BS EN 12900:2013

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Refrigerant compressors — Rating conditions, tolerances and presentation of manufacturer's performance data

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National foreword

This British Standard is the UK implementation of EN 12900:2013. It supersedes BS EN 12900:2005 which is withdrawn.

The UK participation in its preparation was entrusted to Technical Committee RHE/4, Testing of refrigerant compressors.

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

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ISBN 978 0 580 77770 7

ICS 23.140; 27.200

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This British Standard was published under the authority of the Standards Policy and Strategy Committee on 31 August 2013.

Amendments issued since publication

Date	Text affected

EUROPEAN STANDARD

NORME EUROPÉENNE

EUROPÄISCHE NORM

EN 12900

July 2013

ICS 23.140; 27.200

Supersedes EN 12900:2005

English Version

Refrigerant compressors - Rating conditions, tolerances and presentation of manufacturer's performance data

Compresseurs pour fluides frigorigènes - Conditions de détermination des caractéristiques, tolérances et présentation des performances par le fabricant

Kältemittel-Verdichter - Nennbedingungen, Toleranzen und Darstellung von Leistungsdaten des Herstellers

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Ref. No. EN 12900:2013: E

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Foreword

This document (EN 12900:2013) has been prepared by Technical Committee CEN/TC 113 “Heat pumps and air conditioning units”, the secretariat of which is held by AENOR.

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of an identical text or by endorsement, at the latest by January 2014 and conflicting national standards shall be withdrawn at the latest by January 2014.

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 12900:2005.

The main changes with respect to the previous edition are listed below:

a) Clause 3 “Terms and definitions” is modified;

b) the revised standard takes into account the application of CO_2;

c) the requirements on part load conditions according to Mandate M/488 are considered.

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1 Scope

This European Standard specifies the rating conditions, tolerances and the method of presenting manufacturer's data for positive displacement refrigerant compressors. These include single stage compressors and single and two stage compressors using a means of fluid subcooling. This is required so that a comparison of different refrigerant compressors can be made. The data relate to the refrigerating capacity and power absorbed and include requirements for part-load operation where applicable.

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 378-1:2008+A2:2012, *Refrigerating systems and heat pumps — Safety and environmental requirements — Part 1: Basic requirements, definitions, classification and selection criteria*

EN 13771-1, *Compressors and condensing units for refrigeration — Performance testing and test methods — Part 1: Refrigerant compressors*

ISO 817, *Refrigerants — Designation system*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in EN 378-1:2008+A2:2012 and the following apply.

3.1
positive displacement compressor
compressor in which compression is obtained by changing the internal volume of the compression chamber

[SOURCE: EN 378-1:2008+A2:2012, 3.4.6]

3.2
refrigerating capacity
product of the low pressure mass flow of refrigerant through the compressor and the difference between the specific enthalpy of the refrigerant at the low pressure of the compressor inlet and the specific enthalpy of fluid entering the evaporator expansion device

Note 1 to entry: This latter enthalpy is related to the stated fluid temperature under following pressure conditions:

- for single-stage expansion cycles the compressor discharge pressure;
- for multiple-stage expansion cycles the pressure (dew point temperature) at the corresponding compressor intermediate port.

The refrigerant at the low compressor inlet is superheated above the suction dew point temperature to the stated value.

Note 2 to entry: Condensing temperature is defined as saturated dew point temperature.

3.3
subcooling
difference between the bubble point temperature of the refrigerant corresponding to the compressor discharge pressure and the temperature of the liquid refrigerant below the bubble point

3.4
suction gas superheat
difference between the dew point temperature of the refrigerant corresponding to the compressor suction pressure and the suction gas temperature of the refrigerant at the compressor inlet

3.5
power absorbed
- for externally driven compressors: the power at the compressor shaft
- for motor compressors: the electrical power input at the motor terminals
- for motor compressors with a specific means of factory assembled or factory specified frequency inverter for variable speed (part load) capacity regulation, the electrical power input at the inverter input terminals

3.6
coefficient of performance
COP_r
ratio of refrigerating capacity to the power absorbed

3.7
subcritical operation
operating condition with discharge pressure level below the critical pressure

3.8
transcritical operation
operating condition with discharge pressure level above the critical pressure

3.9
part load operation
for compressors with capacity control mechanism, part load is interpreted as operation with active capacity control at reduced capacity

Note 1 to entry: On/off cycling of the compressor motor is not considered as capacity control in this context for declaration of part load performance.

