

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

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National foreword

This Draft for Development has been prepared under the direction of the Refrigeration, Heating and Air Conditioning Standards Policy Committee and is the English language version of ENV 1118:1993 *Heat exchangers — Refrigerant cooled liquid coolers — Test procedure for establishing the performance* published by the European Committee for Standardization (CEN).

ENV 1118 was produced as a result of international discussion in which the UK took an active part.

NOTE This work was originally undertaken under the auspices of E/-/16 which has now been reconstituted to form Technical Committee RHE/30.

This publication is not to be regarded as a British Standard

It is being issued in the Draft for Development series of publications and is of a provisional nature because the subject matter is still under technical development requiring wider exposure. It should be applied on this provisional basis so that information and experience of its practical application may be obtained.

Comments arising from the use of this Draft for Development are requested so that UK experience can be reported to the European organization responsible for its conversion to a European Standard. A review of this publication will be initiated 2 years after its publication by the European organization so that a decision can be taken on its status at the end of its three-year life. The commencement of the review period will be notified by an announcement in *BSI News*.

According to the replies received by the end of the review period, the responsible BSI Committee will decide whether to support the conversion into a European Standard, to extend the life of the prestandard or to withdraw it. Comments should be sent in writing to the Secretary of BSI Technical Committee RHE/30 at 2 Park Street, London, W1A 2BS, giving the document reference and clause number and proposing, where possible, an appropriate revision of the text.

NOTE At places in the text the unit of pressure is expressed in hecto Pascals (hPa). 1 mbar = 100 N/m² = 1 hPa.

Summary of pages

This document comprises a front cover, an inside front cover, pages i and ii, the ENV title page, pages 2 to 30, an inside back cover and a back cover.

This standard has been updated (see copyright date) and may have had amendments incorporated. This will be indicated in the amendment table on the inside front cover.

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Descriptors: Heat exchangers, coolers, liquids, water, classifications, tests, measurements, characteristics

English version

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

Echangeurs de chaleur — Refroidisseurs de
liquides — Procédures d'essais pour la
détermination de la performance

Wärmeaustauscher — Kältemittelgekühlte
Flüssigkeitskühler — Prüfverfahren zur
Leistungsfeststellung

This European Prestandard (ENV) was approved by CEN on 1993-03-09 as a prospective standard for provisional application. The period of validity of this ENV is limited initially to three years. After two years the members of CEN will be requested to submit their comments, particularly on the question whether the ENV can be converted into a European Standard (EN).

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CEN

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

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Foreword

This European Prestandard was prepared by CEN Technical Committee CEN/TC 110 Heat exchangers, the Secretariat of which is held by SIS

This European Prestandard has been adopted during the meeting of CEN/TC 110 as a European Prestandard on 1993-03-09 after consideration of comments received from a public enquiry and establishment of the final version of the European Prestandard.

According to the CEN/CENELEC Common Rules, the following countries are bound to announce the existence of this European Prestandard: Austria, Belgium, Denmark, Finland, France, Greece, Germany, Iceland, Ireland, Italy, Luxembourg, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland and United Kingdom.

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0 Introduction

This European Prestandard is part of a series of European Prestandards dedicated to heat exchangers.

1 Scope and normative references

1.1 Scope

This European prestandard applies to series produced liquid coolers which operate with a (primary) refrigerant and its purpose is to establish uniform methods of testing.

To test and ascertain the following:

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

This European prestandard does not cover technical safety aspects.

1.2 Normative references

1.2.1 This European Prestandard 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 Prestandard only when incorporated in it by amendment or revision. For undated references the latest edition of the publication referred to applies.

ENV 247	Heat exchangers	<i>Terminology</i>
ENV 305	Heat exchangers	<i>Definitions of performance of heat exchangers and the general test procedure for establishing performance of all heat exchangers</i>
ENV 306	Heat exchangers	<i>Methods of measuring the parameters necessary for establishing performance</i>
ENV 307	Heat exchangers	<i>Guidelines to prepare installation, operating and maintenance instructions required to maintain the performance of each type of heat exchanger</i>
EN 45001		<i>General criteria for the operation of testing laboratories</i>

1.2.2 As a general requirement, the European Prestandards ENV 247, ENV 305, ENV 306 and ENV 307 shall apply where appropriate and not otherwise stated in the following clauses.

