_1	h_2
689	Rp 1/2	12,9	34,9	50,9	17,9	40,7	50,7
691		13,1	35,1	51,1	18,1	41,3	51,3

Figure A.1 — Master radiator No. 1 dimensional verification — Measurements to be taken



Ns	*H*	*D*		External column diameter	
		D_1	D_2	*d*A	*d*B
1					
2					
3					
4					
5					
6					
7					
8					
9					
10					
11					
12					
13					
14					
15					
16					
17					
18					
19					

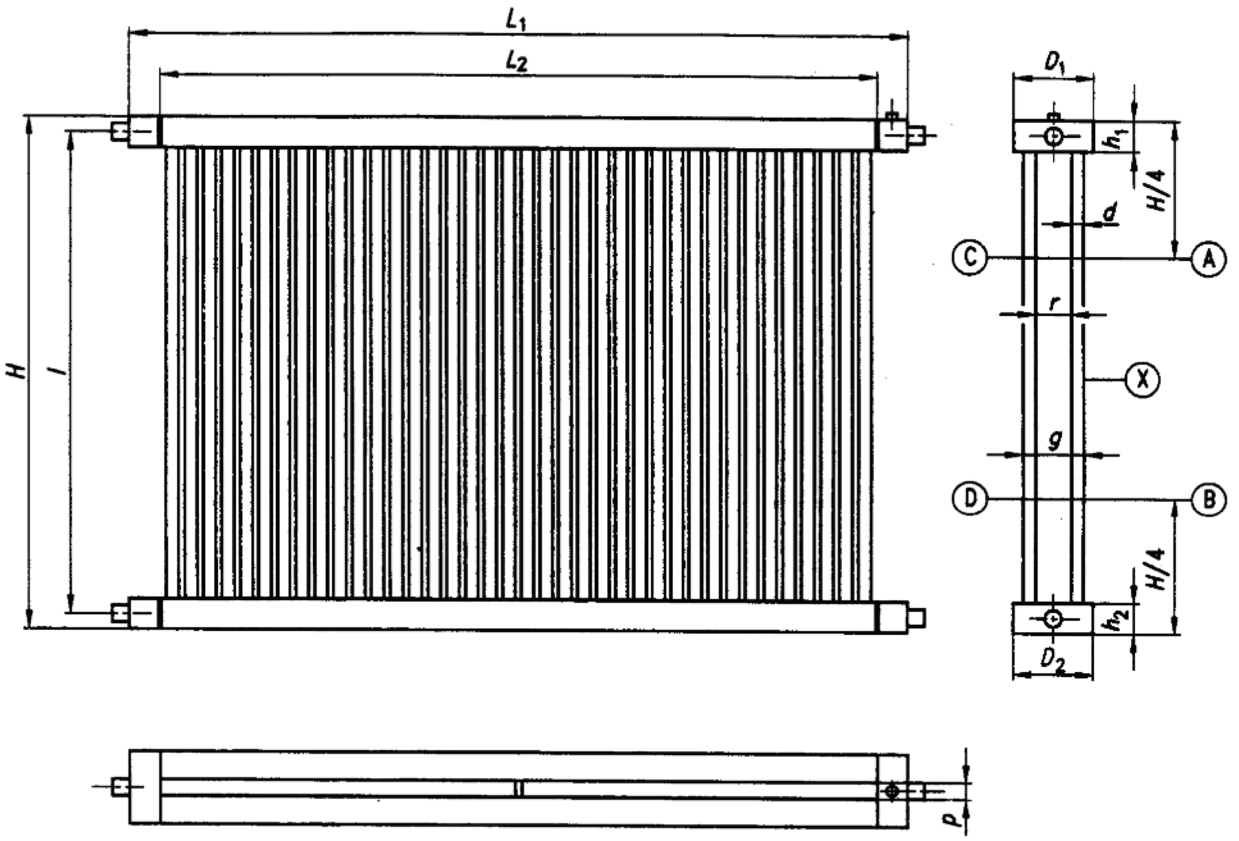
Other data
Length L_1 (1 249 mm to 1 251 mm) L_2 (1 149 mm to 1 151 mm)
Distance between axes *l* (799 mm to 801 mm)

20						
21						
22						
23						
24						
25						
26						
27						
28						
29						
30						
31						
32						
33						
34						
35						
36						
37						
38						
Mean values	*H*	*D*		*d*		

Maximum and minimum accepted values of the relevant dimensions

H	*D*	*d*	*h*
849	49,5	19,9	49,5
851	50,5	20,1	50,5

Figure A.2 — Master radiator No.2 dimensional verification — Measurements to be taken



N_s	*H*	*D*		External column diameter d				g			r		
		D_1	D_2	*d*A	*d*B	*d*C	*d*D	*g*A	*g*X	*g*B	*r*A	*r*X	*r*B
1													
2													
3													
4													
5													
6													
7													
8													
9													
10													
11													
12													
13													
14													
15													
16													

Other data
Length L_1 (1 249 mm to 1 251 mm) L_2 (1 149 mm to 1 151 mm)
Distance between axes *l* (799 mm to 801 mm)

17													
18													
19													
20													
21													
22													
23													
24													
25													
26													
27													
28													
29													
30													
31													
32													
33													
34													
35													
36													
37													
38													
Mean values	*H*	*D*		*d*				*g*A	*g*X	*g*B	*r*A	*r*X	*r*B

Maximum and minimum accepted values of the relevant dimensions

H	*D*	*d*	*e*	*g*	*r*	*h*	*p*
849	129,6	19,9	29,7	99,7	59,7	49,5	29,7
851	130,4	20,1	30,3	100,3	60,3	50,5	30,3

Figure A.3 — Master radiator No.3 dimensional verification — Measurements to be taken

Annex B
(informative)

Determination of pressure drop

B.1 Introduction

Radiators are not very influenced by to water flow rate and pressure drops in them are negligible. Even in convectors, the pressure drop is usually less than 1 000 Pa and for some families of appliances less than 200 Pa. Consequently, the appliance pressure drop is not a major contributor to pressure losses in heating systems.

Nevertheless, in convectors and other appliances the thermal output of which is influenced by the water flow rate, it is necessary to supply each appliance of the heating system with the correct water flow rate in order to obtain the rated thermal output.

It is therefore recommended that such appliances, which will have been tested at more than one water flow rate, be subjected to pressure drop tests and the coefficients of the pressure drop equation be quoted in the catalogue.

The pressure drop through an appliance is related only to the design of the heat emitter (not the casing) and is dependent on:

a) the water flow rate;

b) the water temperature in so far as it affects the fluid density and viscosity;

c) the cross-sectional area of the waterways (governed by the number of parallel paths and their cross-sections);

d) the length of the waterways (that is, the length of each path);

e) the number of local losses (such as bends) in each path;

f) the water distribution between the parallel paths.

If the same samples are used for both heat output tests and pressure drop tests, the effect of length cannot be determined, and the pressure drop equation can be quoted only for the tested models. If pressure drop characteristics are required for a type or family, the effect of length is significant and can only be determined by testing additional samples of other lengths. In this case the models chosen should span the range of lengths of the type.

It is preferable that pressure drop tests be carried out at the standard excess temperature. However, the effect of temperature is generally small and tests may be carried out at 20 °C ± 10 °C provided that this is stated in the catalogue.

If they are taken to be the same as those required for heat output tests, there is the possibility of carrying out pressure drop tests simultaneously with the heat output tests. At least three water flow rates should be chosen to be representative of the manufacturer's recommended installation practice.

B.2 Pressure drop equation of a type

B.2.1 General

The pressure drop equation of a type is of the form:

$$\Delta p = K \times L^{g} \times A^{a} \times q_{m}{}^{d}$$

where A is the cross-sectional area of the waterways. For most existing convector types, the heat emitters differ only in length, so A is not a variable.

Where the types within a type have a simple geometric relationship, one with another, the equation may be applied to the whole family.

Coefficients of the pressure drop equation shall be determined by multiple regression as described in Annex D.

For the equation to be valid, all the measured pressure drops shall fall within ± 10 % of the prediction of the equation. If any fall outside this range, the type should be divided and new equations derived for each subset of the results.

B.2.2 Pressure drop characteristic equation of a model

The pressure drop characteristic equation of a model is:

$$\Delta p = K \times q_{m}{}^{d}$$

where the index d is usually close to 2.

The pressure drop test shall be made on the same model taken for the thermal output test

The pressure drop shall be determined at not less than three water flow rates, corresponding to 50 %, 100 % and 200 % of the standard water flow rate.

The test data shall be correlated with the regression method to determine the parameters of the characteristic equation.

B.3 Test method

B.3.1 Test circuit

An example of a suitable test set-up for determining the pressure drop is shown in Figure B.1.

The heating appliance shall be installed in a test circuit made up of two lines of tubing with the nominal diameter of the respective heater connection. Each line of tubing shall have a length of no less than 20 times its internal diameter Its inner surface shall be clean and smooth.

B.3.2 Pressure tappings

The lines of tubing shall be provided with one measuring head each with several holes or ring opening. The design of a measuring head with hole distribution is shown in Figure B.3. The distance between the measuring heads and the heating appliance to be tested shall be as follows:

— 5 times the internal diameter for the measuring head fitted in flow direction before the heating appliance;

and

— 10 times the internal diameter for the measuring head fitted in flow direction behind the heating appliance.

B.4 Test procedure — Setting up

B.4.1 Connect the lines of tubing to heating appliance and supply line and connect the instrument for measuring the pressure drop to the measuring heads.

B.4.2 Set a water flow rate higher than the standard water flow rate and carefully bleed the water system of air. Before the tests are made, the measuring heads shall be de-aired. Air locks can easily be determined by using transparent plastic pipes.

