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Testing and rating of direct exchange ground coupled heat pumps with electrically driven compressors for space heating and/or cooling

Part 1: Direct exchange-to-water heat pumps

National foreword

This British Standard is the UK implementation of EN 15879-1:2011.

The UK participation in its preparation was entrusted to Technical Committee RHE/17, Testing of air conditioning units.

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

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

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Compliance with a British Standard cannot confer immunity from legal obligations.

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Essais et détermination des caractéristiques des pompes à chaleur à détente directe avec le sol avec compresseur entraîné par moteur électrique pour le chauffage et/ou la réfrigération des locaux - Partie 1: Pompes à chaleur à échange direct avec l'eau

Prüfung und Leistungsbemessung von erdreichgekoppelten Direktübertragung - Wärmepumpen mit elektrisch angetriebenen Verdichtern zur Raumbeheizung und/oder -kühlung - Teil 1: Direktübertragung/Wasser-Wärmepumpe

This European Standard was approved by CEN on 8 January 2011.

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Foreword

This document (EN 15879-1:2011) 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of an identical text or by endorsement, at the latest by August 2011, and conflicting national standards shall be withdrawn at the latest by August 2011.

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.

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1 Scope

This European Standard specifies the terms and definitions, test conditions, test procedures and requirements for the rating and performance of direct exchange-to-water ground coupled heat pumps with electrically driven compressors, used for space heating and/or cooling. Brine can be used instead of water.

This European Standard applies to factory-made units with horizontal in-ground collectors. In the case of units consisting of several parts, this standard applies only to those designed and supplied as a complete package.

Water-to-direct exchange and direct-exchange-to-direct exchange ground coupled heat pumps are covered by EN 15879-2.

Direct exchange-to-air ground coupled heat pumps and air-to-direct exchange heat pumps are covered by EN 15879-3.

This European Standard does not apply to units using transcritical cycles, e.g. with CO_2 as refrigerant.

2 Normative references

The following referenced documents are indispensable for the application of this European Standard. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

EN 12102:2008, *Air conditioners, liquid chilling packages, heat pumps and dehumidifiers with electrically driven compressors for space heating and cooling — Measurement of airborne noise — Determination of the sound power level*

EN 14511-1:2007, *Air conditioners, liquid chilling packages and heat pumps with electrically driven compressors for space heating and cooling — Part 1: Terms and definitions*

EN 14511-3, *Air conditioners, liquid chilling packages and heat pumps with electrically driven compressors for space heating and cooling — Part 3: Test Methods*

EN 60204-1, *Safety of machinery — Electrical equipment of machines — Part 1: General requirements (IEC 60204-1:2005, modified)*

EN 60335-2-40, *Household and similar electrical appliances — Safety — Part 2-40: Particular requirements for electrical heat pumps, air-conditioners and dehumidifiers (IEC 60335-2-40:2002, modified)*

EN 61000-3-11, *Electromagnetic compatibility (EMC) — Part 3-11: Limits; Limitation of voltage changes, voltage fluctuations and flicker in public low-voltage supply systems; Equipment with rated current ≤ 75 A and subject to conditional connection (IEC 61000-3-11:2000)*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in EN 14511-1:2007 and the following apply.

3.1
direct exchange ground coupled heat pump
heat pump which consists of an in-ground heat exchanger and a heat pump module

3.2
in-ground heat exchanger
heat exchanger buried in the ground that consists of a series of parallel loops, each consisting of a single tube, in which the refrigerant is circulating for a direct heat exchange with the ground

NOTE 1 The in-ground heat exchanger is connected to the heat pump module through vapour and liquid refrigerant lines.

NOTE 2 The in-ground heat exchanger is specified by the number and length of the parallel loops and the diameter of the single tubes.

3.3
heat pump module
assembly containing the refrigerating circuit components including the compressor, the expansion device, the indoor heat exchanger, all auxiliary components, control and safety devices and the refrigerant lines excluding the in-ground heat exchanger

3.4
brine-bath temperature
temperature of the brine which is maintained in the bath where the in-ground heat exchanger tubes are immersed, and which is calculated as the mean value of the brine at the inlet and outlet of the bath

4 Classification

The units are denominated in such a way that the heat transfer medium for the outdoor heat exchanger is given first, followed by the heat transfer medium for the indoor heat exchanger (see Table 1).

