**SLOVENSKI STANDARD**
**SIST EN 1118:1999**

**01-december-1999**

---

**Prenosniki toplote ï Hladilniki tekoļ in, hlajeni s hladivom ï Postopki preskuġanja za ugotavljanje tehniļ nih karakteristik**

Heat exchangers - Refrigerant cooled liquid coolers - Test procedures for establishing the performance

Wärmeaustauscher - Kältemittelgekühlte Flüssigkeitskühler - Prüfverfahren zur Leistungsfeststellung



Echangeurs thermiques - Refroidisseurs de liquides - Procédures d'essai pour la détermination de la performance



**Ta slovenski standard je istoveten z:** **EN 1118:1998**

---

**ICS:**

| | | |
|---|---|---|
| 27.060.30 | Grelniki vode in prenosniki toplote | Boilers and heat exchangers |
| 27.200 | Hladilna tehnologija | Refrigerating technology |

**SIST EN 1118:1999** **en**

# EUROPEAN STANDARD
# NORME EUROPÉENNE
# EUROPÄISCHE NORM

**EN 1118**

December 1998

ICS 27.060.30; 27.200

Supersedes ENV 1118:1993

Descriptors: heat exchangers, coolers, liquids, definitions, classifications, calorific power, tests, measurements, characteristics, installations, computation

English version

## Heat exchangers - Refrigerant cooled liquid coolers - Test procedures for establishing the performance

Echangeurs thermiques - Refroidisseurs de liquides - Procédures d'essai pour la détermination de la performance

Wärmeaustauscher - Kältemittelgekühlte Flüssigkeitskühler - Prüfverfahren zur Leistungsfeststellung

This European Standard was approved by CEN on 27 November 1998.

CEN members are bound to comply with the CEN/CENELEC Internal Regulations which stipulate the conditions for giving this European Standard the status of a national standard without any alteration. Up-to-date lists and bibliographical references concerning such national standards may be obtained on application to the Central Secretariat or to any CEN member.



This European Standard exists in three official versions (English, French, German). A version in any other language made by translation under the responsibility of a CEN member into its own language and notified to the Central Secretariat has the same status as the official versions.

CEN members are the national standards bodies of Austria, Belgium, Czech Republic, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Luxembourg, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland and United Kingdom.



EUROPEAN COMMITTEE FOR STANDARDIZATION
COMITÉ EUROPÉEN DE NORMALISATION
EUROPÄISCHES KOMITEE FÜR NORMUNG

**Central Secretariat: rue de Stassart, 36 B-1050 Brussels**



Ref. No. EN 1118:1998 E

## Contents

## 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 replaces ENV 1118:1993.

The document was implemented previously as a ENV 1118 in 1993 and no technical changes have been made.

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 1999, and conflicting national standards shall be withdrawn at the latest by June 1999.

According to the CEN/CENELEC Internal Regulations, the national standards organizations of the following countries are bound to implement this European Standard: Austria, Belgium, Czech Republic, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Luxembourg, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland and the United Kingdom.

## Introduction

This European standard is one of a series of European Standards dedicated to heat exchangers.

## 1 Scope

**1.1** This European Standard applies to series produced liquid coolers which operate with a (primary) refrigerant and its purpose is to establish uniform methods to test and ascertain the following:

- Product identification
- Capacity
- Liquid flow rate
- Liquid side pressure drop

This Standard does not cover technical safety aspects.

**1.2** This standard deals with the following types of series produced liquid coolers for refrigeration:



a) Shell and tube type with
   1) refrigerant in the shell
   2) refrigerant in the tube(s)



b) Co-axial type with
   1) refrigerant in the annulus
   2) refrigerant in the tube(s)

c) Plate type

## 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 45001 General criteria for the operation of testing laboratories

## 3 Definitions

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

**3.1 liquid cooler (refrigerant cooled):** Self-contained refrigeration system component transferring heat from a liquid to be cooled to an evaporating refrigerant. In annex A the liquid cooler is limited by the system boundaries for calculation purposes.

**3.2 shell and tube type:** Liquid cooler consisting of a shell with a tube arrangement inside the shell.

**3.3 co-axial type:** Liquid cooler consisting of an outer tube with one or more inner tubes, all arranged parallel to each other. The two fluids can flow either parallel or counter to each other.