B.5 Measurements of differential pressures using an inverted U tube manometer

B.5.1 Techniques of measurement

The values of the differential pressure obtained in these tests are small and consequently, minor faults in technique of measurement lead to errors that are disproportionately large.

Greater confidence in measurement is ensured by eliminating the common sources of error described in the following subclauses.

B.5.2 Surface tension effect

The stability of the meniscus is improved by:

— the use of manometer tubes with internal bore > 10 mm;

— adding two or three drops of wetting agent to the inverted U tube manometer and the piezometer ring (see Figure B.3).

B.5.3 Leakage

Piping should be inspected for cracks, particularly where there are bends. Care should be taken to ensure that tubing is connected securely to adapter tailpieces or nipples, but at the same time, not cut.

Leakage can also occur through an imperfect equalizing valve. If a leak is suspected, the inverted U tube manometer assembly should be tested hydraulically at a static pressure of > 500 mbar.

B.5.4 Air pockets in connecting piping

Errors can be caused by the lack of homogeneity of the inverted U tube manometer fluid. There is a risk that air will collect at any point in the rim of connecting piping between piezometer ring and inverted U tube manometer and also within the piezometer ring itself. It is therefore important to run connecting piping from the bottom of the piezometer ring to the inverted U tube manometer free from kinks by a continuous upward gradient. Before the tests are made, the piezometer ring should be vented. The use of transparent/translucent plastic tubing enables air pockets to be detected more easily.

B.5.5 Blocked pressure holes

Pressure holes should be checked before and after a series of tests to ensure that they are not blocked.

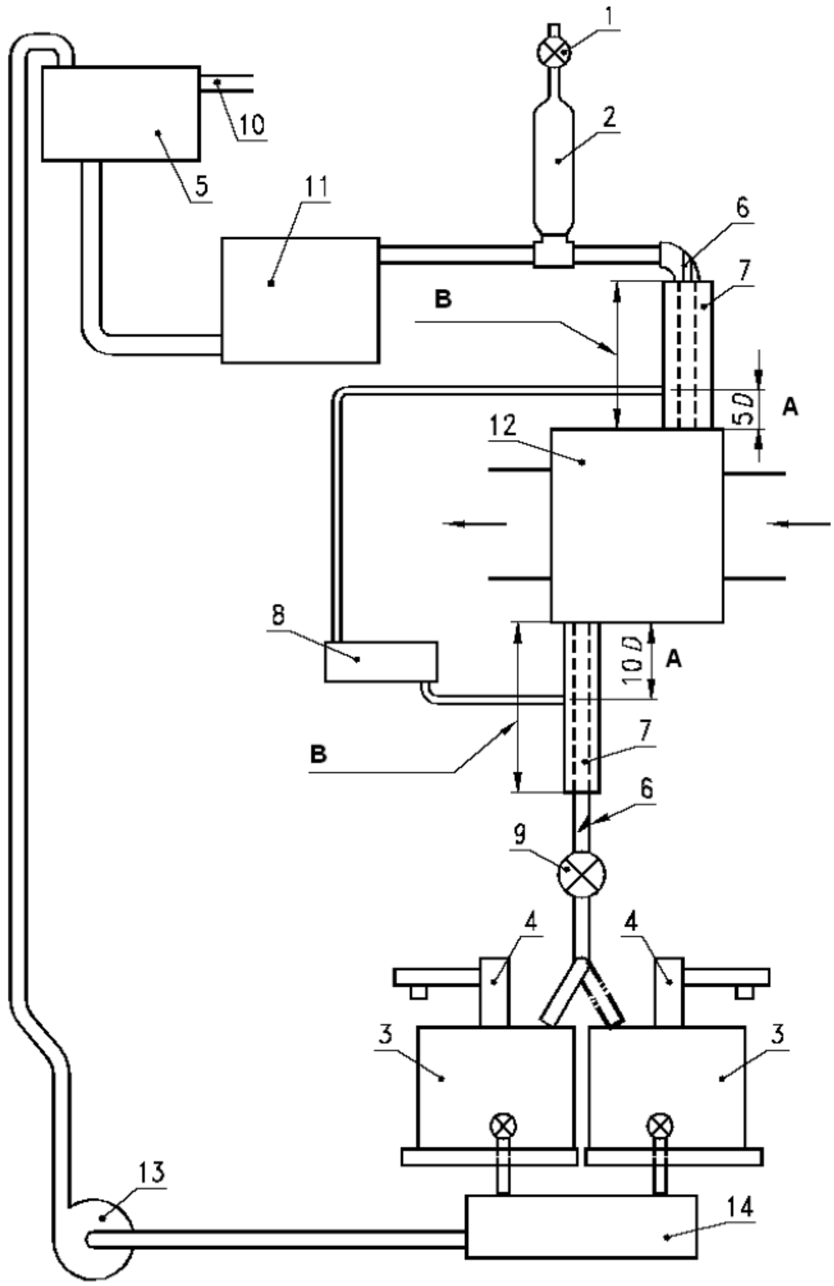
The plugs of the piezometer ring provide access through which the blockage may be cleared by means of a thin probe.

B.5.6 Level of inlet and outlet connections

The inlet and outlet connections should preferably be on the same horizontal centreline.

B.5.7 Damping (throttling) of excessive movement (oscillation) of inverted U tube manometer liquid

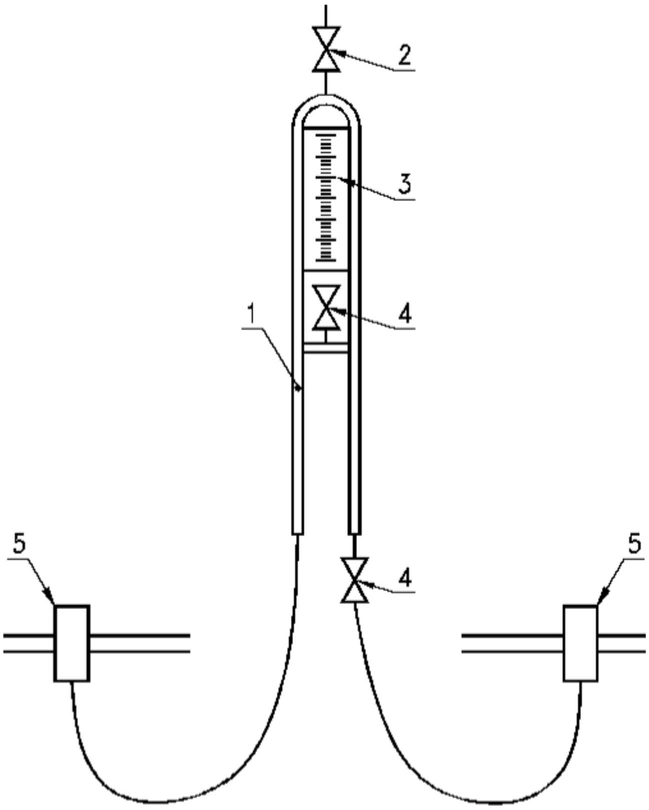
Damping may be affected by use of plug or pinch cocks, by a capillary (viscous) restriction or by porous plugs in the connecting piping. Excessive damping causes error and it is essential that damping is equal on each side of the inverted U tube manometer (see Figure B.2).



Key

1	air cock	8	inverted U tube manometer
2	air receiver	9	flow regulating valve
3	water container	10	overflow
4	beam type	11	water heating device
5	constant level tank	12	appliance under test
6	thermometer pocket	13	pump
7	insulated constant section pipe	14	sump
A	pressure tapping	B	20 pipe diameters

Figure B.1 — Pressure drop measuring set-up (open-circuit water system)



Key

1 tubing ϕ 10 mm

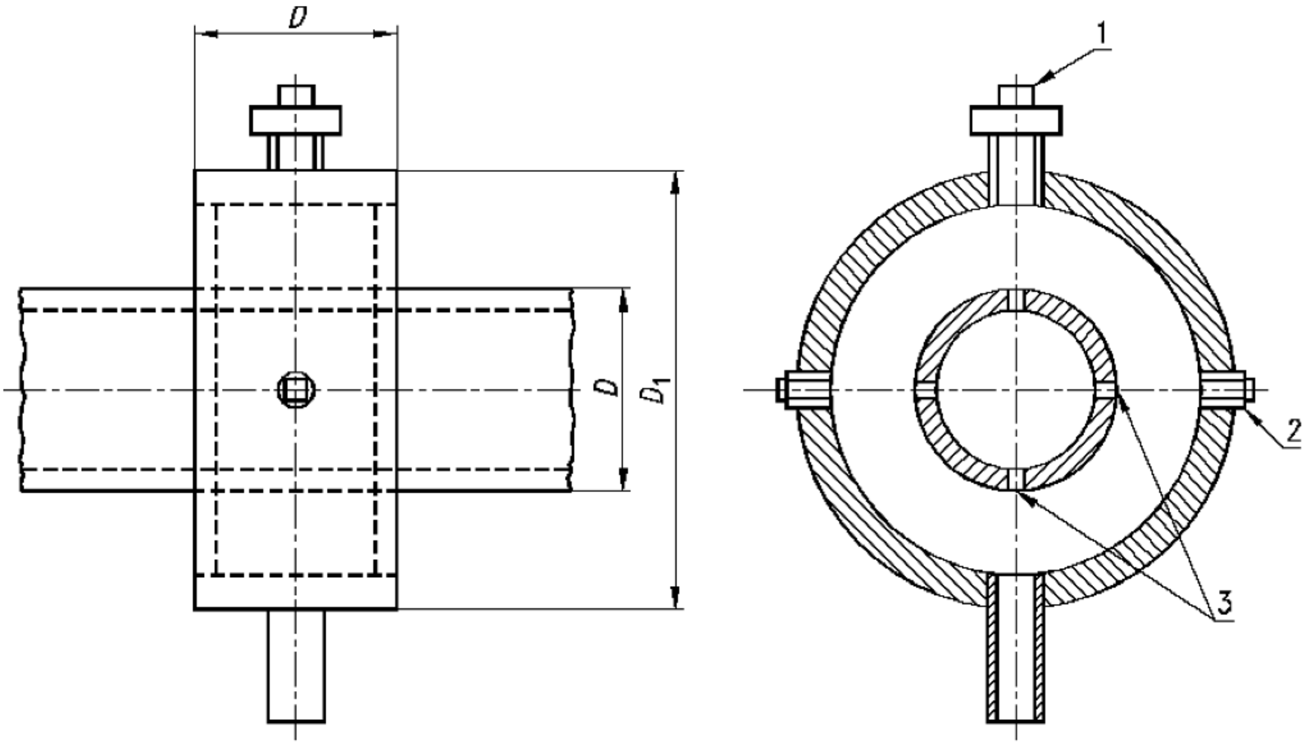
2 valve

3 scale with magnifier

4 valve

5 piezometer ring

Figure B.2 — Inverted U tube manometer



BPS pipe nipple to the inverter U tube manometer

Key

1 air vent

2 pipe plug

3 1 mm drill (remove burrs)