Table 1 — Designation of direct exchange-to-water (brine) heat pumps

Outdoor heat exchanger	Indoor heat exchanger	Designation	Classification
In-ground heat exchanger	Water	Direct exchange-to-water units	DX / water
	Brine	Direct exchange-to-brine units	DX / brine

5 Test conditions

5.1 Environmental conditions and electrical power supply requirements

The test shall be carried out under the environmental conditions around the heat pump module specified in Table 2.

For all units, electrical power, voltage and frequency shall be given by the manufacturer.

Table 2 — Environmental conditions

Type	Measured quantity	Environmental conditions
DX / water or DX / brine to be installed outdoors – heating operation	Air dry bulb temperature	0 °C to 7 °C
DX / water or DX / brine to be installed outdoors – cooling operation	Air dry bulb temperature	25 °C to 35 °C
DX / water or DX / brine to be installed indoors – heating or cooling operation	Air dry bulb temperature	15 °C to 30 °C

5.2 Rating conditions

For the rating tests, the appropriate test conditions shall be applied in accordance with:

Table 3 for the heating mode;

Table 4 for the cooling mode.

Table 3 — Rating conditions for the heating mode

		In-ground heat exchanger	Indoor heat exchanger	
		Bath temperature (°C)	Inlet temperature (°C)	Outlet temperature (°C)
Standard rating conditions	DX / water or DX / brine for low heating temperature applications	4	30	35
	DX / water or DX / brine for medium heating temperature applications	4	40	45
	DX / water or DX / brine for high heating temperature applications	4	47	55
	DX / water or DX / brine for very high heating temperature applications	4	55	65
Application rating conditions	DX / water or DX / brine for low heating temperature applications	4	25	30
	DX / water and DX / brine for low heating temperature applications	1,5	30	35
	DX / water and DX / brine for medium heating temperature applications	1,5	40	45

Table 4 — Rating conditions for the cooling mode

		In-ground heat exchanger	Indoor heat exchanger	
		Bath temperature (°C)	Inlet temperature (°C)	Outlet temperature (°C)
Standard rating conditions	DX / water or DX / brine for high cooling temperature applications	30	23-[a]	18
	DX / water or DX / brine for low cooling temperature applications	30	12-[a]	7
Application rating conditions	DX / water or DX / brine for high cooling temperature applications	10	[b]	18
	DX / water or DX / brine for low cooling temperature applications	10	[b]	7

(a) For reversed cycle units, the test is performed at the flow rate obtained during the test for the corresponding standard rating conditions in the heating mode in Table 3.

(b) With the water flow rate as determined for the standard rating condition.

6 Rating capacity tests

6.1 Basic principles

6.1.1 Heating capacity

The heating capacity of direct exchange heat pumps shall be determined in accordance with the direct method at the water or brine heat exchanger. This shall be done by determination of the volume flow of the heat transfer medium and the inlet and outlet temperatures, taking into consideration the specific heat capacity and density of the heat transfer medium.

The heating capacity shall be determined using the following formula:

$$P_H = q \times \rho \times c_p \times \Delta T \quad (1)$$

where

P_H is the heating capacity, in watts;

q is the volume flow rate, in cubic meters per second;

ρ is the density, in kilograms per cubic meter;

c_p is the specific heat at constant pressure, in joules per kilogram per kelvin;

ΔT is the difference between inlet and outlet temperatures, in kelvin.

The heating capacity shall be corrected for the heat from the circulating pump:

— if the pump at the indoor heat exchanger is an integral part of the unit, the same power (calculated in 6.1.3.1) which is excluded from the total power input shall also be subtracted from the heating capacity;

— if the pump at the indoor heat exchanger is not an integral part of the unit, the same power (calculated in 6.1.3.2) which is included in the effective total power input shall also be added to the heating capacity.

6.1.2 Cooling capacity

The cooling capacity of direct exchange heat pumps shall be determined in accordance with the direct method at the water or brine heat exchanger. This shall be done by determination of the volume flow of the heat transfer medium and the inlet and outlet temperatures, taking into consideration the specific heat capacity and density of the heat transfer medium.

The cooling capacity shall be determined using the following formula:

$$P_C = q \times \rho \times c_p \times \Delta T \tag{2}$$

where

P_C is the cooling capacity, in watts;

q is the volume flow rate, in cubic meters per second;

ρ is the density, in kilograms per cubic meter;

c_p is the specific heat at constant pressure, in joules per kilogram per kelvin;

ΔT is the difference between inlet and outlet temperatures, in kelvin.