**3.4 plate type:** Liquid cooler consisting of parallel plates separating the two fluids.

**3.5 working fluids**

**3.5.1** ***refrigerant (Primary):*** Working fluid in a refrigeration system, that absorbs heat by evaporation at a low temperature and rejects it by condensation at a higher temperature.



**3.5.2** ***liquid:*** Working fluid, circulated through the refrigeration system and remaining in liquid phase during the absorption or rejection of heat.



**3.6 capacity**

**3.6.1** ***capacity (liquid side):*** The cooling effect on the liquid, passing through the liquid cooler. It is defined as the product of the liquid mass flow rate and the difference between the specific enthalpies at the outlet and inlet connections of the liquid cooler.

**3.6.2** ***capacity (refrigerant side):*** The heat flow removed by the refrigerant between the inlet and the outlet connections of the system. It is defined as the product of the refrigerant mass flow rate and the difference between the specific enthalpies at the outlet and inlet connections of the liquid cooler.

**3.7 temperatures**

NOTE: All temperatures are average values ascertained over the measuring period.

**3.7.1** ***liquid inlet temperature:*** The average temperature of the liquid at the inlet connection of the liquid cooler system taking into consideration the local liquid velocities (see system boundaries in annex A).

**3.7.2** ***liquid outlet temperature:*** The average temperature of the liquid at the outlet connection of the liquid cooler system, taking into consideration the local liquid velocities (see system boundaries in annex A).

**3.7.3** ***ambient air temperature:*** Temperature of the air surrounding the liquid cooler.

**3.7.4** ***evaporating temperature:*** Saturation temperature, corresponding to the absolute pressure of the refrigerant, at the suction outlet connection of the liquid cooler system (see system boundaries in annex A).

**3.7.5** ***vapour outlet temperature:***

a) For direct expansion, flooded operation and liquid feed by gravity; the directly measured temperature of the refrigerant vapour at the suction outlet connection of the liquid cooler system (see system boundaries in annex A).

b) For liquid overfeed by pump circulation; the directly measured temperature of the refrigerant vapour at the suction outlet connection of the separator (see annex A).

**3.7.6** ***subcooled refrigerant temperature:*** Temperature of the liquid refrigerant at the inlet of the expansion device (not part of the liquid cooler).

**3.8 temperature differences**

**3.8.1** ***inlet temperature difference:*** Difference between the liquid inlet temperature and the evaporating temperature.



**3.8.2** ***superheating:*** Difference between the vapour outlet temperature and the evaporating temperature.



**3.8.3** ***subcooling:*** Difference between the saturation temperature corresponding to absolute pressure of the refrigerant at the inlet of the expansion device and the subcooled refrigerant temperature.

**3.8.4** ***liquid temperature difference:*** Difference between the liquid inlet and outlet temperatures.

**3.9 liquid pressure**

NOTE: All pressures are average values ascertained over the measuring period.

**3.9.1** ***liquid inlet pressure:*** Static pressure of the liquid at the inlet connection of the liquid cooler.

**3.9.2** ***liquid outlet pressure:*** Static pressure of the liquid at the outlet connection of the liquid cooler.

**3.10 operation**

**3.10.1** ***direct expansion operation:*** Evaporation process in which the primary refrigerant enters the liquid cooler via a direct expansion device as a liquid-vapour mixture and leaves it in superheated state (see system boundaries in annex A).

**3.10.2** ***flooded operation:*** Evaporation process in which the refrigerant flow is controlled by keeping the refrigerant liquid level in the liquid cooler constant (see system boundaries in annex A).

**3.10.3** ***operation with liquid feed by gravity:*** Evaporation process in which the refrigerant leaves the liquid cooler in partially evaporated state. The refrigerant is circulated by gravity and the difference in refrigerant density at the liquid cooler inlet and outlet. The process is accomplished in a system which consists of a liquid cooler, a low pressure separator and the connecting lines. The refrigerant flow is controlled by keeping the refrigerant liquid level in the separator constant (see system boundaries in annex A).

**3.10.4** ***operation with liquid overfeed by pump circulation:*** Evaporation process in which the refrigerant leaves the liquid cooler in partially evaporated state. The process is accomplished in a system which consists of a liquid cooler only, and is operated by a liquid pump and a separator which is a part of a refrigerating machine. The refrigerant is transported between the separator and the liquid cooler by a mechanical pump (see system boundaries in annex A).