$D_1 = D$ + 10 mm + 2 mm x pipe wall thickness

Figure B.3 — Piezometer ring detail

Annex C
(normative)

Least squares regression for a model

The characteristic equation:

$$\Phi = K_{\mathrm{M}} \cdot \Delta T^{\mathrm{n}}$$

becomes in logarithmic coordinates:

$$\log \Phi = \log K_{\mathrm{M}} + n \cdot \log \Delta T$$

Applying the least squares method, the log K_{m} and $_{\mathrm{n}}$ values are obtained as follows:

$$\log K_{\mathrm{M}} = \frac{\sum(\log \Phi) \cdot \sum\left[(\log \Delta T)^2\right] - \sum(\log \Delta T \cdot \log \Phi) \cdot \sum(\log \Delta T)}{N \cdot \sum\left[(\log \Delta T)^2\right] - \left(\sum(\log \Delta T)\right)^2}$$

$$n = \frac{N \cdot \sum\left[(\log \Delta T \cdot \log \Phi)\right] - \sum(\log \Delta T) \cdot \sum(\log \Phi)}{N \cdot \sum\left[(\log \Delta T)^2\right] - \left(\sum(\log \Delta T)\right)^2}$$

where

n is the number of measured points.

Annex D
(normative)

Analysis of test results by the method of least squares multiple regression

The general equation which describes the heat output of a type is:

$$\Phi = K_{\mathrm{T}} \times L^{\alpha} \times H^{b} \times \Delta T^{(c_o + c_1 H)} \times (q_{\mathrm{m}})^{\mathrm{c}} \qquad \text{(D.0)}$$

Any invariant parameters of a series of tests are omitted from the equation. The equation may be expressed in logarithmic form as:

$$\log \Phi = \log K_{\mathrm{T}} + \alpha \log L + b \log H + c_0 \log \Delta T + c_1 H \log \Delta T + c \log q_{\mathrm{m}} \qquad \text{(D.1)}$$

For simplicity of notation this can be rewritten as:

$$\Phi = K' + aL' + bH' + c_0 \Delta T' + c_1 H \Delta T' + cq' \qquad \text{(D.2)}$$

This equation has six unknowns, so a further five equations are required to permit a solution. These are obtained by multiplying Formula (D.2) by each of five of the variables in turn. If the test results comprise N sets of measurements of the test variables, each equation can be expressed as the summation of N identical equations in each of which one set of measurements has been substituted. The six equations then become:

$$\sum \Phi' = K'N + a\sum L' + b\sum H' + c_0 \sum T' + c_1 \sum HT' + c\sum q'$$

$$\sum \Phi' L' = K' \sum L' + a\sum \left(L'\right)^2 + b\sum H'L' + c_0 \sum T'L' + c_1 \sum HT'L' + c\sum q'L'$$

$$\sum \Phi' H' = K' \sum H' + a\sum L'H' + b\sum \left(H'\right)^2 + c_0 \sum T'H' + c_1 \sum HT'H' + c\sum q'H'$$

$$\sum \Phi' T' = K' \sum T' + a\sum L'T' + b\sum H'T' + c_0 \sum \left(T'\right)^2 + c_1 \sum HT'T' + c\sum q'T'$$

$$\sum \Phi' HT' = K' \sum H\ T' + a\sum L'HT' + b\sum H'HT' + c_0 \sum T'HT' + c_1 \sum \left(HT'\right)^2 + c\sum q'HT'$$

$$\sum \Phi' q' = K' \sum q' + a\sum L'q' + b\sum H'q' + c_0 \sum T'q' + c_1 \sum HT'q' + c\sum \left(q'\right)^2$$

These equations may be solved simultaneously to give the least squares best fit estimates of the six unknowns $\boldsymbol{K}$, $\boldsymbol{a}$, $\boldsymbol{b}$, $\boldsymbol{c_0}$, $\boldsymbol{c_1}$, $\boldsymbol{c}$. in most cases, one or more of the parameters will be invariant, and all terms containing that variable will be omitted.

The equations can be conveniently written in matrix form:

$$
\begin{matrix}
\sum \Phi' & = N & \sum L & \sum H' & \sum T' & \sum H'T' & \sum q' & K' \\
\sum \Phi' L' & = \sum L' & \sum (L')^2 & \sum L'H' & \sum L'T' & \sum HT'L' & \sum q'L' & a \\
\sum \Phi' H' & = \sum H' & \sum L'H' & \sum (H')^2 & \sum T'H' & \sum HT'H' & \sum q'H' & b \\
\sum \Phi' T' & = \sum T' & \sum L'T' & \sum H'T' & \sum (T')^2 & \sum HT'T' & \sum q'T' & c_0 \\
\sum \Phi' HT' & = \sum HT' & \sum L'HT' & \sum H'HT' & \sum T'HT' & \sum (HT')^2 & \sum q'HT' & c_1 \\
\sum \Phi' q' & = \sum q' & \sum Lq' & \sum H'q' & \sum T'q' & \sum HT'q' & \sum (q')^2 & c
\end{matrix}
$$

in which variables may be omitted by leaving out the appropriate rows and columns.

The matrices may be written as:

$$\{Y\} = [X]\{A\}$$

This can be rearranged to give an explicit equation for the regression coefficient vector **{A}:**

$$\{A\} = [X]^{-1}\{Y\}$$

The matrix **[X]** has maximum size 6 × 6, and is easily inverted by the many standard techniques available.

For the equation to be valid, all the measured thermal outputs shall fall within **± 2 %** of the prediction of the equation.

If any fall outside this range, the type shall be divided and new equations derived for each subset of the results.

Annex E
(normative)

Specimen of the test report

INSTITUTE..

ASSESSMENT REPORT No...

ISSUED BY .... DATE....................................

A brief description of the test booth is attached.

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

TEST REPORT No... DATE....................................

APPLICANT ....

APPLICANT ADDRESS ....

TEST ACCORDING TO EUROPEAN STANDARD EN 442-2..

BRIEF DESCRIPTION OF THE APPLIANCE (material, construction, etc.)

....
....
....

DRAWINGS (indicate the identification data, of the drawings on the basis of which the dimensional verifications have been carried out)

....
....
....

TYPE...

MANUFACTURERS TRADEMARK................. ....

IDENTIFICATION SYMBOL OF THE TYPE...

THE TYPE COMPRISES THE FOLLOWING MODELS (in case of a single model indicate the model only):

Model	Drawing no.	Tested (Y/N)

....

Characteristic equation of the type

Characteristic variable dimension (see drawing N ....):

1. OVERALL HEIGHT .... 2. OTHER ……………..……………………………

Characteristic equation...

Operator	Laboratory manager	Institute director
....	....	....

DESCRIPTION OF THE TEST INSTALLATION AND PROCEDURE

……
……
……
……
……
……
……
……
……
……..

STANDARD THERMAL OUTPUT OF THE TESTED MODELS

Model	**Length** mm	**Height** mm	**Depth** mm	**Mass** kg	**Water content** l	**Thermal output 50 K** W/m W/section W/(m finned length)	**Thermal output 30 K** W/m W/section W/(m finned length)	n

Characteristic equations Regression equation of the type:

$$\Phi_{\mathrm{L}} = K_{\mathrm{T}} \times H^{b} \times q_{m}{}^{c} \times \Delta T^{(c_0 + c_1 \quad H)}$$

where:

K_{T} = …………………………

b = …………………………

c_0 = …………………………

c_1 = …………………………

c = ………………………… (= 0 if radiator)

Characteristic equation of the tested models:

MODEL ....

$$\Phi = K_{\mathrm{M}} \times \Delta T^{n}$$

where:

K_{M} = …………………………

n = …………………………

Difference between tested value and the value calculated by the regression equation of the type:

Difference = ...%

Non-tested models (calculated values):

MODEL ....