The cooling capacity shall be corrected for the heat from the circulating pump:

— if the pump at the indoor heat exchanger is an integral part of the unit, the same power (calculated in 6.1.3.1) which is excluded from the total power input shall also be added to the cooling capacity;

— if the pump at the indoor heat exchanger is not an integral part of the unit, the same power (calculated in 6.1.3.2) which is included in the effective total power input shall also be subtracted from the cooling capacity.

6.1.3 Power input of liquid pumps

If the liquid pump is integrated in the unit, it shall be connected for operation. When the liquid pump is delivered by the manufacturer apart from the unit, it shall be connected for operation according to the manufacturer's instructions and be considered as an integral part of the unit.

6.1.3.1 If a liquid pump is an integral part of the unit, only a fraction of the input to the pump motor shall be included in the effective power absorbed by the unit. The fraction which is to be excluded from the total power absorbed by the unit shall be calculated from the following formula:

$$P_{LP} = \frac{q \times \Delta p_e}{\eta} \ [W] \tag{3}$$

where

η is the efficiency of the liquid pump according to EN 14511-3;

Δp_e is the measured external static pressure difference as defined in EN 14511-1, in pascal;

q is the nominal heat transfer medium flow rate, in cubic meters per second.

6.1.3.2 If no liquid pump is provided with the unit, the proportional power input which is to be included in the effective power absorbed by the unit, shall be calculated using the following formula:

$$P_{LP} = \frac{q \times (-\Delta p_i)}{\eta} \, [W] \tag{4}$$

where

η is the efficiency of the liquid pump according to EN 14511-3;

Δp_i is the measured internal static pressure difference as defined in EN 14511-1, in pascal;

q is the nominal heat transfer medium flow rate, in cubic meters per second.

6.2 Test equipment and facility

6.2.1 General requirements

The test apparatus shall be designed such that all requirements on adjustment of set values, stability criteria and uncertainties of measurement according to this European Standard are satisfied.

6.2.2 Indoor heat exchanger

The test apparatus shall be able to provide and maintain constant during the tests the temperatures and flow rates at the values specified in Table 3 and/or Table 4 with the requirements of Table 5.

6.2.3 Brine-bath requirements

The in-ground heat exchanger shall be immersed in a brine-bath. An informative description of the brine-bath is given in Annex A.

The test apparatus shall be able to provide and maintain constant during the tests the brine temperature in the bath at the values specified in Table 3 and Table 4 with the requirements of Table 5.

Monoethylene glycol shall be used as antifreeze agent in the brine with a concentration of 33 % volume per volume. The velocity of the brine in the bath shall be kept as low as possible not to enhance the heat transfer between the brine and the in-ground heat exchanger too much.

6.3 Installation and connection of the test object

6.3.1 Installation

The module of the heat pump shall be connected according to the manufacturer's installation and/or operation manual.

The in-ground heat exchanger shall be immersed in a brine-bath. The length of the loops in the bath shall be as stated by the manufacturer. The distance between the neighbouring windings of the loops shall be larger then 0,035 m, measured form the centres of the adjacent pipes.

The in-ground heat exchanger shall be installed in accordance with the following requirements:

— the number and the length of the loops as well as their connection to the heat pump module shall be in accordance with the manufacturer instructions;

— the maximum length of the refrigerant lines between the brine bath and the heat pump module shall not exceed 7 meters;

— the refrigerant lines shall be installed so that the difference in elevation between the lowest and the highest point of each of the lines does not exceed 0,3 m plus the height of the heat pump module itself;

— the thermal insulation of the refrigerant lines shall be in accordance with the manufacturer's instructions.

6.3.2 Refrigerant charge

The charge of refrigerant is dependent on the length of the loops of the in-ground heat exchanger. The charge shall be defined for each standard rating condition and remains constant during the test.

If the unit is operating in both heating and cooling mode, the charge is defined for the heating mode and shall remain the same for the cooling mode.

If the unit is operating in the cooling mode only, the refrigerant charge is defined for this mode.

Heat pump start-up should be performed by a manufacturer's representative. Otherwise, the test laboratory shall charge the unit according to the prescriptions of the manufacturer, which shall include:

— a pre-charge quantity of refrigerant for the chosen standard rating condition;

— the superheating temperature to be obtained;

— the setting of the expansion device or other components for achieving a correct refrigerant charge and operation of the heat pump.