3.10
fluid
refrigerant liquid, gas or vapour including the state of appearance close to and above the critical pressure

3.11
evaporating temperature
dew temperature corresponding to the suction pressure of the compressor

3.12
condensing temperature
dew temperature corresponding to the discharge pressure of the compressor

4 Parameters for the presentation of performance data

The parameters as shown in Table 1 to Table 4 shall be used for the presentation of the performance data.

Table 1 — Parameters for the presentation of performance data with compressors used in standard applications

Refrigerant	Parameters		
	Suction gas temperature (°C) or superheat (K) at the compressor inlet	Ambient temperature around the compressor	Compressor Application
Halocarbons and hydrocarbons including refrigerant blends	32 °C	35 °C	Household and similar refrigerators/ freezers
	20 °C or 10 K		Other applications
R 744 (CO_2)	32 °C		Household and similar refrigerators/ freezers
	10 K (30 °C[a])		Other applications
R 717	5 K		Any application using ammonia
Other refrigerants	As appropriate, to be clearly specified in performance data		
[a] Reference point A5, Table 6.			

The refrigerating capacity shall not allow for any fluid subcooling for subcritical operation. For transcritical operation refrigeration capacity has to be related to the gas cooler outlet temperature and the compressor discharge pressure.

If reference points mentioned in Table 5 to Table 7 fall inside the compressor application envelope, compressor performances shall be displayed at those rating conditions.

For CO_2 transcritical applications gas cooler outlet temperature shall be displayed.

NOTE Tables 2 to 4 refer to economised cycles.

Table 2 — Parameters for the presentation of performance data with compressors using a specific means of factory assembled or factory specified liquid subcooler (subcritical operation) or aftercooler (transcritical operation)

Refrigerant	Suction gas temperature (°C) or superheat (K) at the compressor inlet	Ambient temperature around the compressor	Compressor application
Halocarbons and hydrocarbons including refrigerant blends	20 °C or 10 K	35 °C	Any application with factory assembled or factory specified subcooler or aftercooler
R 744 (CO_2)	10 K [a]		
R 717 (NH_3)	5 K		
Other refrigerants	As appropriate, to be clearly specified in performance data		
NOTE For subcritical operation liquid entering the subcooler is at saturated (bubble) temperature equivalent to the refrigerant pressure at the compressor outlet. For transcritical operation fluid entering the aftercooler is at gas cooler outlet temperature and compressor discharge pressure.			
[a] Or other conditions from Table 6.			

The refrigerating capacity includes the subcooling provided by the subcooler or additional cooling provided by the aftercooler. For CO_2 transcritical applications gas cooler outlet temperature shall be displayed.

Table 3 — Parameters for the presentation of performance data with compressors using an individually selected liquid subcooler (subcritical operation) or aftercooler (transcritical operation)

Refrigerant	Suction gas temperature (°C) or superheat (K) at the compressor inlet	Liquid subcooling (K) or temperature (°C)	Saturated intermediate (dew) temperature (°C) or pressure (bar)	Ambient temperature around the compressor	Compressor application
Halocarbons and hydrocarbons including refrigerant blends	20 °C or 10 K	5 K above bubble point temperature corresponding to the pressure at the intermediate port of the compressor	to be specified with reference to suction and discharge pressure	35 °C	Any application with individually selected subcooler or aftercooler
R 744 (CO_2)	10 K[a]				
R-717 (NH_3)	5 K				
Other refrigerants	As appropriate, to be clearly specified in performance data				
NOTE For subcritical operation liquid entering the subcooler is at saturated (bubble) temperature equivalent to the refrigerant pressure at the compressor outlet. For transcritical operation fluid entering the aftercooler is at gas cooler outlet temperature and compressor discharge pressure.					
[a] Or other conditions from Table 6.					

The refrigerating capacity includes the subcooling provided by the subcooler or additional cooling provided by the aftercooler. For CO_2 transcritical applications gas cooler outlet temperature shall be displayed.

Table 4 — Parameters for the presentation of performance data with compressors using an open flash interstage receiver (tank)

Refrigerant	Suction gas temperature (°C) or superheat (K) at the compressor inlet	Liquid temperature (°C)	Saturated intermediate (dew) temperature (°C) or pressure (bar)	Ambient temperature around the compressor	Compressor application
Halocarbons and hydrocarbons including refrigerant blends	20 °C or 10 K	bubble point temperature corresponding to the pressure at the intermediate port of the compressor	to be specified with reference to suction and discharge pressures	35 °C	Any application with open flash receiver
R 744 (CO_2)	10 K[a]				
R 717 (NH_3)	5 K				
Other refrigerants	As appropriate, to be clearly specified in performance data				
NOTE For subcritical operation liquid entering the interstage receiver is at saturated (bubble) temperature equivalent to the refrigerant pressure at the compressor outlet. For transcritical operation fluid entering the expansion device to the interstage receiver is at gas cooler outlet temperature and compressor discharge pressure.					
[a] Or other conditions from Table 6.					