Φ_{50} = ………………………… n = …………………………

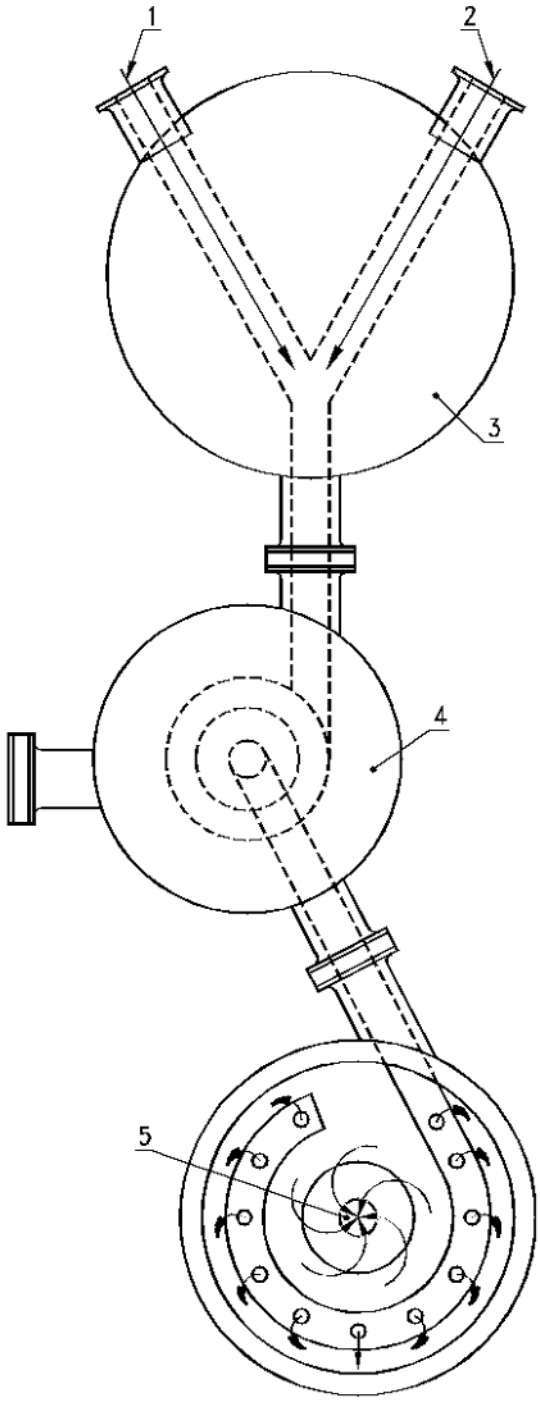
Φ_{30} = ………………………… n = …………………………

Average measured values and results (one sheet for each tested model)					
	Symbol	**Unit**	**Measuring point**		
			1	**2**	**3**
Air pressure	p	kPa			
Air ref. temperature	t_r	°C			
Water inlet temperature	t_1	°C			
Water outlet temperature	t_2	°C			
Temperature difference	t_1-t_2	K			
Inlet water enthalpy	h_1	J/kg			
Outlet water enthalpy	h_2	J/kg			
Enthalpy difference	Δh	J/kg			
Mean water temperature	t_m	°C			
Excess temperature	ΔT	K			
Weighing method Water flow rate	q_m	kg/s			
Thermal output measured	Φ_{me}	W			
Electric method Electric power input	P_{el}	W			
Circuit heat losses	Φ_V	W			
Thermal output corrected for barometric pressure influence	Φ	W			

Annex F
(informative)

Apparatus and method for checking the bulk temperature measuring devices

Figure F.1 shows the apparatus to check the bulk temperature measuring device. Temperature differences of approximately 10 K can be stabilized in the inlet to the measuring device. The temperature recorded in the test device is compared with the temperature in a second device (or the special blender) mounted behind the test device. Both measuring devices are extremely well insulated. The temperature recorded in the test device shall not differ by more than 0,1 K at 10 K temperature difference from the temperature recorded in the second device. On the assumption that there is a temperature difference of 2 K within the water flow at the inlet of the measuring device during the test an uncertainty in determining the bulk temperature of 0,01 K can be extrapolated.



Key

1 cold

2 hot

3 layer device

4 measuring device

5 blender measuring of real bulk temperature (or a second measuring device)

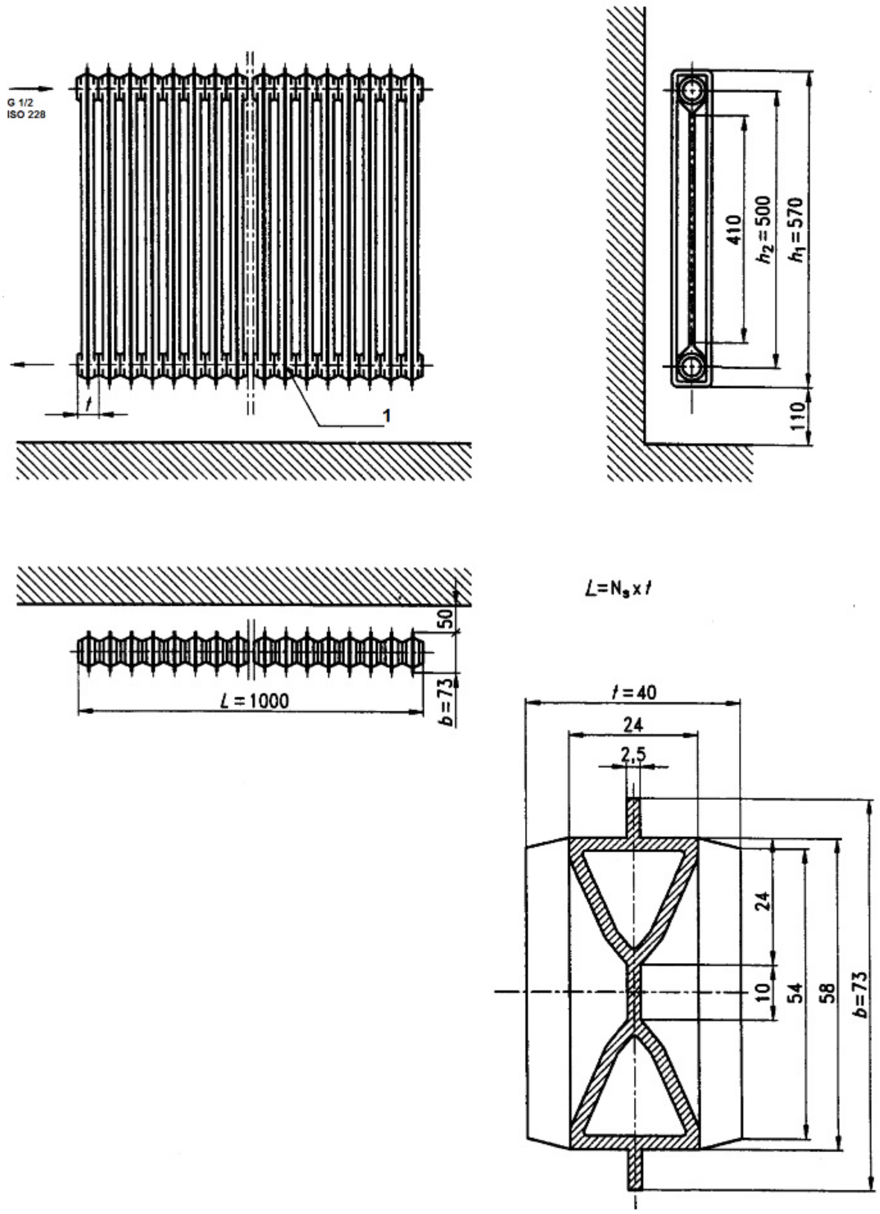
Figure F.1— Apparatus for checking the bulk temperature measuring devices

Annex G
(informative)

Examples of typical appliances according to Table 4

Figure G.1, Figure G.2, Figure G.3, Figure G.4, Figure G.5, Figure G.6, Figure G.7, Figure G.8 and Figure G.9 are different examples of typical radiators design indicated in Table 4.