**3.11 refrigerant enthalpies**

**3.11.1** ***refrigerant inlet specific enthalpy:*** Specific enthalpy of the refrigerant at the inlet connection of the liquid cooler system. It is defined as the specific enthalpy of the saturated liquid refrigerant at the inlet of the expansion device corresponding to the subcooled refrigerant temperature.

This also applies to liquid overfeed by pump circulation as there the refrigerant inlet enthalpy cannot be defined by temperature and pressure measurement (see annex A).

**3.11.2** ***refrigerant outlet specific enthalpy:*** Specific enthalpy of the refrigerant at the outlet connection of the liquid cooler system. It is defined as the specific enthalpy of the refrigerant corresponding to the evaporating temperature and the vapour outlet temperature.

This also applies to liquid overfeed by pump circulation as there the refrigerant outlet enthalpy cannot be defined by temperature and pressure measurement and this definition is only applicable to capacity calculations (see annex A).

**3.11.3** ***specific vaporization enthalpy:*** Enthalpy at the evaporation temperature without regard to the pressure drop across the liquid cooler system.

**3.12 refrigerant recirculation rate:** Ratio between the actual mass flow rate through the liquid cooler and the mass flow rate necessary for the total evaporation of the refrigerant. i.e. refrigerant recirculation rate $rr = \Delta h_O / \Delta h_e$

[see also F.2.]

**3.13 fouling resistance:** Thermal resistance of a layer of unwanted deposit on the heat exchanger surface reducing it's heat transfer performance.

NOTE: The fouling resistance for a clean surface is zero. Clean, in this context, means that all production residues have been removed from the heat transfer surface by the factory's cleaning process.

**3.14 set of tests:** A number of individual tests at a constant liquid flow rate and different conditions on the refrigerant side of the liquid cooler.

NOTE: A duplicate set of tests consists of two sets of tests.

## 4 Symbols

For the purposes of this European Standard the following apply

### 4.1 Letters

| | | |
|---|---|---|
| $c_pL$ | specific heat capacity of the liquid | kJ/kg/K |
| $h_{L1}$ | specific enthalpy of the liquid at the inlet connection | kJ/kg |
| $h_{L2}$ | specific enthalpy of the liquid at the outlet connection | kJ/kg |
| $h_{R1}$ | specific refrigerant inlet enthalpy | kJ/kg |
| $h_{R2}$ | specific refrigerant outlet enthalpy | kJ/kg |
| $h_{R3}$ | specific refrigerant enthalpy at the outlet connection of the liquid cooler for pump circulation | kJ/kg |
| $p_{atm}$ | atmospheric pressure | Pa |
| $p_e$ | saturation pressure corresponding to the evaporating temperature | bar |
| $p_{e1}$ | refrigerant pressure at separator outlet connection for pump circulation | bar |
| $p_{L1}$ | liquid pressure at the inlet connection | bar |
| $p_{L2}$ | liquid pressure at the outlet connection | bar |
| $p_{R1}$ | refrigerant pressure at expansion device inlet | bar |
| $P_L$ | capacity (liquid side) | kW |
| $P_R$ | capacity (refrigerant side) | kW |
| $q_L$ | liquid flow rate | |
| $q_R$ | refrigerant flow rate | |
| $q_{mRPu}$ | refrigerant mass flow through pump | kg/s |
| $RL$ | refrigerant liquid level | mm |
| $rd$ | relative deviation | - |
| $rr$ | recirculation rate | - |
| $\varrho_L$ | liquid density | kg/m$^3$ |
| $t_{amb}$ | ambient air temperature | °C |
| $t_{MR}$ | temperature of refrigerant at flow measuring point | °C |
| $t_e$ | evaporating temperature | °C |
| $t_{L1}$ | liquid inlet temperature | °C |
| $t_{L2}$ | liquid outlet temperature | °C |
| $t(p_{R1})$ | saturation temperature corresponding to $p_{R1}$ | °C |
| $t_{R1}$ | subcooled refrigerant temperature | °C |
| $t_{R2}$ | vapour outlet temperature at the liquid cooler or separator outlet connection | °C |
| $t_{R3}$ | actual temperature at liquid cooler system outlet connection (pump circulation) | °C |
| $\Delta t_{sup}$ | superheating = $t_{R2}$ - $t_e$ | K |

| | | |
|---|---|---|
| $\Delta t_1$ | inlet temperature difference = $t_{L1} - t_e$ | K |
| $\Delta t_{sub}$ | subcooling = $t(p_{R1}) - t_{R1}$ | K |
| $\Delta t_L$ | liquid temperature difference = $t_{L1} - t_{L2}$ | K |
| $\Delta h_0$ | specific vaporization enthalpy | kJ/kg |
| $\Delta h_e$ | refrigerant specific enthalpy change in the liquid cooler system | kJ/kg |
| $\Delta p_L$ | pressure drop on the liquid side = $p_{L1} - p_{L2}$ | Pa |
| $Z$ | test duration | s |