The refrigerating capacity refers to the bubble point temperature corresponding to the pressure at the compressor intermediate port. For CO_2 transcritical applications gas cooler outlet temperature shall be displayed.

5 Requirements

The performance data of a refrigerant compressor shall be presented in tabular or graphical form as shown in 6.2 or in polynomial form as shown in 6.3. At least one of the selected forms shall show the performance data covering the entire application range. Any operating point published by the manufacturer and falling within the envelopes shown in Figures 1 and 2 shall comply with the tolerances defined in Table 8.

The performance of the compressor at the standard reference points in Clause 7 shall also be reported.

To generate the performance at other suction gas temperatures, superheat or compressor speed, calculation methods shall be given as shown in Clause 9.

Refrigerants shall be designated in accordance with ISO 817. The source from which the thermodynamic properties are taken shall be stated.

Other data such as the swept volume, number of cylinders and speed range may also be shown.

6 Performance data

6.1 General

6.1.1 Published performance shall be based on data obtained from tests performed in accordance with EN 13771-1.

If an oil separator is required to reach the performance, then this shall be indicated.

The power for possible ancillaries shall be stated.

6.1.2 The performance data shall be presented for:

— open compressors at the rated speed;

— motor compressors at the rated voltage and frequency.

6.1.3 The performance data with capacity control shall be presented for:

— all capacity control steps for compressors with 2 to 4 control steps, e.g. blocked suction or multi-speed motor;

— compressors with more than 4 steps or otherwise variable capacity (e.g. variable speed or quasi stepless) at maximum, minimum and at least one additional control step inside the control range.

In the case of non linear performance behaviour between published values, the interpolation method, necessary to keep within the tolerances, is to be stated.

6.2 Tabular or graphical form

The performance data to be given shall comprise:

a) refrigerating capacity, in values able to be read to an accuracy of ± 2 %;

b) absorbed power, in values able to be read to an accuracy of ± 2 %;

c) evaporating temperatures at suction dew point with intervals not greater than 5 K;

d) condensing temperatures at discharge dew point with intervals not greater than 10 K; (For transcritical operating conditions gas cooler outlet temperature and related high pressure shall be stated. Temperature intervals shall not exceed 5 K. Possible means for fluid subcooling shall be stated.)

e) for compressors using a specific means of liquid subcooling, the temperature of the liquid leaving the subcooler shall be specified.

6.3 Polynomial form

6.3.1 The polynomial formula shall be a third degree formula utilising ten coefficients as follows:

$$X = C_1 + C_2 \times (S) + C_3 \times (D) + C_4 \times (S^2) + C_5 \times (S \times D) + C_6 \times (D^2) + C_7 \times (S^3) + C_8 \times (D \times S^2) + C_9 \times (S \times D^2) + C_{10} \times (D^3) \quad (1)$$

where:

X is the refrigerating capacity, in watts (W) or mass flow in kilograms per second $\left(\frac{\text{kg}}{\text{s}}\right)$, absorbed power,in watts (W);

S is the evaporating temperature at suction dew point, in degree Celsius (°C);

D is the condensing temperature at discharge dew point, in degree Celsius (°C), or discharge pressure in bar (bar);

C is a coefficient.

6.3.2 The polynomial formula above shall not be used to extrapolate beyond the application envelope. Interpolation for different superheats is allowed, if the polynomials for different superheat conditions are given.

7 Standard reference points

The standard reference points shall be in accordance with Tables 5 to 7.

Table 5 — Reference points for standard applications

Reference points	Compressor applications			
	High evaporating temperature	**Medium evaporating temperature**	**Low evaporating temperature**	**Household and similar refrigerators/ freezers**
Evaporating temperature (°C) at suction dew point	+ 5	– 10	– 35	– 25
Condensing temperature (°C) at discharge dew point	+ 50	+ 45	+ 40	+ 55
Suction gas temperature (°C) or superheat (K)	+ 20 10 or 5[a]	+ 20 10 or 5[a]	+ 20 10 or 5[a]	+ 32
Subcooling (K)	0	0	0	0

[a] For R 717.

