

# **Heat exchangers — Water-to-water heat exchangers for district heating — Test procedures for establishing the performance data**

The European Standard EN 1148:1998 has the status of a  
British Standard

ICS 91.140.10

# National foreword

This British Standard is the English language version of EN 1148:1998. It supersedes DD ENV 1148:1994, which is withdrawn.

The UK participation in its preparation was entrusted to Technical Committee RHE/30, Heat exchangers, which has the responsibility to:

- aid enquirers to understand the text;
- present to the responsible European committee any enquiries on the interpretation, or proposals for change, and keep the UK interests informed;
- monitor related international and European developments and promulgate them in the UK.

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## Summary of pages

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English version

## Heat exchangers — Water-to-water heat exchangers for district heating — Test procedures for establishing the performance data

Echangeurs thermiques — Echangeurs eau/eau pour chauffage urbain — Procédures d'essai pour la détermination des performances

Wärmeaustauscher — Wasser/Wasser-Wärmeaustauscher für Fernheizung — Prüfverfahren zur Feststellung der Leistungsdaten

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**CEN**

European Committee for Standardization  
Comité Européen de Normalisation  
Europäisches Komitee für Normung

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Foreword

This European Standard has been prepared by Technical Committee CEN/TC 110, Heat exchangers, the Secretariat of which is held by BSI.

This European Standard supersedes ENV 1148:1993.

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of an identical text or by endorsement, at the latest by March 1999, and conflicting national standards shall be withdrawn at the latest by March 1999.

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## Introduction

This European Standard is part of a series of European Standards dedicated to heat exchangers. It has been drawn up by CEN/TC 110.

## 1 Scope

This standard applies to series-produced water-to-water heat exchangers for district heating appliances, and its purpose is to establish uniform methods to test and ascertain the following:

- product identification;
- performance characteristics;
- pressure drop.

This European Standard does not cover technical safety aspects.

## 2 Normative references

This European Standard incorporates by dated or undated reference, provisions from other publications. These normative references are cited at the appropriate places in the text and the publications are listed hereafter. For dated references, subsequent amendments to or revisions of any of these publications apply to this European Standard only when incorporated in it by amendment or revision. For undated references, the latest edition of the publication referred to applies.

EN 306:1997, *Heat exchangers — Methods of measuring the parameters necessary for establishing the performance*.

EN 45001, *General criteria for the operation of testing laboratories*.

## 3 Definitions

For the purposes of this standard, the following definitions apply.

### 3.1

#### classification

series-produced water-to-water heat exchangers for district heating of the following types:

- a) shell and tube heat exchangers;
- b) plate heat exchangers

### 3.2

#### district heating heat exchanger

heat exchanger transferring heat energy from a district heating network to a radiator network, domestic warm water system, ventilation system or to some special applications

In the following text, the term “heat exchanger” is used.

### 3.3

#### shell and tube type

heat exchanger consisting of a shell with a tube arrangement inside the shell

### 3.4

#### plate type

heat exchanger consisting of parallel plates separating the two fluids

### 3.5 Water flow

#### 3.5.1

##### primary water flow

water flow through the heat exchanger with the higher inlet temperature

#### 3.5.2

##### secondary water flow

water flow through the heat exchanger with the lower inlet temperature

### 3.6

#### capacity

product of the water mass flow rate and the difference between the specific enthalpies at the inlet and outlet connections

### 3.7 Temperatures

NOTE All temperatures are average values ascertained over a certain period of time.

#### 3.7.1

##### water inlet temperature

temperature of the water at the inlet connection, taking into consideration the inlet water velocities

#### 3.7.2

##### water outlet temperature

temperature of the water at the outlet connection, taking into consideration the outlet water velocities

### 3.8 Types of test

#### 3.8.1

##### type testing

testing of a generic type of heat exchanger for specified duty at a selected range of operating conditions

NOTE Type testing is usually carried out for series- or mass-produced heat exchangers in the laboratory.

#### 3.8.2

##### acceptance testing

testing of a specific heat exchanger, at the appropriate operating conditions

#### 3.8.3

##### performance testing

testing of heat exchangers, usually carried out in situ

NOTE It can be similar to acceptance testing when detailed thermal hydraulic performance data is required.

4 Symbols

For the purposes of this European Standard the following apply.

