

Heat exchangers — Refrigerant cooled liquid coolers — Test methods for establishing the performance

The European Standard EN 1118:1998, with the incorporation of amendment A1:2002, has the status of a British Standard

ICS 27.060.30; 27.200

National foreword

This British Standard is the English language version of EN 1118:1999, including amendment A1:2002. It supersedes DD ENV 1118:1994 which is withdrawn.

The start and finish of text introduced or altered by amendment is indicated in the text by tags **A1** **A1**. Tags indicating changes to CEN text carry the number of the CEN amendment. For example, text altered by CEN amendment A1 is indicated by **A1** **A1**.

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.

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

Cross-references

The British Standards which implement international or European publications referred to in this document may be found in the *BSI Catalogue* under the section entitled “International Standards Correspondence Index”, or by using the “Search” facility of the *BSI Electronic Catalogue* or of British Standards Online.

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

Compliance with a British Standard does not of itself confer immunity from legal obligations.

Summary of pages

This document comprises a front cover, an inside front cover, the EN title page, pages 2 to 31 and a back cover.

The BSI copyright notice displayed in this document indicates when the document was last issued.

This British Standard, having been prepared under the direction of the Engineering Sector Committee, was published under the authority of the Standards Committee and comes into effect on 15 May 1999

© BSI 8 April 2003

ISBN 0 580 30974 6

Amendments issued since publication

Amd. No.	Date	Comments
14282	8 April 2003	See national foreword

ICS 27.060.30; 27.200

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

(includes amendment A1:2002)

Echangeurs thermiques — Refroidisseurs de liquides — Procédures d'essai pour la détermination de la performances
(inclut l'amendement A1:2002)

Wärmeaustauscher — Kältemittelgekühlte Flüssigkeitskühler — Prüfverfahren zur Leistungsfeststellung
(enthält Änderung A1:2002)

This European Standard was approved by CEN on 27 November 1998. Amendment A1 was approved by CEN on 14 September 2002.

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.

CEN

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

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

© 1998 CEN All rights of exploitation in any form and by any means reserved worldwide for CEN national Members.
Ref. No. EN 1118:1998 + A1:2002 E

Documents
AVA Document Sharing Hub

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 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.

Foreword to amendment A1

This document (EN 1118:1998/A1:2002) has been prepared by Technical Committee CEN/TC 110, Heat exchangers, the Secretariat of which is held by BSI.

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 April 2003, and conflicting national standards shall be withdrawn at the latest by April 2003.

This amendment is introduced to accommodate newly available refrigerants such as R404A, R407C and R410A.

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, Malta, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland and the United Kingdom.

Contents

Page		
	Foreword	2
	Introduction	3
1	Scope	3
2	Normative references	3
3	Definitions	3
4	Symbols	7
5	Standard capacity	8
6	Manufacturer's data	9
7	Measurements	10
8	Testing methods and equipment	12
9	Test procedures	13
10	Capacity calculations	15
11	Conversion to standard conditions	16
12	Test report	17
	Annex A (normative) Circuit diagrams	18
	Annex B (normative) Direct expansion operation	22
	Annex C (normative) Flooded operation	21
	Annex D (normative) Operation with liquid feed by gravity	25
	Annex E (normative) Operation with liquid overfeed by pump circulation	27
	Annex F (informative) Basic illustrations	27
	Annex G (informative) Flow diagrams for conversion to standard conditions	28
	Annex H (informative) Oil content measurement procedure	31
	Annex I (informative) Bibliography	31

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

t_{A1} dew point temperature of the refrigerant, corresponding to the evaporating pressure p_{A1}

3.7.5

vapour outlet temperature

- 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)
- 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)

[A1] 3.7.7**bubble point temperature**

temperature corresponding to the absolute pressure of the refrigerant at the inlet connection of the expansion devices **[A1]**

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**

[A1] difference between the bubble point temperature corresponding to the absolute pressure of the refrigerant at the inlet connection to the expansion device and the subcooled refrigerant temperature **[A1]**

3.8.4**liquid temperature difference**

difference between the liquid inlet and outlet temperatures

[A1] 3.8.5**high glide**

refrigerant where the difference between the condensing and bubble point temperatures at a condensing temperature of 40 °C is greater than 3 K **[A1]**

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

[A1] 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 pressure 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). **[A1]**

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,

$$rr = \Delta h_0 / \Delta h_e$$

[see also **F.2**]

3.13

fouling resistance

thermal resistance of a layer of unwanted deposit on the heat exchanger surface reducing its 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.

[A1] 3.15

oil content

proportion of oil by mass in the refrigerant related to the pure refrigerant **[A1]**

4 Symbols

For the purposes of this European Standard the following apply.

4.1 Letters

$c_p L$	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	—
ρ_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
Δt_{sup}	superheating = $t_{R2} - t_e$	K
Δt_1	inlet temperature difference = $t_{L1} - t_e$	K
Δt_{sub}	subcooling = $t(p_{R1}) - t_{R1}$	K
Δt_L	liquid temperature difference = $t_{L1} - t_{L2}$	K
Δh_0	specific vaporization enthalpy	kJ/kg
Δh_e	refrigerant specific enthalpy change in the liquid cooler system	kJ/kg
Δp_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.

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

5.2.4 For flooded operation and liquid overfeed by gravity

- a) $t_e = +2\text{ °C}$;
- b) $t_{L1} = +10\text{ °C}$;
- c) either:
 - 1) $\Delta t_L = 5\text{ K}$;
 - 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) $t_{R1} = +30\text{ °C}$;
- f) R_L as required by manufacturer:
 - 1) in the liquid cooler for flooded operation;
 - 2) in the low pressure separator for pump circulation operation;
- g) the static head on the refrigerant side shall not be smaller than 1m for liquid feed by gravity.

5.2.5 For pump circulation operation

- a) $t_e = +2\text{ °C}$;
- b) $t_{L1} = +10\text{ °C}$;
- c) either:
 - 1) $\Delta t_L = 5\text{ K}$;
 - 2) q_{mL} as specified by manufacturer, but $(\Delta t_L / \Delta t_1) \leq 0,60$;
- d) $t_{R1} = +30\text{ °C}$;
- e) oil content as specified by manufacturer;
- f) rr 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;