2 Definitions

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

2.1 Classification

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

- a) Shell and tube type with
 - a1) refrigerant in the shell
 - a2) refrigerant in the tube(s)
- b) Co-axial type with
 - b1) refrigerant in the annulus
 - b2) refrigerant in the tube(s)
- c) Plate type

2.1.1

liquid cooler (refrigerant cooled)

a 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

2.1.2

shell and tube type

liquid cooler, consisting of a shell with a tube arrangement inside the shell

2.1.3

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 may flow either parallel or counter to each other

2.1.4

plate type

liquid cooler, consisting of parallel plates separating the two fluids

2.2 Working fluids

2.2.1

refrigerant (primary)

the working fluid in a refrigeration system, that absorbs heat by evaporation at a low temperature and rejects it by condensation at a higher temperature. In the following the term “refrigerant” is used

2.2.2

liquid

the working fluid, circulated through the refrigeration system and remaining in liquid phase during the absorption or rejection of heat

2.3 Capacity

2.3.1

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

2.3.2

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

2.4 Temperatures

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

2.4.1

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)

2.4.2

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)

2.4.3

ambient air temperature

the temperature of the air surrounding the liquid cooler

2.4.4

evaporating temperature

the 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)

2.4.5**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).

2.4.6**subcooled refrigerant temperature**

the temperature of the liquid refrigerant at the inlet of the expansion device (not part of the liquid cooler)

2.5 Temperature differences**2.5.1****inlet temperature difference**

the difference between the liquid inlet temperature and the evaporating temperature

2.5.2**superheating**

the difference between the vapour outlet temperature and the evaporating temperature

2.5.3**subcooling**

the difference between the saturation temperature corresponding to absolute pressure of the refrigerant at the inlet of the expansion device and the subcooled refrigerant temperature

2.5.4**liquid temperature difference**

the difference between the liquid inlet and outlet temperatures

2.6 Liquid pressure

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

2.6.1**liquid inlet pressure**

the static pressure of the liquid at the inlet connection of the liquid cooler

2.6.2**liquid outlet pressure**

the static pressure of the liquid at the outlet connection of the liquid cooler

2.7 Operation**2.7.1****direct expansion operation**

an 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)

2.7.2**flooded operation**

an 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)

2.7.3**operation with liquid feed by gravity**

an 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)

2.7.4

operation with liquid overfeed by pump circulation

an 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)

2.8 Refrigerant enthalpies

2.8.1

refrigerant inlet specific enthalpy

the 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)

2.8.2

refrigerant outlet specific enthalpy

the 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)

2.8.3

specific vaporization enthalpy

is defined at the evaporation temperature without regard to the pressure drop across the liquid cooler system

2.9 Other definitions

2.9.1

refrigerant recirculation rate

the ratio between the actual mass flow rate through the liquid cooler and the mass flow rate necessary for the total evaporation of the refrigerant. It is defined by the following equation:

$$\text{refrigerant recirculation rate} \quad r_r = \Delta h_o / \Delta h_e$$

see also Annex F.2

2.9.2

fouling resistance

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

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

2.9.3

set of tests

consists of a number of individual tests at a constant liquid flow rate and different conditions on the refrigerant side of the liquid cooler

a duplicate set of tests consists of two sets of tests

3 Symbols

For the purposes of this European Prestandard the following applies:

	is the	in
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
R_L	refrigerant liquid level	mm
rd	relative deviation	—
rr	recirculation rate	—
ρ_{oL}	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
$t_{(PR1)}$	saturation temperature corresponding to $PR1$	°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 = $t_{(pR1)} - t_{R1}$	K
Δt_L	liquid temperature difference = $t_{L1} - t_{L2}$	K
Δh_O	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