6.3.3 Setting of inverter type control units

For inverter type control units, if the manufacturer gives instructions for the setting of the frequency for each rating condition, this setting shall be done.

6.4 Uncertainties of measurement

The uncertainties of measurement shall not exceed the values specified in Table 5.

Table 5 — Uncertainties of measurement for indicated values

Measured quantity	Unit	Uncertainty of measurement
Environmental air dry bulb temperature	°C	± 1 K
Heat transfer medium temperature	°C	± 0,1 K
Brine temperature in the bath	°C	± 0,1 K
Brine concentration	vol/vol	± 2 %
Liquid volume flow	m^3/s	± 1 % of the measured value
Static pressure difference	Pa	± 5 % of the measured value
Electrical power	W	± 1 % of the measured value
Voltage	V	± 0,5 % of the measured value
Current	A	± 0,5 % of the measured value
Electrical energy	kWh	± 1 % of the measured value

The heating and/or cooling capacity shall be determined with a maximum uncertainty of 5 % with 95 % confidence independent of the individual uncertainties of measurement including the uncertainties on the properties of fluids.

6.5 Test procedure

6.5.1 Steady state condition

This condition is considered obtained and maintained when all the measured quantities remain constant without having to alter the set values, for a minimum duration of 1 hour, with respect to the tolerances given in Table 6.

Periodic fluctuations of measured quantities caused by the operation of regulation and control devices are permissible, on condition that the mean value of such fluctuations does not exceed the permissible deviations listed in Table 6.

Table 6 — Permissible deviations from set values

Measured quantity	Permissible deviation of the arithmetic mean values from the set values	Permissible deviation of the individual measured values from the set values
Bath temperature	± 0,2 K	± 0,2 K [a]
Temperature difference between the inlet and the outlet of the brine bath	—	± 0,5 K
Temperature difference between the highest and the lowest location of the brine flow inlet (outlet)	—	± 0,2 K
Inlet water/brine temperature	± 0,2 K	± 0,5 K
Outlet water/brine temperature	± 0,3 K	± 0,6 K
Volume flow	± 2 %	± 5 %
Static pressure difference	—	± 10 %
Voltage	± 4 %	± 4 %

[a] This deviation applies to the calculated mean temperature of the brine bath from the individual measured values for the inlet and outlet temperatures.

6.5.2 Measurement of heating capacity or cooling capacity

For the output measurement, it is necessary to record all meaningful data continuously. In the case of recording instruments which operate on a cyclic basis, the sequence shall be adjusted such that a complete recording is effected at least once every 30 seconds.

The output measurement shall be measured in the steady state condition. The duration of the data collection period shall be at least 35 minutes.

6.6 Test results

6.6.1 Data to be recorded

The data to be recorded for the rating capacity tests are given in Table 7. The table identifies the general information required but is not intended to limit the data to be obtained.

Table 7 — Data to be recorded

Measured quantity	Symbol	Unit
Ambient temperature	T_a	°C
Electrical quantities		
Voltage	U	V
Total current	I	A
Total power input	P_t	W
Effective power input	P_e	W
Indoor heat exchanger		
Inlet water or brine temperature	T_{in}	°C
Outlet water or brine temperature	T_{out}	°C
Volume (or mass) flow rate	q (or q_m)	m^3/s (or kg/s)
Internal or external static pressure difference	Δp_i or Δp_e	Pa
(Brine bath)		
Inlet temperature	$T_{b,i}$	°C
Outlet temperature	$T_{b,o}$	°C
Mean temperature	T_b	°C
Heat transfer medium		
Type	—	—
Volume concentration	x	%
Specific heat [a]	c_p	J/kg.K
Density [b]	ρ	kg/m^3
Refrigerant circuit		
Superheating	T_{sh}	K
Refrigerant charge	M_r	kg

[a] Values not directly measured. To be obtained from standardised property tables as a function of the arithmetic mean water or brine temperature in the indoor heat exchanger.

[b] Either directly measured or calculated from standardised property tables as a function of the arithmetic mean water or brine temperature in the indoor heat exchanger.

6.6.2 Performance calculation

An average heating or cooling capacity shall be determined from the set of heating or cooling capacities recorded over the data collection period. This heating or cooling capacity shall be corrected with the power input of the pump, in accordance with 6.1.1 or 6.1.2, where applicable.