Dimensions in millimetres

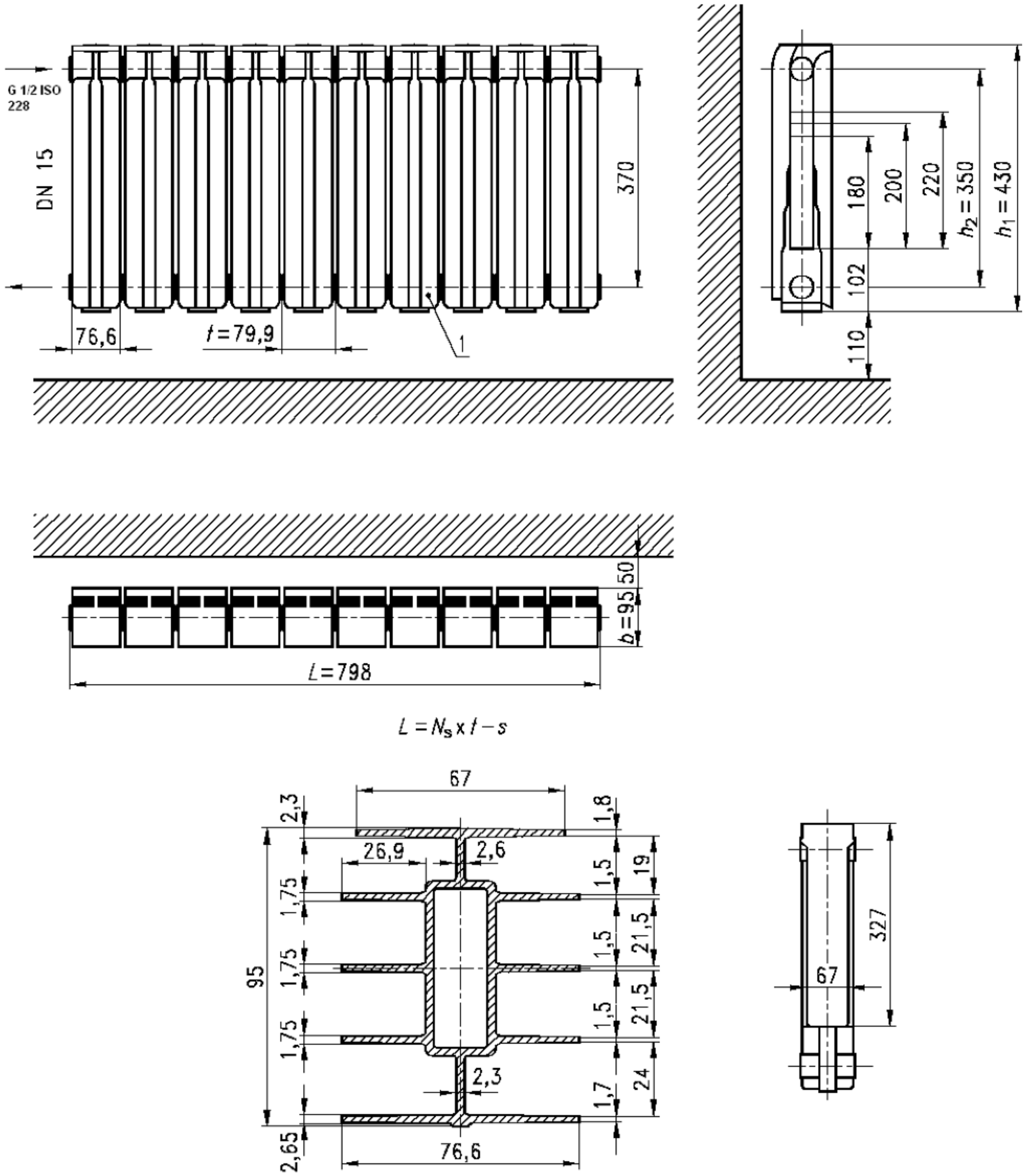


Key

1 25 section

Figure G.1 — Steel sectional radiator (vertical flow rate)

Dimensions in millimetres



Key

1 10 sections

s gasket thickness

*N*s number of sections

Figure G.2 — Cast aluminium sectional radiator (vertical water flow, front closed)

Dimensions in millimetres

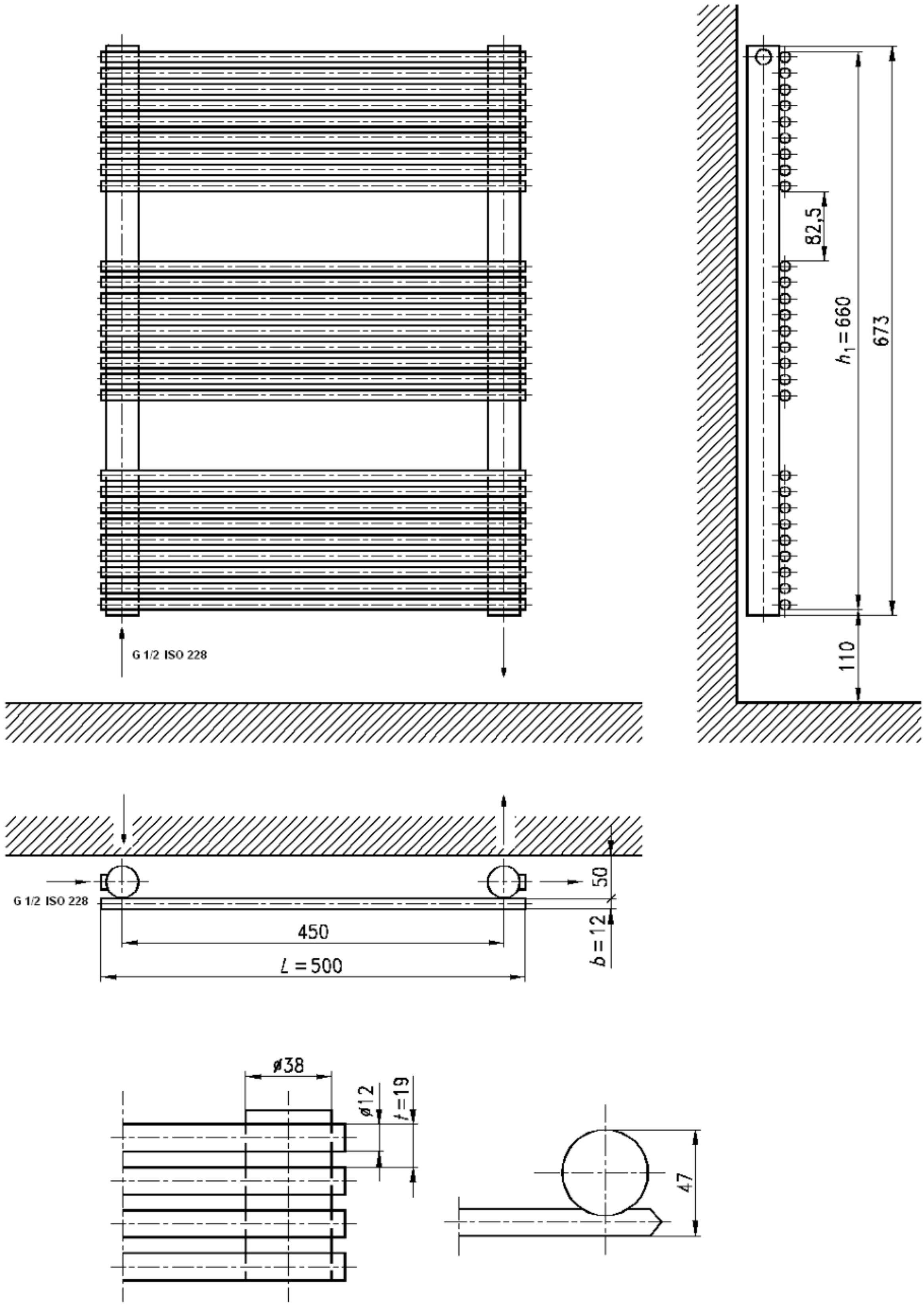
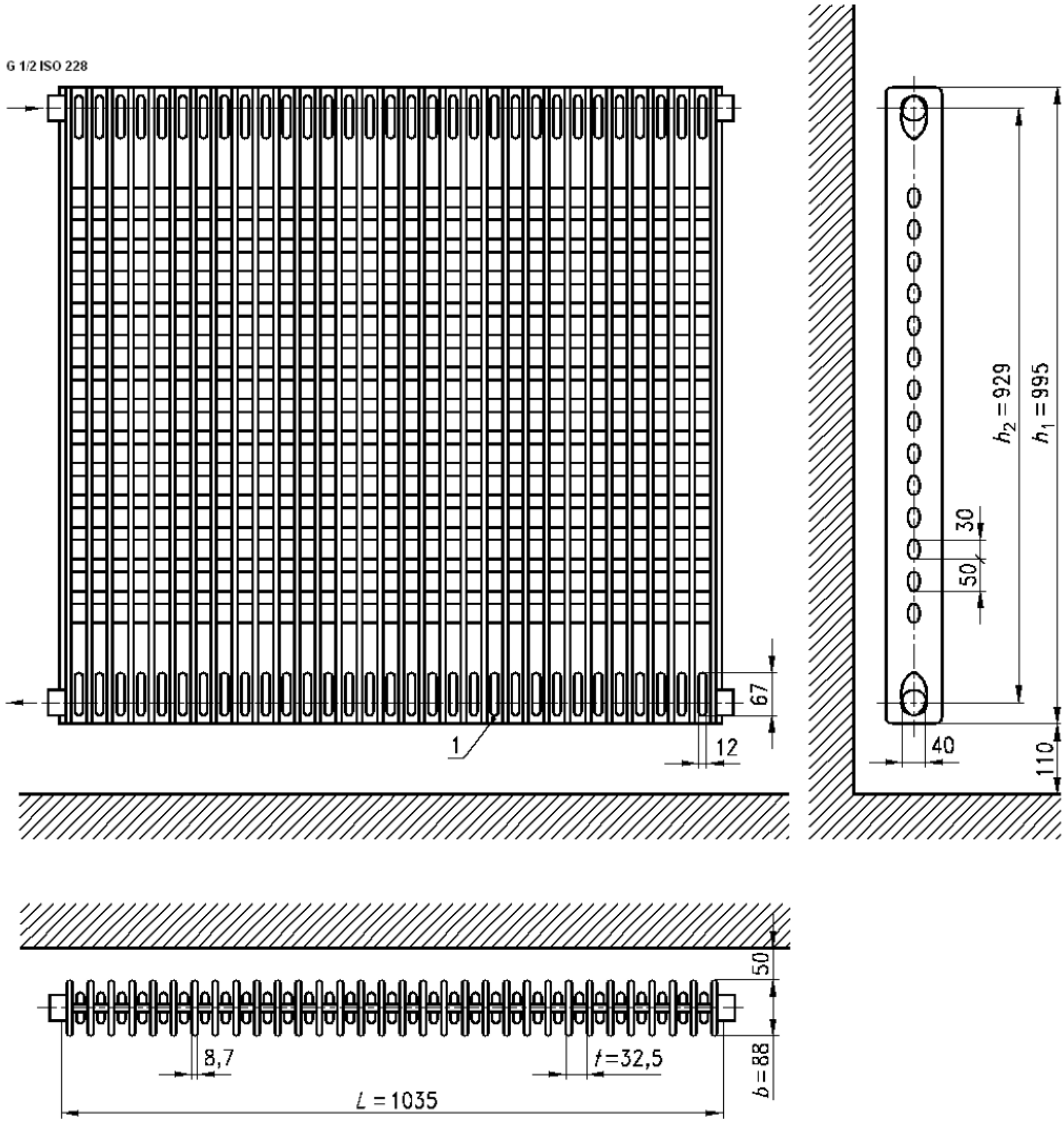