Table 6 — Reference points for R 744 (CO_2) applications – commercial/industrial use

A		Evaporating temperature (°C)	Useful superheat, without internal heat exchanger (K)	Suction temperature with internal heat exchanger (°C)	Absolute discharge pressure (bar)	Gas cooler outlet temperature (°C)	Ambient temperature around the compressor(s) (°C)
	1	-35	10	-	90	35	35
	2	-10	10	-	90	35	35
	3	-5	10	-	90	35	35
	4	5	10	-	100	40	35
	5	5	-	30	100	40	35
	6	5[a]	10	-	100	25	35
B[b]		Evaporating temperature (°C)	Useful superheat, without internal heat exchanger (K)	Suction temperature with internal heat exchanger (°C)	Condensing temperature (°C)	Subcooling (K)	Ambient temperature around the compressor(s) (°C)
	1	-35	10	-	15	0	35
	2	-10	10	-	15	0	35
	3	-5	10	-	15	0	35
C		**Additional reference points for household and similar applications**					
		Evaporating temperature (°C)	Useful superheat, without internal heat exchanger (K)	Suction temperature (°C)	Absolute discharge pressure (bar)	Gas cooler outlet temperature (°C)	Ambient temperature around the compressor(s) (°C)
	1	-25	-	32	90	35	35
	2	-5	-	32	90	35	35

[a] Rating point for domestic hot water heat pump. A6: Compressor performance can be calculated from A4.

[b] Trans-critical systems are designed to work at discharge pressure levels above the critical point. Under certain boundary conditions a trans-critical system will be able to work in subcritical mode.

Table 7 — Reference points for R 744(CO_2) applications – commercial /industrial use

		Reference points for commercial / industrial applications				
		Evaporating temperature (°C)	Suction superheat (K)	Condensing temperature (°C)	Liquid subcooling (K)	Ambient temperature around the compressor(s) (°C)
D	1	-50	10	-5	0	35
	2	-35	10	-5	0	35
E[a]	1	-50	10	5	0	35
	2	-35	10	5	0	35
[a] Mainly industrial application.						

8 Tolerances

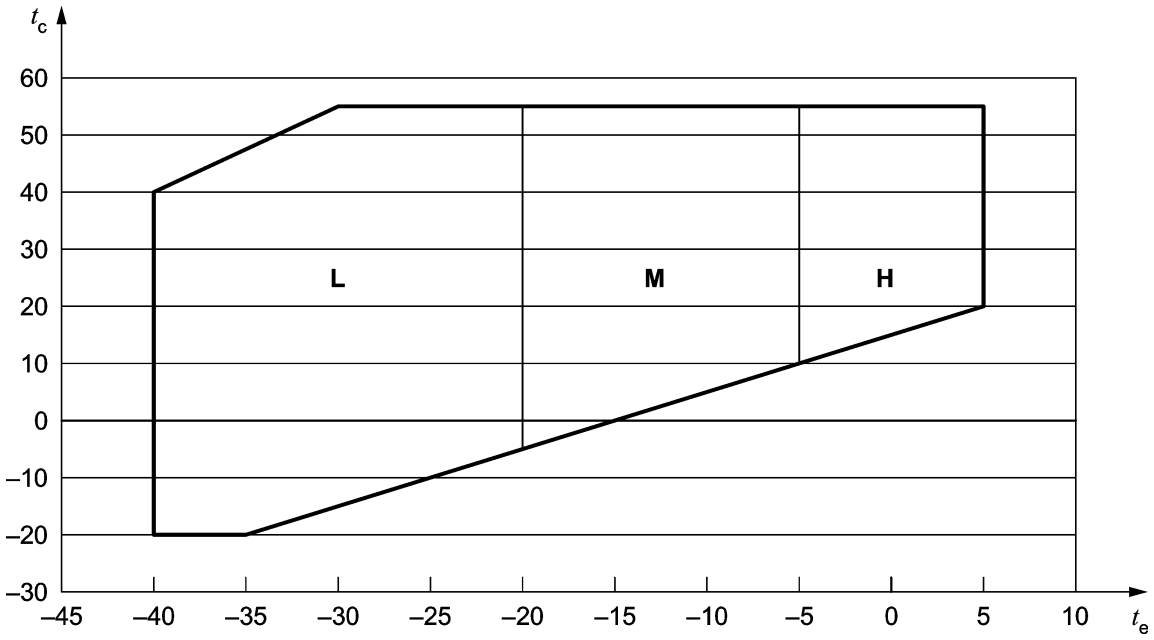
Component differences during production may result in deviations from the manufacturer's stated performance. To comply with this European Standard the performance of any individual compressor shall be within the following tolerances:

Refrigerating capacity or mass flow and COP_r shall not be lower than shown in Table 8. Power absorbed shall not be more than the percentage shown in Table 8.