An average electric power input shall be determined on the basis of the integrated electrical power over the same data collection period as the one used for heating or cooling capacity calculation. The effective power input is calculated from this average electric power, according to 6.1.3.

The coefficient of performance COP and the energy efficiency ratio EER are determined from the above calculations, where applicable.

7 Operational requirements

7.1 Temperature operating range

The unit shall be capable of operating within the limits of use indicated by the manufacturer.

For every condition stated in Table 8 and/or Table 9, the unit shall start up and operate for at least 20 minutes, without being stopped by the safety devices.

Table 8 — Operational requirement conditions — Heating mode

Type	Brine bath temperature	Water outlet temperature	Voltage
All types	4	Upper limit of use	Rated voltage
All types	4	Lower limit of use	Rated voltage

Table 9 — Operational requirement conditions – Cooling mode

Type	Brine bath temperature	Water outlet temperature	Voltage
All types	30	Upper limit of use	Rated voltage
All types	30	Lower limit of use	Rated voltage

The temperatures and the voltage shall be set at the beginning of the test as defined in Table 8 and/or Table 9 and maintained constant during the test.

The environmental conditions during the test shall be as specified in Table 2. The flow rates shall be the same as those used for the rating capacity test. Deviation between individual values and set values shall be between:

— zero and minus twice the permissible deviation according to Table 6, for the upper limit of use;

— zero and plus twice the permissible deviation according to Table 6, for the lower limit of use.

Uncertainties of measurement shall be as specified in Table 5.

7.2 Safety tests

7.2.1 General

The safety tests shall prove whether the safety mechanisms provide an efficient protection of the heat pump from possible damages caused by the simulated failures on the heat pump.

The unit shall have attained steady state in the standard rating conditions according to Table 3 with the permissible deviations given in Table 5 before every fault is simulated.

In order to check the safety devices of the heat pump, three different failure situations shall be consecutively simulated.

7.2.2 Pressure drop

The pressure of the refrigerant in the suction line of the compressor is reduced until the low-pressure safety device is triggered. The unit shall turn off and lock immediately. The unit is checked for any damage sustained during the test and if any safety devices have operated during the test.

The failure is simulated by closing the valve, if any, or by discharging refrigerant into a recycling container.

7.2.3 Shutting off the heat transfer medium flow

Shutting off the heat transfer medium flow at the indoor heat exchanger side is obtained e.g. by turning off the circulation pump. The fault shall be maintained for at least one hour.

The unit is checked for any damage sustained during the test, as well as if any safety devices were triggered during the test. The unit shall suffer no damage and shall remain capable of operating after restoration of the flow rate. A safety device that does not automatically reset may trip, provided that a warning device is fitted.

7.2.4 Complete power supply failure

Complete power supply failure lasting approximately 5 s shall be simulated. After restoration of power, the unit shall restart automatically no more than 20 minutes after the compressor has been allowed to restart by the control devices of the unit.

The unit is checked for any damage sustained during the test, as well as if any safety devices were triggered during the test.

The test does not apply when the manufacturer states that the machine does not automatically restart after power supply failure.

8 Test report

8.1 General information

The test report shall include at least the following data:

a) date;

b) test institute;

c) test location;

d) test supervisor;

e) test object designation:

   1) type,

   2) serial number,

   3) name of the manufacturer,

   4) year of production;

f) type and mass of the refrigerant;

g) properties of heat transfer fluids;

h) reference to this European Standard.

8.2 Additional information

8.2.1 Rating plate

Additional information given on the rating plate shall be noted, as well as any other information relevant for the test.

8.2.2 Refrigerant lines

In order to assure the repeatability of the tests, the dimensions and lengths of the refrigerant lines between the in-ground heat exchanger and the heat pump module shall be stated in the report.

8.2.3 Design and dimensions of the in-ground heat exchanger

The in-ground heat exchanger shall be characterised with the following data:

— number of parallel loops;

— tube length per loop [m];

— inside diameter of loop tube [mm];

— wall thickness of the loop tube [mm];

— inside diameter and length of each refrigerant line [mm] and [m];

— materials of the refrigerant lines and of the loop tubes.

8.3 Test results

8.3.1 Performance rating tests

For each rating test, the test report shall include at least the following items for each of the rating conditions:

— refrigerant charge;

— superheating;

— heating capacity (where applicable);

— cooling capacity (where applicable);

— effective power input;

— coefficient of performance (COP), where applicable;

— energy efficiency ratio (EER), where applicable;

— static pressure drop or external static pressure on the indoor heat exchanger side.