Figure G.3 — Towel radiator / horizontal water flow radiator

Dimensions in millimetres

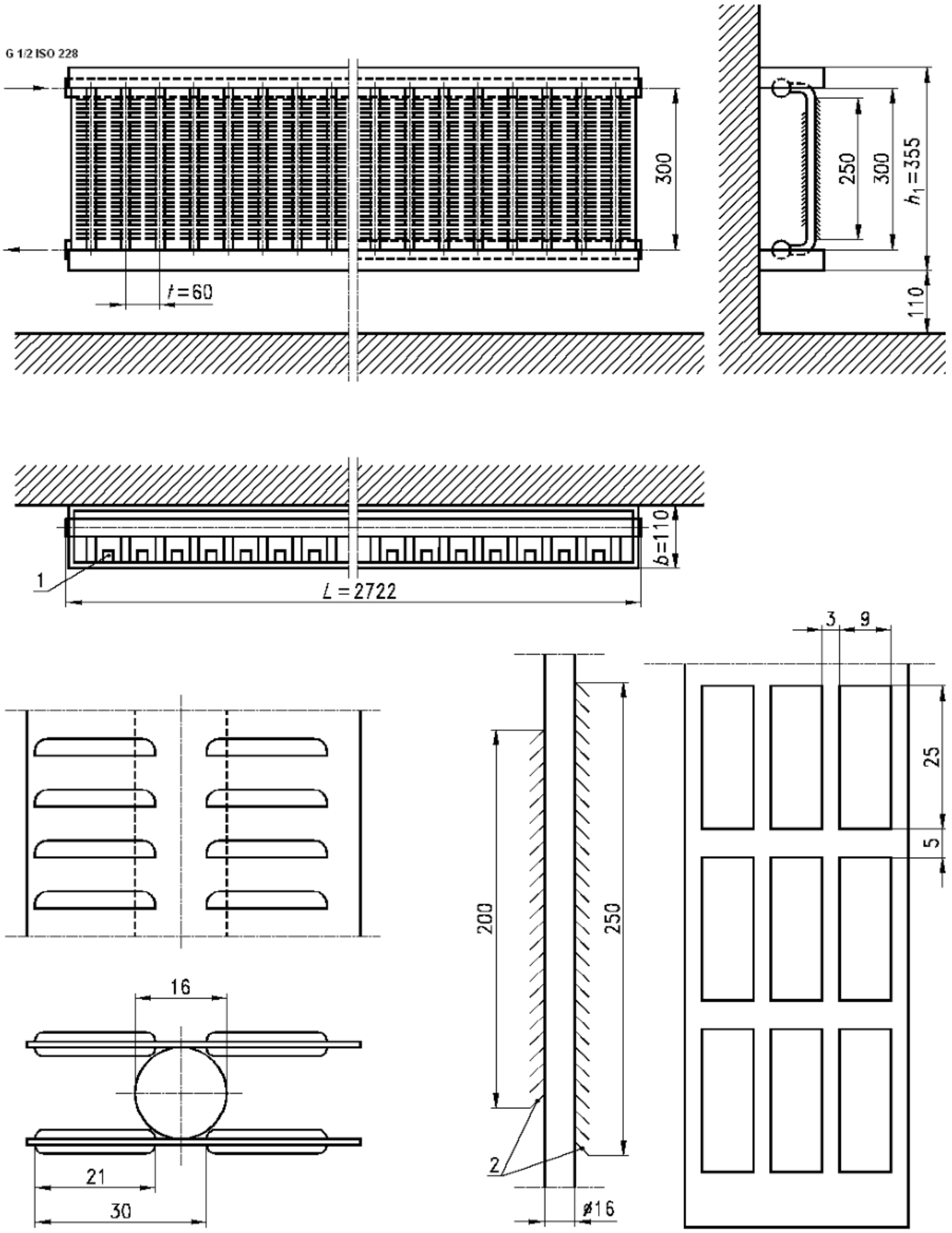


Key

1 32 modules

Figure G.4 — Pleated steel radiator

Dimensions in millimetres



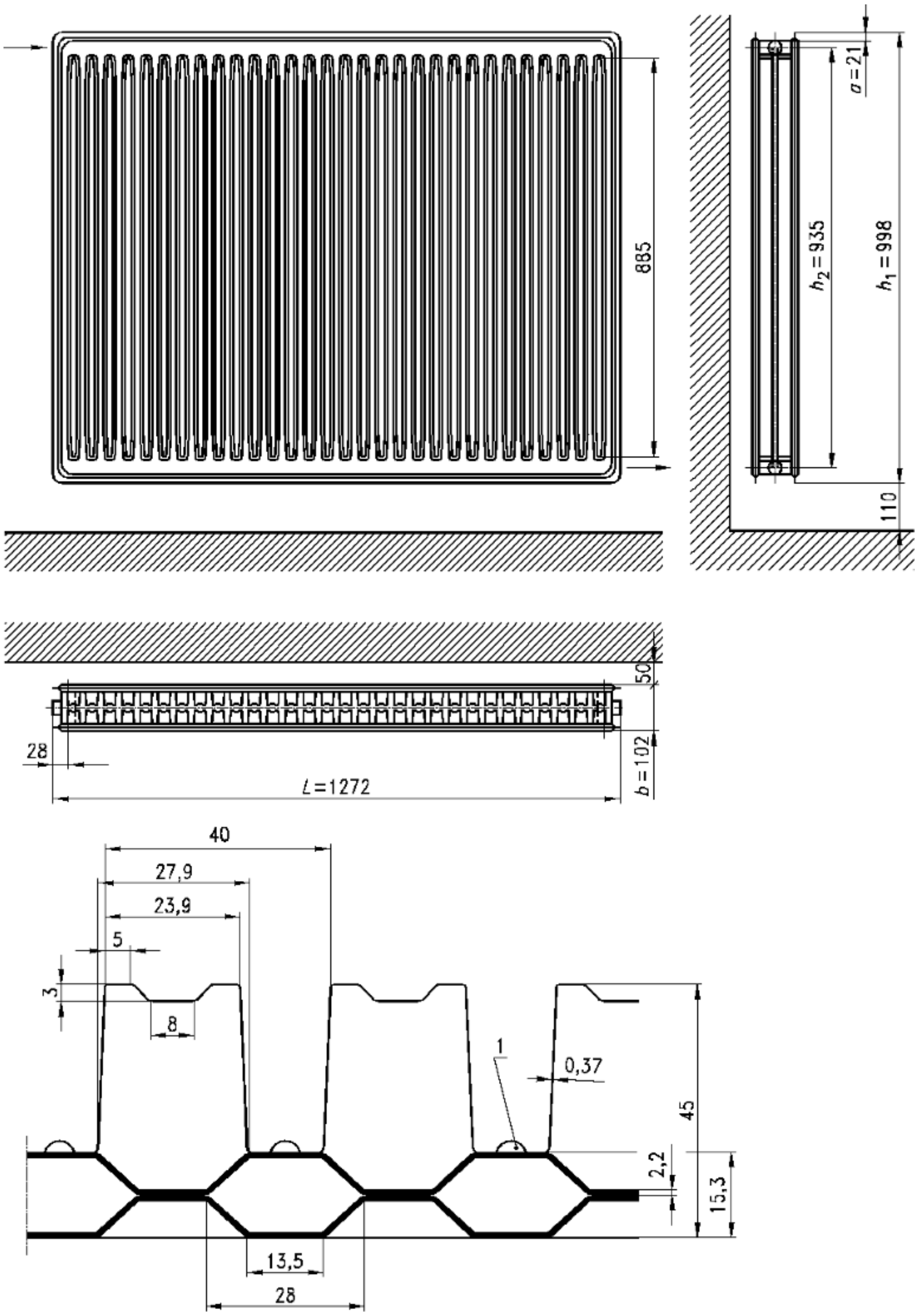
Key

1 air opening in the bottom part of the enclosure

2 air inlets

Figure G.5 — Pipe grill radiator

Dimensions in millimetres



2x2 convective chimneys height 878 mm

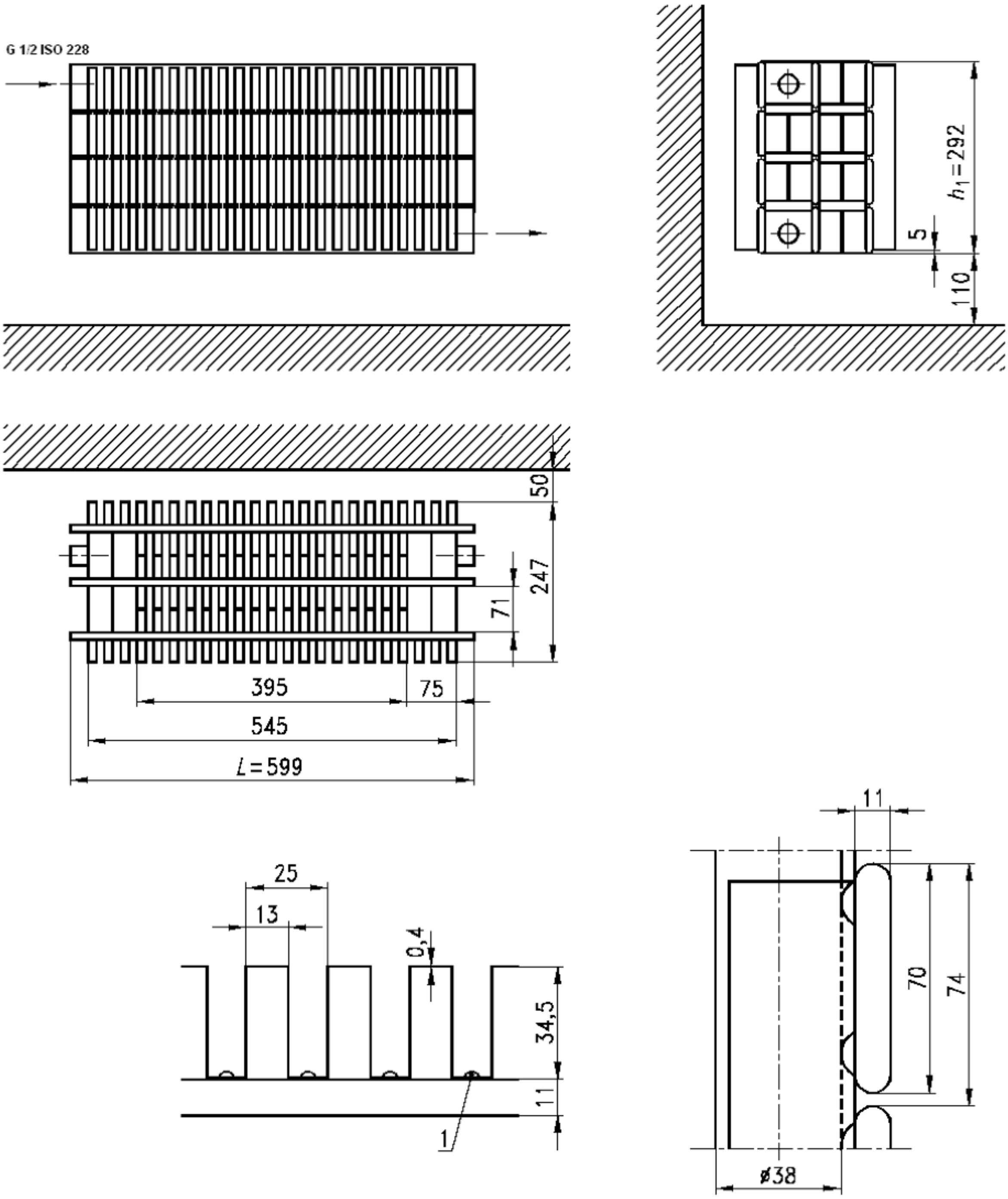
2x29 convective chimneys height 960 mm

Key

1 welding spots

Figure G.6 — Double panels radiator with convective fins

Dimensions in millimetres



4x16 convective chimneys height 4x60 mm