Table 8 — Actual performance in relation to published data

	High evaporating temperature	**Medium evaporating temperature**	**Low evaporating temperature and part load**	**Part load**	**Household and similar refrigerators / freezers**
	H	**M**	**L**		
Refrigerating capacity or mass flow	95,0 %	92,5 %	90,0 %	90,0 %	95,0 % or – 5W[a]
Power absorbed within the application envelopes (Figures 1 and 2) excluding reference points	105,0 %	107,5 %	110,0 %	110,0 %	105,0 % or + 5W[a]
Power absorbed at reference points	105,0 %	105,0 %	105,0 %	-	105,0 % or + 5W[a]
COP_r	90,0 %	90,0 %	90,0 %	90,0 %	90,0 %
[a] For values less than 100 W.					
[b] Valid for full load conditions only					

NOTE The areas of high, medium and low evaporating temperatures are shown in Figure 1.

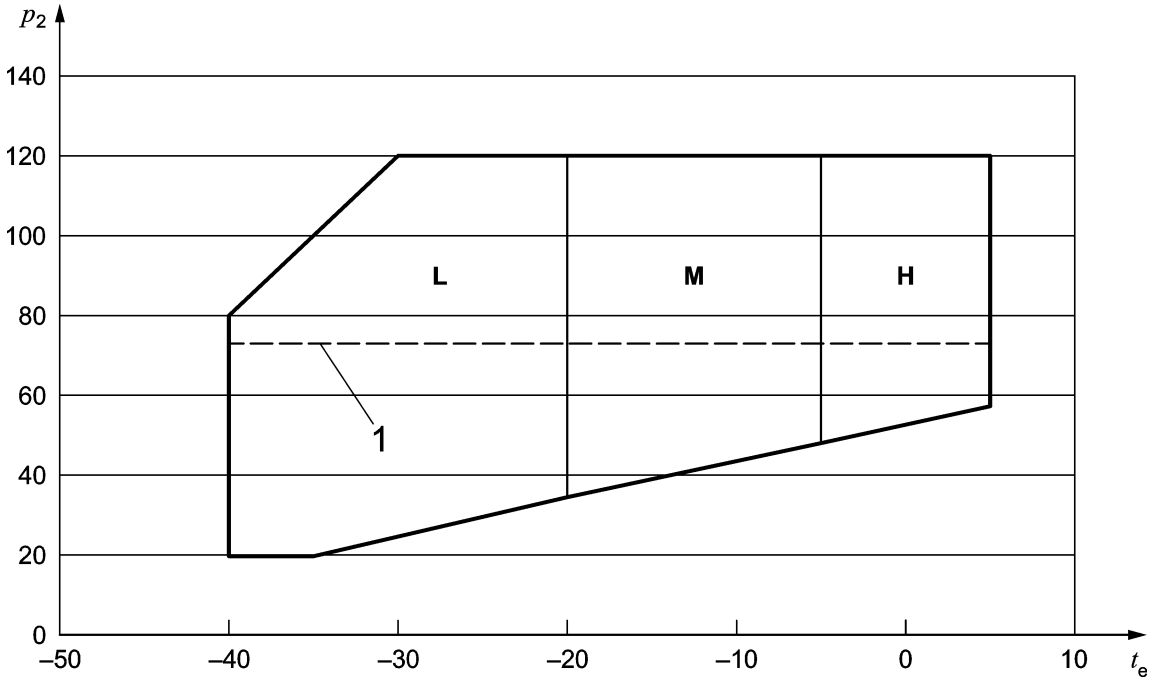


Key

t_e saturated Evaporating Temperature (°C)

t_c saturated Condensing Temperature (°C)

Figure 1 — Application envelope for tolerances (standard applications)



Key

t_e saturated Evaporating Temperature (°C)

p_2 discharge pressure (bar)

1 critical pressure

Figure 2 — Application envelope for tolerances (R744/$C0_2$ applications)

9 Conversion methods

9.1 Suction gas superheat

The conversion method applicable to the performance data relating to superheat (see Clause 5) shall comprise:

a) change in refrigerating capacity (or mass flow) as a function of the superheat;

b) change in power absorbed as a function of the superheat.

Conversion factors or calculation method for different values of superheat shall be based on experimental data.

9.2 Compressor speed for open drive compressors

The conversion factors or calculation method applicable to the performance data relating to the rated speed (see 6.1.2) shall comprise:

a) refrigerating capacity (or mass flow) as a function of varying compressor speeds;

b) power absorbed as a function of varying compressor speeds.

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