8.3.2 Limits of operation

The measured points shall be noted with the remark "passed" or "not passed".

8.3.3 Safety tests

The performance of the unit during the safety tests shall be recorded with a remark "passed" or "not passed" for every failure simulation.

9 Marking

Each unit shall have a durable, permanently fixed rating plate that is easily readable or accessible when the unit is installed, bearing at least the following information in addition to information required by safety standards:

- manufacturer or supplier;
- manufacturer's model designation and serial number;
- the COP and/or EER with three significant figures and the standard rating conditions at which it is measured according to Table 3 and/or Table 4;
- heating and/or cooling capacity in kilowatts, with two digits after the decimal comma but not more than 3 significant figures at the test condition according to Table 3 and/or Table 4;
- type of refrigerant.

Further information may be provided; with regard to rating, only the other rating conditions given in Table 3 and Table 4 are to be used.

10 Technical data sheet

10.1 General description

The manufacturer shall provide the following information:

- trade mark, model designation;
- power supply (voltage, frequency);
- denomination of the unit (e.g. direct exchange-to-water unit, DX / water);
- intended use of the unit according to Tables 3 and 4 (e.g. heat pump for low heating temperature applications);
- type, number, length and diameter of in-ground heat-exchanger loops;
- length and diameter of each refrigerant line;
- type and mass of refrigerant charge;
- overall dimensions and weight of the heat pump module.

10.2 Performance characteristics

10.2.1 Rating characteristics

The manufacturer shall provide in a table or as a graph the rating characteristics according to this standard.

Rating characteristics include:

— the heating capacity, the effective power input and the COP (where applicable);

— the cooling capacity, the effective power input, and the EER (where applicable).

The manufacturer shall state that the characteristics apply to a new unit with clean heat exchangers.

10.2.2 Additional characteristics

In addition, the manufacturer shall provide the following characteristics for the rated point(s):

— nominal water flow rate and internal/external static pressure, where applicable.

10.2.3 Sound characteristics

The manufacturer shall provide the sound power level measured at the standard rating condition and the corresponding test method according to EN 12102:2008.

10.3 Electrical characteristics

The manufacturer shall specify the electrical characteristics in accordance with EN 60335-2-40 or EN 60204-1 as applicable and:

— maximum starting current of the unit, as defined in EN 61000-3-11;

— total power input and current at the rated point, excluding the starting period;

— reactive power or power factor at the rated point, for units with a total power input greater than 10 kW;

— power input of pump if included in the units.

10.4 Operating range

The manufacturer shall specify:

— limits of use (temperatures);

— the presence of any devices which do not allow the unit to operate when these limits are exceeded.

11 Instructions

11.1 General

If not already required by other standards, the manufacturer shall provide the information as described.

11.2 Physical description

11.2.1 Refrigerant and liquid circuits

The manufacturer shall:

— specify the refrigerant and liquid circuits preferably providing circuit diagrams, showing every functional unit, control and safety device and specifying their type;

— if used, specify the type of brine and the concentration into any other liquid;

— specify the type of oil to be used in the compressor.

11.2.2 Additional heating devices, when integral to the unit

The manufacturer shall specify the type and location of additional heating devices and their control and safety devices.

11.2.3 Control and safety

The manufacturer shall:

- state the functions achieved by the control and safety devices provided with the unit and specify when applicable their provision for adjustment and the method by which the safety devices are reset;
- provide specifications for any control or safety devices necessary to ensure correct operation of the unit but which are not provided with the unit;
- specify any limitation to the use of the rest of the installation.

11.3 Instructions for installation

The manufacturer shall specify in particular:

a) the required location conditions (whether units are to be installed outside or in a weather proof enclosure, or in a heated space);

b) requirements of physical layout, access and clearance;

c) requirements for the electrical, liquid, and refrigerant connections, to be made on site;

d) the location of warning and tripping devices;

e) the installation precautions to be taken to ensure, in particular:

   1) correct circulation of the heat transfer media;

   2) water draining;

   3) cleanliness of heat exchange surfaces;

   4) to minimise noise, vibration or other adverse effects.

Special indications for units using soil, sea water, ground water or surface water: specify any materials which are in contact with the water or with the brine.