2x22 convective chimneys height 282 mm

Key

1 3 welding spots per tube

Figure G.7 — Flat tubes radiator with convective fins

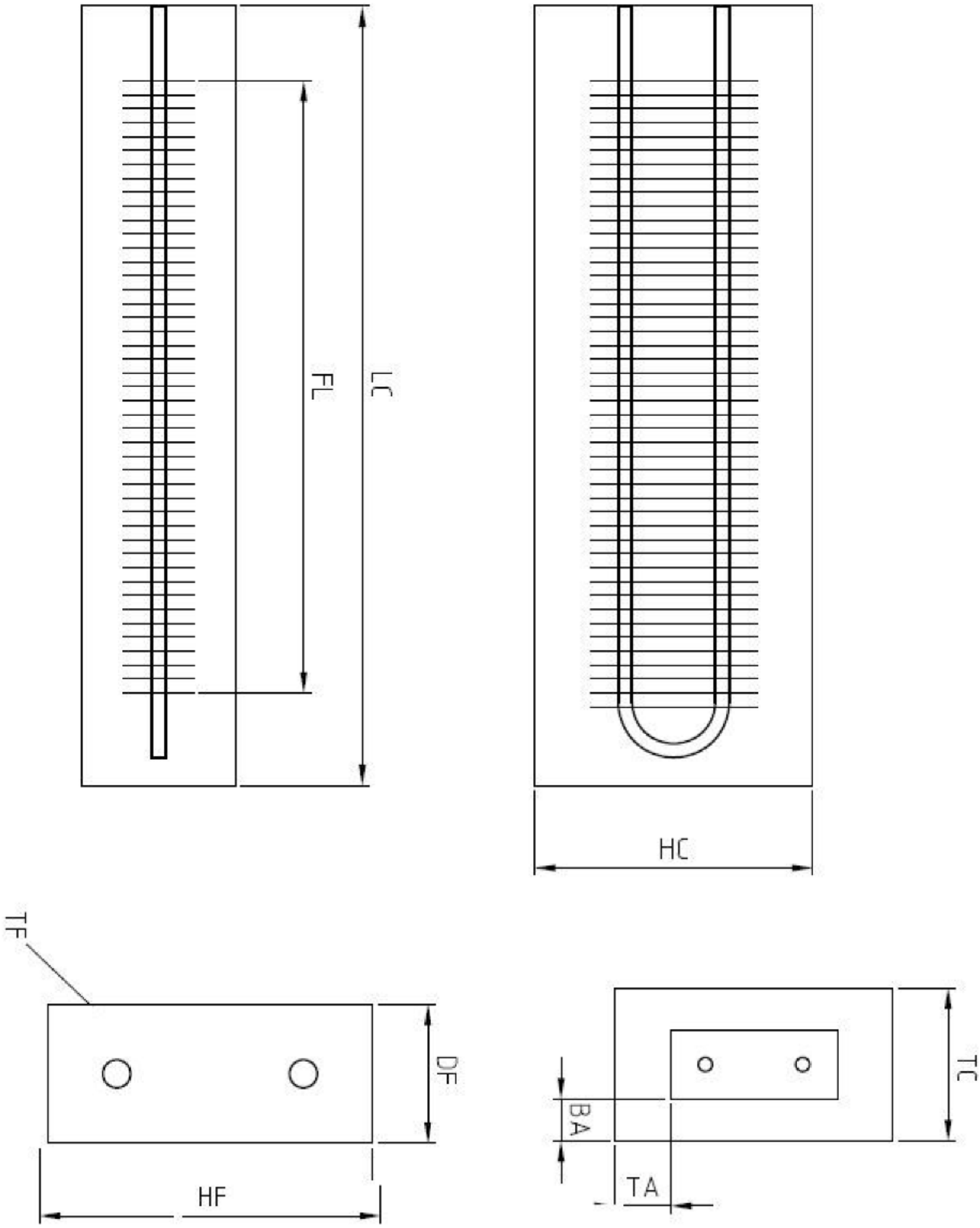
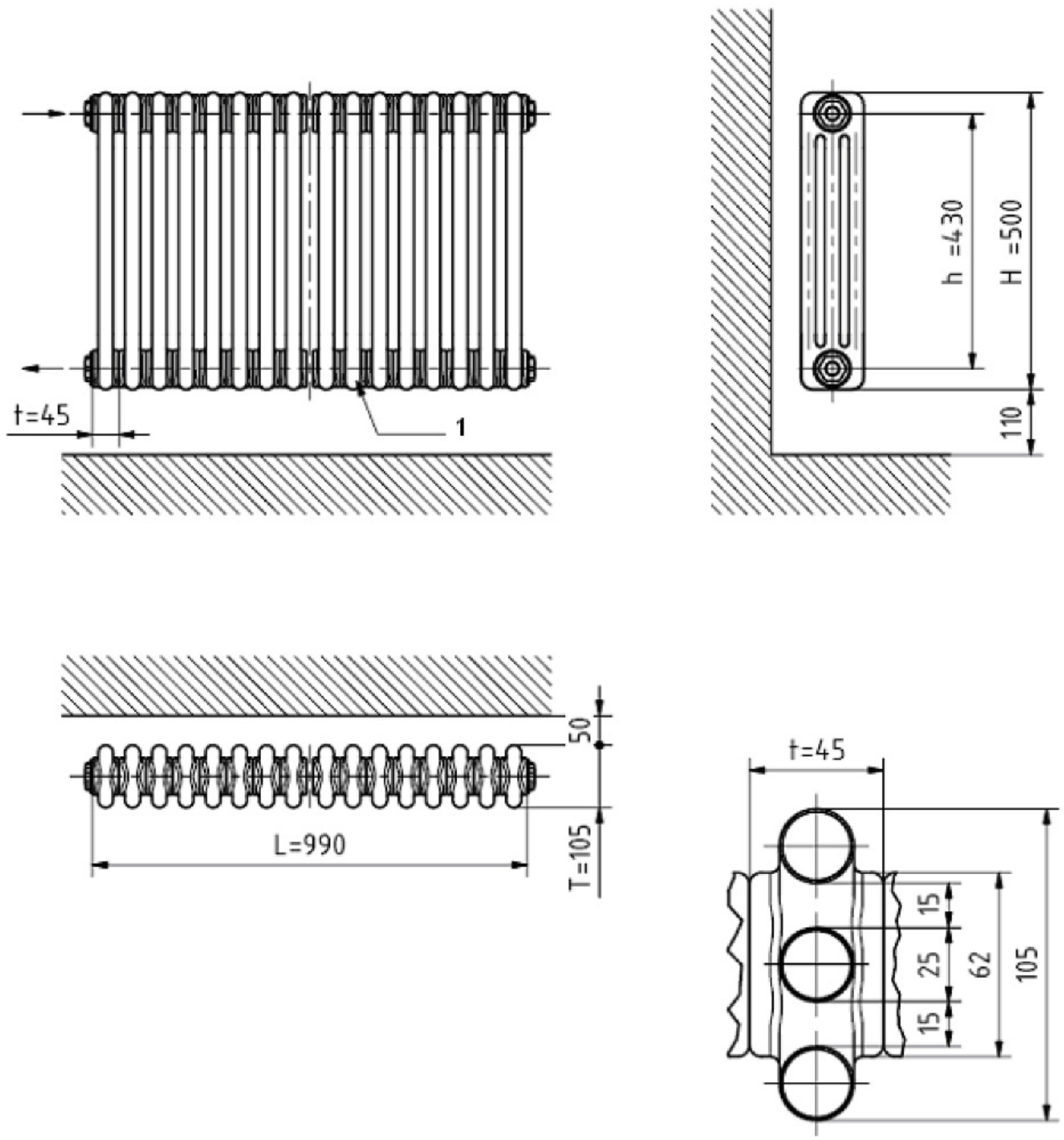


Figure G.8 — Finned tube convector

Dimensions in millimetres



Key

1 22 columns

Figure G.9 — Multi column radiator

Annex H
(normative)

Determination of the Φ_M values of the master radiators primary set

This annex contains the Φ_M reference values of a primary set of master radiators complying with this European Standard as indicated in Table H.1. These Φ_M values have been determined by a circuit of test installations as specified in 5.2.4.1.