4.1 Letters

$A$	heat transfer surface	$m^2$
$c_p$	specific heat capacity	$kJ/(kg \cdot K)$
$F$	correction factor for LMTD	—
$h$	specific enthalpy	$kJ/kg$
$k$	overall heat transfer coefficient	$W/(m^2 \cdot K)$
LMTD	logarithmic mean temperature difference	K
$p$	pressure	Pa
$P$	capacity	kW
$q_v$	volume flow rate	$m^3/s$
$q_m$	mass flow rate	$kg/s$
$\rho$	density	$kg/m^3$
$T$	absolute temperature	K
$t$	temperature	$^{\circ}C$
$\Delta t$	temperature difference	K

4.2 Subscripts

1	primary side (cooled flow)
2	secondary side (heated flow)
11	inlet conditions on primary side
12	outlet conditions on primary side
21	inlet conditions on secondary side
22	outlet conditions on secondary side
av	average
m	mass
max	maximum
min	minimum
v	volume

4.3 Special characters

(...')	measured value or value calculated from measurements
(...)	value calculated from the manufacturer's formula

5 Manufacturer's data

The manufacturer or supplier shall supply the test house with the following minimum information for every heat exchanger, to identify the heat exchanger and allow its traceability:

- a) manufacturer (name and address);
- b) type (designation);
- c) manufacturing number and year;
- d) internal volumes (primary and secondary);
- e) installation instructions;
- f) materials;
- g) nominal capacity at clean heat exchanger surface (inlet and outlet temperatures, mass flows, pressure drops and capacity).

The data shall be supplied to the test house before the test is started.

6 Performance conditions

6.1 Temperature ranges of European district heating companies

The operating temperatures of the district heating companies are classified into three groups. They mainly comprise the operating ranges of the heat exchangers for heating and domestic hot water.

6.2 Test conditions

The temperature ranges in Table 1 serve as a guide for the temperature programs. The manufacturer shall indicate the temperature ranges along with a specification of the cases of application.

Table 1 — Temperature ranges

Values in degrees Celsius			
Temperature	Range 1 Heating	Range 2 Heating	Range 3 Domestic warm water
$t_{11}$	110 to 190	65 to 130	65 to 130
$t_{12}$	70 to 120	30 to 80	15 to 35
$t_{21}$	40 to 70	25 to 70	5 to 15
$t_{22}$	80 to 90	30 to 90	50 to 60