11.4 Instruction for maintenance

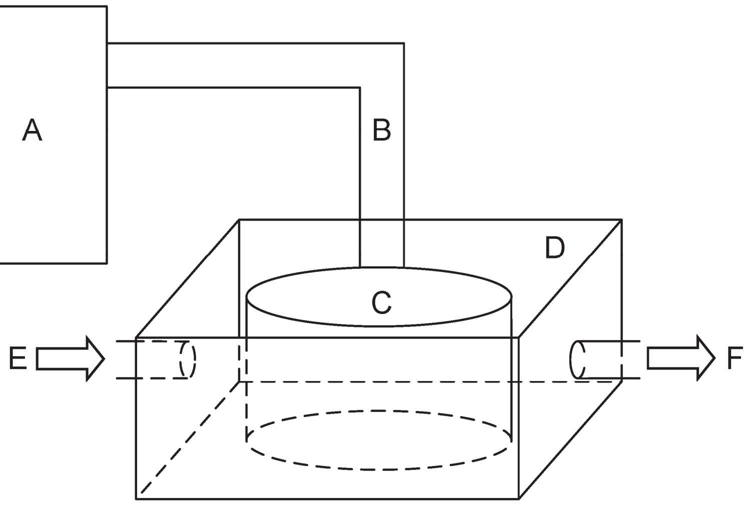
The manufacturer shall state:

- content and frequency of routine maintenance operations to be performed by the user;
- content and frequency of maintenance and inspection operations which shall be performed by a specialist.

Annex A
(informative)

A.1 Description of the brine bath

This Annex summarises some of the requirements and gives general guidelines for building a brine bath as needed for the tests on direct exchange ground coupled heat pumps according to this standard.



Legend

A heat pump unit

B refrigerant lines

C collector lines of the outdoor heat exchanger, submerged in the brine bath

D brine vessel

E brine inlet of the brine bath

F brine outlet of the brine bath

Figure A.1 — Possible design of the test rig configuration for the in-ground heat exchanger

The brine bath consists of a vessel, preferable circular, with insulated outer wall, which contains the brine of a defined composition. An apparatus for the distribution of the brine is positioned in such a way to facilitate the maintenance of a constant brine temperature over the measurement time within the defined tolerance. The velocity of the brine in the bath should be as small as possible. Also, the number and position of the inlets and the outlets should ensure a small vertical temperature gradient in the bath.

The tubes of the in-ground heat exchanger should be mounted on a firm structure inside the brine bath. The structure must ensure that the tubes of the in-ground heat exchanger lines remain in their position throughout the testing period. It must also ensure the right positioning of the neighbouring tubes, according to this standard. It should be possible to cover and insulate the vessel from the top to minimise the losses thus improving the accuracy of the whole apparatus and to protect the bath from dirt.

The control system includes thermometers at the inlet and outlet lines of the vessel. It could also include a variable speed pump to adjust the mass flow to the cooling capacity of the unit under test.

Annex B
(informative)

Example for the calculation of the Coefficient of Performance (COP) and the Energy Efficiency Ratio (EER)

This Annex gives an example on how to calculate the COP and the EER from the measured values.

B.1 Calculation of the COP for heating applications

B.1.1 Input Data

The measurement was conducted for the standard rating condition for low temperature heating applications (E4/W35). The heat transfer medium in the indoor heat exchanger was water.

Data from the measurement (mean values over the testing period):

Table B.1 — Example measurement data for the calculation of the COP of a DX / water heat pump in the heating mode

Measured quantity	Symbol	Unit	Value
Ambient temperature	T_a	°C	23
Electrical quantities			
Voltage	U	V	400,54
Total current	I	A	5,76 [a] 5,35 [b]
Power factor	$cos\ \varphi$	—	0,74
Total power input	P_T	W	3 997,86 [a] 3 713,59 [b]
Effective power input	P_E	W	2 958,42 [a] 2 748,06 [b]
Indoor heat exchanger			
Inlet water or brine temperature	T_{in}	°C	29,89
Outlet water or brine temperature	T_{out}	°C	34,96
Mass flow rate	q_m	kg/s	0,568
External static pressure difference	Δp_e	Pa	127 734 [a]
Internal static pressure difference	Δp_i	Pa	-15 851 [b]
Brine bath			
Inlet temperature	$T_{b,i}$	°C	4,07
Outlet temperature	$T_{b,o}$	°C	3,85
Mean temperature	T_b	°C	3,96
Heat transfer medium			
Type	—	—	water
Volume concentration	x	%	—
Specific heat	c_p	J/kg.K	$4{,}179 \cdot 10^3$
Density	ρ	kg/m^3	994,18
Refrigerant circuit			
Superheating	T_{sh}	K	6,78
Refrigerant charge	M_r	kg	6,83

[a] Measured values for the case with an integrated liquid pump.