The test installations forming the circuit comply with EN ISO/IEC 17025, accredited by a National Standards Body.

The Φ_M reference values contained in the following table are the mean values calculated from the values obtained by each reference test installation.

Table H.1 — Φ_M reference values of a primary set of master radiators

Master radiator N°	Relevant figure in the Standard	Φ_M reference value
Master radiator N. 1 – Single panel	Figure 6	788 W
Master radiator N. 2 – Single column	Figure 7	1 272 W
Master radiator N. 3 – Double column	Figure 8	2 292 W

Annex I
(normative)

Traceability of the thermal output measurement of radiators and convectors

I.1 General

Annex H contains the Φ_M reference values of a primary set of master radiators complying with this European Standard. As specified in 5.2.3, these reference values have been determined in a circuit formed by a group of laboratories2) having completed a test installation complying with requirements of this standard as detailed in 5.2.4.2.1. Laboratories shall be considered working to the specific requirements of this standard when they demonstrate their conformity to this standard and the traceability of the outputs achieved using their master radiators in comparison with the reference standard output Φ_M of each radiator of the primary master radiator, detailed within Annex H.

This annex specifies the procedure with which the reference and approved test installations shall both verify and demonstrate their conformity to this standard and the calibration of the system. The procedure specified in this European Standard concerns the initial assessment as well as the maintenance of the traceability of the measurements for reference and approved test installations.

I.2 Thermal output traceability

I.2.1 Reference test installations

All reference test installations shall produce repeatability and reproducibility data in accordance with 5.2.4.2.1.

Verification to the primary set of master radiators shall be undertaken within a maximum period of 24 months. All the test data which is obtained shall be made available for inspection by any of the national standards or accreditation bodies.

All reference test installations shall be nominated by their national standards body. These laboratories shall fulfil all the requirements of this European Standard specifically those construction requirements contained in 5.2.2 and the verification of test installation repeatability and reproducibility requirements contained in 5.2.4.2.1. Failure to comply with any of the requirements contained in the standards precludes recognition as a reference test installation.

It is the duty of all reference test installations to maintain and circulate the primary set of master radiators.

---

2) The laboratories that have determined the reference values of Φ_M stated in Annex H are:

- BSRIA (UK)	Reference Laboratory	United Kingdom;
- CETIAT (FR)	Reference Laboratory	France;
- LHR/FGHLK (D) *	Reference Laboratory	Germany;
- MRT (I)	Reference Laboratory	Italy.

Additionally within the project SMT - CT97-2127, LGAI (E) (at present APPLUS) Reference Laboratory Spain confirmed the determined values.

* At present LHR/FGHLK shall be read as IGE/HLK.

I.2.2 Approved test installations

The traceability of thermal output measurements for approved test installations is maintained through the verification of the repeatability and reproducibility tolerances as described in 5.2.4.3.3 and 5.2.4.3.4. using master radiators or other radiators.

The verification of the repeatability tolerance shall be made within a maximum period of 24 months using radiators from a reference test installation. All reproducibility tests shall be undersigned by the reference laboratory.

All approved test installations which apply for third party accreditation for testing according to this European Standard shall demonstrate traceability of measurements through a reference test installation.

I.3 Handling of the Master radiator sets

All master radiators shall be securely packaged to prevent damage, and shall be stored in a dry location.

In the event of damage to any master this shall be segregated to prevent use.

Annex J
(normative)

Calibration Procedure

J.1 General

Every Laboratory shall take part in a round robin test **every two years**. This test shall be performed by all Laboratories after verifications specified in 5.2.4.2.

For the calibration purpose it is recognized that the SG03-WG1, group of Notified Bodies, registered on Nando WEB site exists. The Leader of the Group is appointed by the CPR technical sector.

J.2 RRT Organizational course

The SG03 WG1 shall select the design (panel radiator, aluminium, etc.) of the sample radiator for the next test taking in account possible advice from laboratories.

The sample shall be selected by the **SG03 WG1** and checked at the beginning and at the end of the RRT.

The test sample shall be unknown to all participants in the RRT.

The **SG03 WG1** shall prepare the time schedule for the complete procedure and present its draft during a kick off meeting, taking in account that:

— each laboratory shall be informed of the date for its next test at least 3 weeks in advance,

— each participating laboratory shall have two working days available to perform the test.

The costs of the test and of transportation of the test sample to the next Laboratory shall be taken by the tested Laboratory.

If for any reason a participant cannot maintain the scheduling, he will inform the **SG03 WG1** which will provide for sending immediately the sample to be tested to the next participant included in the scheduling list.

The participant which cannot respect the scheduled time, could re-enter in this RRT scheme at the end, and all costs for shipping the sample will be again on its charge.

Laboratory which fails for the second time to perform scheduled test, will be deleted for one year from the Calibrated Laboratories List.

On decision and by nomination of **SG03 WG1** an expert can attend the tests for the Laboratories which participate for the first time at the RRT, the costs will be on charge of Laboratory.

Every Reference Laboratory (Annex I) at the same time as the RRT, will check itself using also the Primary Master Radiators (PMRs). The compliance of test results with Annex H and Annex I tables ensure the calibration of the reference Laboratory.

If one Reference Laboratory fall outside tolerance in RRT, it shall retest the unknown sample and also one PMR second set, in presence of an expert; if the laboratory overcome the failure, it shall motivate the reason of the previous deviation.

In addition, all costs arising from the performance of the test on its test installation and from transportation of the test sample/s to the next address, shall be covered by the tested Reference Laboratory.

Relative costs for the travel and accommodation of expert will be invoiced to the Laboratory which fails the test.

Test results of PMRs will be submitted to **SG03 WG1.**

J.3 Test procedure and submission of results

The test result shall be established by one single test.

The filled in check-list together with the test results, i.e. measured thermal output and characteristic equation, shall be submitted to **SG03 WG1** immediately after finishing the test.

J.4 Test analysis and assessment

The reference value for comparison of test results shall be the **calculated mean value** according to the form below (see ISO 16269-7):

——————————————————————————Procedure——————————————

Preliminary operation:

Arrange the observations into ascending order, X_1, X_2, X_3, …, X_n

Information required:

Sample size *n* = . . .: Select case: **a)** Sample size is odd; **b)** Sample size is even

Initial calculation required:

If case = **a)** then m = (n+1)/2 *m* = …

If case = **b)** then m = n/2 *m* = …

Calculation of the sample median, X:

If case = **a)** then X is equal to the m^th^ smallest (or largest) observation, i.e. $X = X_m$

If case = **b)** then X is equal to the arithmetic mean of the m^th^ and (m+1)^th^ smallest (or largest) observation

i.e. $X = (X_m + X_{m+1})/2$

Result:

The sample median (estimate of population median) is X = …

——

This procedure shall be iterated removing one at time the outliers value until the remaining are within ± 1,0 %.

NOTE The value considered in the above evaluation for the Laboratory having in charge RRT, is the arithmetic average between the value of the first test (initial test) and the result of the last scheduled test (final control test), premised that the difference between the two results is within ± 1,0 %.

If one laboratory presents a test result exceeding the admissible deviation of ± 1 % it shall submit to the following conditions:

a) the reason for the arisen deviation shall be identified,

b) the period during which the deviation could have arisen shall be unambiguously identified,

c) measures shall be taken to avoid such deviations in future,

d) by means of appropriate controls it shall be realized that the taken measures are meeting the purpose,

e) the carrying out and the results of above mentioned steps shall be recorded and submitted to the **SG03 WG1** for examination.

In case of a slight exceeding of a test result **SG03 WG1** shall hear the responsible of Notified Body and shall decide how to proceed in this case.

The Notified Body shall reserve the right to induce verification tests for those test report that are based on measurements established within the period according to b).

In any other case of exceeding of the admissible deviation the following additional measures are recommended to the responsible Notified Body:

f) the approval granted by the Notified Body shall be suspended until the success of taken correcting measures can be proved,

g) test reports delivered starting from the last periodic verification of test installation shall be withdrawn,

h) in agreement with the Approving Certifying Body, **SG03 WG1** will propose to re-start a RRT for the Laboratories outside tolerance. The new test shall be witnessed by an expert designed by **SG03 WG1**. All costs relative to the travel of the expert shall be paid in advance directly to expert by the Laboratory concerned.

Annex K
(normative)

Pretreatment and paint testing method

Scope of this test is to demonstrate the absence of surface corrosion after 100 h humidity exposure.

The test shall be carried out in a chamber in which the air temperature and humidity shall be controlled.

A sample of radiator belonging to each family shall be tested. The sample of radiator shall be empty.

The relative humidity shall be cycled within 60 % and 100 %, to obtain condensation on the surface of the sample of radiator. The period of the cycle shall last one hour.

The temperature of the air shall cycle around the average value of 45 °C.

After test, through a visual inspection, there shall be no evidence of damage to the surface coating, like blistering, spots, rust staining and change of colour.

If preferred by the manufacturer, a salt fog test of a minimum duration of 100 h shall be considered an acceptable alternative to the above described method.

Bibliography

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[2] EN ISO 228 (all parts), *Pipe threads where pressure-tight joints are not made on the threads*

[3] ISO 31-4, *Quantities and units — Part 4: Heat*

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