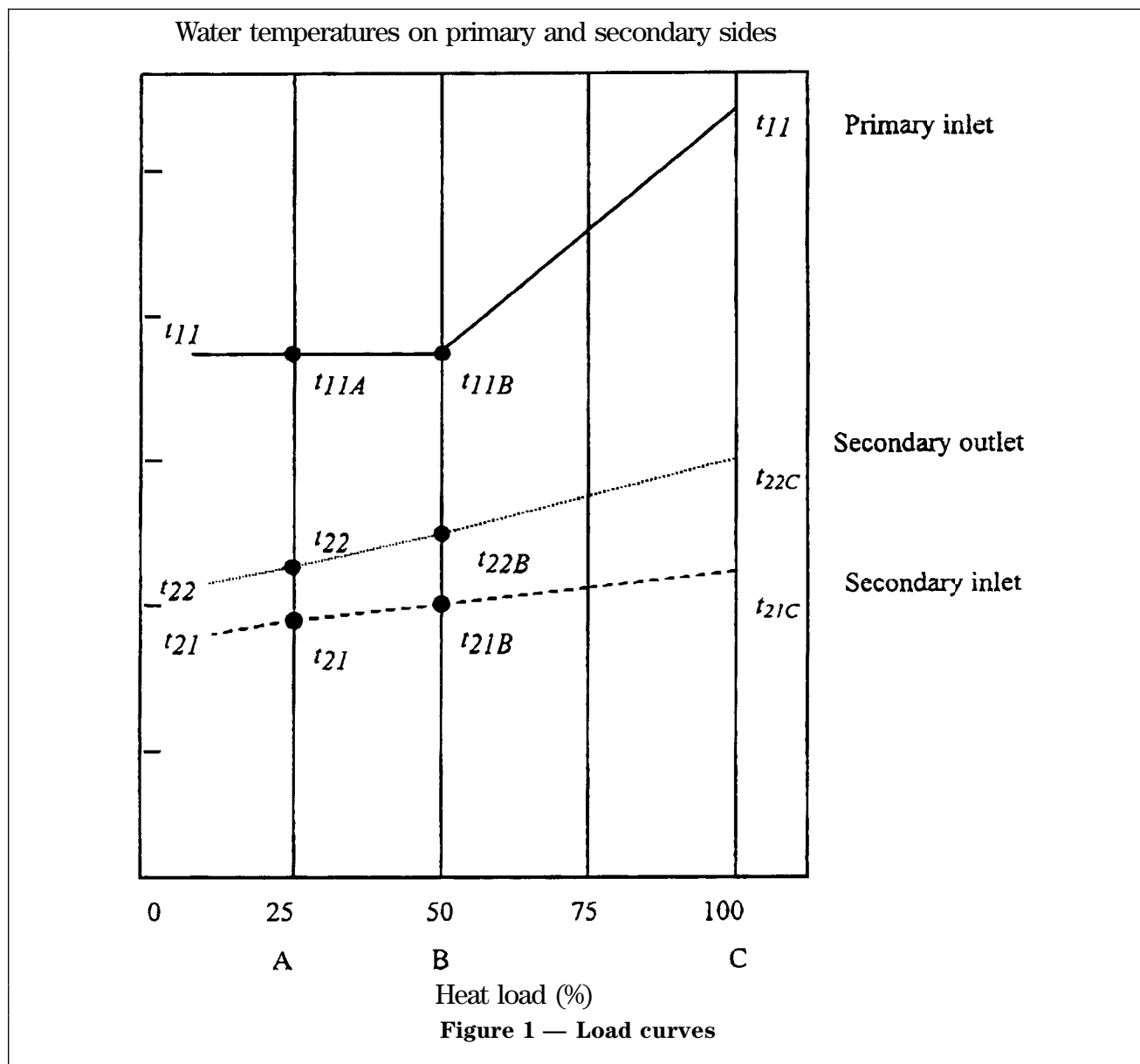
a) Heat exchanger for room heating

The heat exchanger shall as a minimum be tested at three different heat loads and at two different mass flows on the secondary side. That means six different points as a minimum for a complete test of range 1 and range 2 respectively.

The three different heat loads shall be chosen from a heat load curve related to the outdoor temperature (see example in Figure 1). Mass flows on the secondary side are 100 % and 50 % of the design value. Test points are shown in Table 2.

Table 2 — Test point specification

Point number	Primary inlet	Secondary inlet	Secondary outlet	Mass flow %
1	$t_{11A}$	$t_{21A}$	$t_{22A}$	100
2	$t_{11B}$	$t_{21B}$	$t_{22B}$	100
3	$t_{11C}$	$t_{21C}$	$t_{22C}$	100
4	$t_{11A}$	$t_{21A}$	$t_{22A}$	50
5	$t_{11B}$	$t_{21B}$	$t_{22B}$	50
6	$t_{11C}$	$t_{21C}$	$t_{22C}$	50



b) *Heat exchanger for domestic hot water*

The heat exchanger shall as a minimum be tested at three different heat loads and with two different primary inlet temperatures. That means six different points as a minimum for a complete test of range 3 in Table 1.

The three different capacities shall be calculated from the flows on the secondary side (100 %, 50 % and 25 % of nominal flow  $q_2$ ). Secondary side temperature values  $t_{21}$  and  $t_{22}$  are taken from range 3 in Table 1. These temperatures shall be constant during the whole test period.

The first test shall be conducted with the lowest primary inlet temperature according to Figure 1. The second test shall be conducted with an inlet temperature at least 20 K higher than the first test.

Test points are shown in Table 3.

Table 3 — Test point specification

Point number	Primary inlet	Secondary inlet	Secondary outlet	Mass flow %
1	$t_{11A}$	$t_{21}$	$t_{22}$	100
2	$t_{11A}$	$t_{21}$	$t_{22}$	50
3	$t_{11A}$	$t_{21}$	$t_{22}$	25
4	$\geq t_{11A} + 20 \text{ K}$	$t_{21}$	$t_{22}$	100
5	$\geq t_{11A} + 20 \text{ K}$	$t_{21}$	$t_{22}$	50
6	$\geq t_{11A} + 20 \text{ K}$	$t_{21}$	$t_{22}$	25

7
Measurements

7.1
Uncertainty of measurements

The permissible uncertainty for various measurements is given in Table 4.

Table 4 — Uncertainty of measurements

Measurements	Uncertainty of measurements
Temperature	Above 100 °C ± 0,15 K Up to 100 °C ± 0,1 K
Flow rate	±2 % of the reading
Pressure	±10 kPa
Pressure drop	±1,0 % of the reading, or 2 kPa (the higher value applies)

7.2
Measurement criteria

7.2.1
General

Methods of measuring the parameters necessary for establishing the performance are described in EN 306.

7.2.2
Temperature measuring points

a) Method A

When the temperature is measured on the outside of the connecting pipe, it shall be measured at two opposite points of the same cross-section and, if the pipe is horizontal, there shall be one point above and one below.