## 4.2 Subscripts

| | |
|---|---|
| *m* | mass |
| *v* | volume |
| *M* | flow meter |
| *numbers* | positions defined on the circuit diagrams in annex A |

## 4.3 Superscripts

| | |
|---|---|
| *(st)* | standard |
| *(a,b)* | identifies a *set of tests* |
| *(v,w,x)* | identifies an individual test within a *set of tests* with |

- different levels of superheating (direct expansion) or
- refrigerant levels (flooded operation, liquid feed by gravity) or
- recirculation rates (pump circulation).



# 5 Standard capacity

## 5.1 Basis for standard capacity data

The capacity of a given liquid cooler depends on:

a) the evaporating temperature;

b) the temperature differences between liquid and refrigerant;

c) the mass flows of refrigerant and liquid;

d) the way of operation e.g. refrigerant level or its state of superheating at the outlet;

e) the oil content;

f) further conditions e.g. of subcooled refrigerant temperature, rate of recirculation;

g) the type of refrigerant and liquid;

h) the fouling conditions.

Therefore the liquid cooler capacity shall be specified for specific operating conditions.

## 5.2 Standard capacity conditions

### 5.2.1 *General*

The standard capacity shall be based on tests performed on a clean liquid cooler under the conditions given in 5.2.2, 5.2.3, 5.2.4 and 5.2.5.

### 5.2.2 *Liquid*

The liquid type is *water*.

It's quality shall be such that it does not cause measurable fouling during the entire operation for establishing the test.

### 5.2.3 *For direct expansion operation*

| | |
|---|---|
| a) $t_e$ | = + 2 °C |
| b) $t_{L1}$ | = + 12 °C |
| c.1) $\Delta t_L$ | = 5 K |
| c.2) $q_{mL}$ | as specified by manufacturer, but $(\Delta t_L/\Delta t_1) \leq 0,60$ |
| d) oil content | ≤ 1 % (by mass) |
| e) $t_{R1}$ | = + 30 °C |
| f) $\Delta t_{sup}$ | = 6,5 K |



### 5.2.4 *For flooded operation and liquid overfeed by gravity*

| | |
|---|---|
| a) *te* | + 2 °C |
| b) $t_{L1}$ | +10 °C |
| c.1) $\Delta t_L$ | 5K |
| c.2) $q_{mL}$ | as specified by manufacturer, but $(\Delta t_L/\Delta t_1) \leq 0,60$ |
| d) oil content | as specified by manufacturer |
| e) $t_{R1}$ | + 30 °C |

| | |
|---|---|
| f) *RL* | as required by manufacturer |
| f.1) | in the liquid cooler for flooded operation |
| f.2) | in the low pressure separator for pump circulation operation |
| g) | the static head on the refrigerant side shall not be smaller than 1 m for liquid feed by gravity. |

**5.2.5** ***For pump circulation operation***

| | |
|---|---|
| a) $t_e$ | + 2 °C |
| b) $t_{L1}$ | +10°C |
| c.1) $\Delta t_L$ | 5K |
| c.2) $q_{mL}$ | as specified by manufacturer, but $(\Delta t_L/\Delta t_1) \leq 0{,}60$ |
| d) $t_{R1}$ | + 30 °C |
| e) oil content | as specified by manufacturer |
| f) *r r* | as specified by manufacturer but not lower than 1,3. |



## 6 Manufacturer's data

To identify the liquid cooler and allow its traceability, the manufacturer or supplier shall supply the test house with the following minimum information for every liquid cooler:

a) type;

b) capacity at standard conditions;

c) refrigerant;

d) method of operation, e.g. direct expansion or flooded operation;

e) where applicable: the influence of superheating on the capacity;

f) where applicable: the refrigerant level;

g) cooler refrigerant side, internal volume;

h) cooler liquid side, internal volume;