[b] Measured values for the case without an integrated liquid pump.

B.1.2 Calculation of the heating power P_H

The heating power P_H is calculated using Equation (1). Since Equation (1) features volume flow rate q and in this example the measured quantity was mass flow rate q_m, it can be used directly instead of the term $q x \rho$.

$$P_H = q \times \rho \times c_p \times \Delta T = q_m \times c_p \times \Delta T \quad \text{(B.1)}$$

Hence,

$$P_H = 0{,}568\ kg/s \times 4{,}179 \cdot 10^3\ J/kg \cdot K \times (34{,}96 - 29{,}89)°C = 12\ 034{,}52\ W \tag{B.2}$$

Notice that both the density ρ and the specific heat capacity c_p of the heat transfer fluid are functions of both pressure and temperature. Since the influence of the pressure is very small in the relevant range of the liquid phase, it can be neglected.

B.1.3 Calculation of the volume flow rate *q*

The liquid pump power P_{LP} is calculated according to Equations (3) or (4), depending on whether a liquid pump is an integral part of the heat pump unit or not. Both equations feature the measured volume flow rate q of the heat transfer medium. Since in this example the mass flow rate q_m was measured, q has to be calculated.

$$q = \frac{q_m}{\rho} = \frac{0{,}568\ kg/s}{994{,}18\ \text{kg}/m^3} = 5{,}71 \cdot 10^{-4}\ m^3/s \tag{B.3}$$

B.1.4 Calculation of the COP if a liquid pump is integrated into the heat pump unit

For the case where a liquid pump is included, the pumping work P_{LP} is calculated from Equation (3). The value for the efficiency of the liquid pump is assumed to be 0,3.

$$P_{LP} = \frac{q \times \Delta p_e}{\eta} = \frac{5{,}71 \cdot 10^{-4}\ m^3/s \times 127\ 734\ \text{Pa}}{0{,}3} = 243{,}12\ W \tag{B.4}$$

The COP is calculated subtracting the liquid pump power P_{LP} from both P_H and P_E as follows:

$$COP = \frac{P_H - P_{LP}}{P_E - P_{LP}} = \frac{12\ 034{,}52\ W - 243{,}12\ W}{2\ 958{,}42\ W - 243{,}12\ W} = 4{,}34 \tag{B.5}$$

B.1.5 Calculation of the COP if a liquid pump is not integrated into the heat pump unit

If a liquid pump is not included into the heat pump unit, the pumping work P_{LP} is calculated from Equation (4).

$$P_{LP} = \frac{q \times (-\Delta p_i)}{\eta} = \frac{5{,}71 \cdot 10^{-4}\ m^3/s \times 15\ 851\ Pa}{0{,}3} = 30{,}17\ W \tag{B.6}$$

The COP is calculated adding the liquid pump power P_{LP} to both P_H and P_E as follows:

$$COP = \frac{P_H + P_{LP}}{P_E + P_{LP}} = \frac{12\ 034{,}52\ W + 30{,}17\ W}{2\ 748{,}06\ W + 30{,}17\ W} = 4{,}34 \tag{B.7}$$

B.2 Calculation of the EER for cooling applications

B.2.1 General

The calculation of the EER is analogous to the calculations for the COP given in B.1. The cooling capacity P_C is calculated using Equation (2).

B.2.2 Calculation of the EER if a liquid pump is integrated into the heat pump unit

If a liquid pump is integrated into the heat pump unit, the power input of the liquid pump will be calculated according to Equation (3). The EER is then calculated from Equation (B.8):

$$EER = \frac{P_C + P_{LP}}{P_E - P_{LP}} \quad (B.8)$$

B.2.3 Calculation of the EER if a liquid pump is not integrated into the heat pump unit

If a liquid pump is not integrated into the heat pump unit, the power input of the liquid pump will be calculated according to Equation (4). The EER is then calculated from Equation (B.9):

$$EER = \frac{P_C - P_{LP}}{P_E + P_{LP}} \quad (B.9)$$

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