The pipe shall be insulated on each side of the temperature measuring point for a length of at least 10 times its outside diameter. It shall be ensured that good thermal contact exists between the sensor and the pipe at the measuring point.

This method is only applicable if the active temperature difference is small and the internal heat transfer is much better than the external one.

b) Method B

When the temperature is measured by a sensor immersed into the pipe, care shall be taken that temperature stratifications and flow patterns do not influence the accuracy of the measurements.

7.2.3
Pressure measuring points

The pressure measuring points shall be located in the middle of a straight part of pipe of constant diameter, equal to that of the heat exchanger connections, having a length of not less than 10 times its diameter, ensuring that there is no restriction involved. They shall be placed between the temperature measuring points and the connections of the heat exchanger.

7.2.4
Flow rate

The flow rates shall be measured according to the recommendations of the installation instructions for the flow measuring devices.

8
Testing method

8.1
General

In order to fulfil the requirements of this standard, the capacity shall be determined simultaneously on both the primary and secondary sides of the heat exchanger and both results shall agree to within 3 %. The test capacity shall be the average of the two measured capacities.

8.2
Principle

The principle of the methods is to measure the water flow rate and to multiply it by the difference between the specific enthalpies at the water inlet and outlet connections.

The specific enthalpy difference of the water shall be determined from the temperature measurements and physical properties of the water.

9
Testing procedures

9.1
Conducting the test

9.1.1 After achieving steady-state conditions, test data shall be taken for a minimum of 300 s. The measuring data, particularly the temperatures, shall be measured and recorded at the same time. Steady-state conditions are assumed to exist when all changes and periodic fluctuations of individual temperatures remain within ±0,5 K of their average and mass flows remain within ±1,5 % of their average.

9.1.2 The sampling frequency or the time between two consecutive readings shall be sufficient for the medium around transducers and measurement outputs to have been replaced. The sampling frequency shall also be high enough to identify all significant fluctuations.

9.1.3 Flows and temperatures shall be held constant throughout the duration of the test, to minimize errors associated with sensor response time and to allow the heat exchanger time to reach equilibrium conditions.

9.1.4 The following data shall be recorded:

$$t'_{11}, t'_{12}, t'_{21}, t'_{22}, q'_{m1}, q'_{m2}, \Delta p'_{1}, \Delta p'_{2}$$

9.2
Application of test results

The application of test results will depend on the purpose of the test and is therefore classified according to one of the following three categories:

- I) type testing of new heat exchangers;
- II) acceptance testing of new heat exchangers;
- III) performance testing of heat exchangers in use.



### 9.2.1 Type testing

NOTE The type testing of a heat exchanger in a testing laboratory serves as a practical proof for the accuracy of the manufacturer's data, which can be used for the calculation of the performance within certain mass flows and temperature ranges.

Type testing can be used for a single heat exchanger as well as for a range of products. When applied to a range of products, type tests are only considered as valid for capacities between 50 % and 200 % of the test unit capacity. The material and geometry shall be the same throughout the range.

#### EXAMPLE

Shell and tube heat exchangers:

tube diameter, arrangement of the tubes, form and arrangement of baffles, hydraulic diameter, number of passes, flow geometry, types of tube

Plate heat exchanger:

heat transfer area/plate, plate gap, flow angle, etc.

For the remaining heat exchanger types, the geometries shall be determined accordingly.

### 9.2.2 Acceptance testing

Acceptance testing can be carried out for both mass-produced or specially built heat exchangers. It can be carried out either in the laboratory or in situ. The acceptance testing can be done according to type testing.

### 9.2.3 Performance testing

The performance testing can be carried out in accordance with type testing but at current operating conditions. It may also consist of simple monitoring activities to determine the general behaviour of the unit.

## 10 Capacity calculation

### 10.1 General

The capacity shall be calculated in accordance with the equations of the manufacturer for certain operating temperatures and mass flows. The validity of the equations shall be checked by the type test.

### 10.2 Calculated parameters

From the measured parameters the following are calculated:

$t'_{av1}$ ,  $t'_{av2}$ ,  $LMTD'$ ,  $\rho$ ,  $c_p$ ,  $P'$ ,  $(k \times A)'$  and  $k'$ :

$$t'_{av1} = \frac{t'_{11} + t'_{12}}{2}$$

$$t'_{av2} = \frac{t'_{21} + t'_{22}}{2}$$

For counterflow arrangement:

$$LMTD' = \frac{(t'_{11} - t'_{22}) - (t'_{12} - t'_{21})}{\ln \frac{(t'_{11} - t'_{22})}{(t'_{12} - t'_{21})}}$$

if  $(t'_{11} - t'_{22}) \neq (t'_{12} - t'_{21})$ ;

$$LMTD' = (t'_{11} - t'_{22}) \text{ or } (t'_{12} - t'_{21})$$

if  $(t'_{11} - t'_{22}) = (t'_{12} - t'_{21})$ .

For parallel flow arrangement:

$$LMTD' = \frac{(t'_{11} - t'_{21}) - (t'_{12} - t'_{22})}{\ln \frac{(t'_{11} - t'_{21})}{(t'_{12} - t'_{22})}}$$

The fluid property  $c_p$  shall be chosen in accordance with the calculated mean temperatures  $t'_{av1}$  and  $t'_{av2}$ .

The fluid property  $\rho$ , used to calculate the mass flow rate, shall be chosen in accordance with the actual temperature at the flowmeter, usually the outlet temperature  $t'_{12}$  and  $t'_{22}$ .

$$P' = \frac{q'_{1m} \times c_{p1} \times \Delta t'_{11} + q'_{2m} \times c_{p2} \times \Delta t'_{22}}{2}$$

where

$$\Delta t'_{11} = t'_{11} - t'_{12}$$

$$\Delta t'_{22} = t'_{22} - t'_{21}$$

$$q'_{1m} = q'_{1v} \times \rho_1$$

$$q'_{2m} = q'_{2v} \times \rho_2$$

The uncertainties of the measurements shall be observed and announced in the measured parameters  $\Delta p'_{12}$  and the calculated parameters  $LMTD'$  and  $P'$ .

The results shall be presented as  $\Delta p'_{11}$ ,  $\Delta p'_{22}$  and  $P'$  with the associated uncertainty respectively.

The expected pressure losses  $\Delta \bar{p}_1$  and  $\Delta \bar{p}_2$  are calculated from the manufacturer's formula and data, using the measured flows  $q_{m1}$  and  $q_{m2}$ .

With the calculated overall heat transfer coefficient  $\bar{k}$ , regarding the known heat surface, the heat power  $P$  shall be calculated and compared with  $P'$ .

$$\bar{P} = \bar{k} \times \bar{A} \times LMTD'$$

### 10.3 Manufacturer's calculations

The manufacturer is given the calculated parameters  $q'_{1m}$  and  $q'_{2m}$ ,  $t'_{av1}$  and  $t'_{av2}$ . The manufacturer calculates the value of  $(\bar{k} \times \bar{A})$  or calculates the value of the heat transfer coefficient  $\bar{k}$  and states the known heat surface  $A$ .

#### 10.4 Testing laboratory's calculation

With the calculated value of  $(\bar{k} \times \bar{A})$  or  $\bar{k} \times A$ , the heat power  $\bar{P}$  can be calculated at the final evaluation as:

$$\bar{P} = (\bar{k} \times \bar{A}) \times \text{LMTD}' \text{ or}$$
$$\bar{P} = \bar{k} \times A \times \text{LMTD}'$$

The expected pressure losses  $\Delta \bar{p}_1$  and  $\Delta \bar{p}_2$  are calculated by the manufacturer, using the measured parameters  $q'_{m1}$  and  $q'_{m2}$  and calculated parameters  $t'_{av1}$  and  $t'_{av2}$ .

The uncertainties of the measurements shall be observed and announced with the calculated parameters  $\Delta \bar{p}_1$ ,  $\Delta \bar{p}_2$  and  $\bar{P}$ .

#### 10.5 Acceptance limits

The manufacturer's data and the calculated programs shall be accepted if the measured parameters meet the calculated parameters in every test point within the following range:

$$P' \geq 0,97 \bar{P}$$
$$\Delta p'_1 \leq 1,05 \Delta \bar{p}_1$$
$$\Delta p'_2 \leq 1,05 \Delta \bar{p}_2$$

#### 11 Test report

The test report shall be in accordance with EN 45001.

Diagrams and tables regarding the process of the measuring data or the parameters shall be enclosed in the test report.

The inaccuracy estimation shall include a discussion of crude errors, systematic errors and statistical errors.

The comparing of  $P'$  and  $\bar{P}$  shall be presented in explicit values and in a graphic form.

## **Annex A (informative)**

### **Bibliography**

EN 247, *Heat exchangers — Terminology.*

EN 305, *Heat exchangers — Definitions of performance of heat exchangers and the general test procedure for establishing performance of all heat exchangers.*

EN 307, *Heat exchangers — Guidelines to prepare installation, operating and maintenance instructions required to maintain the performance of each type of heat exchanger.*

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