BS EN 14511-3:2011

BSI Standards Publication

Air conditioners, liquid chilling packages and heat pumps with electrically driven compressors for space heating and cooling

Part 3: Test methods

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National foreword

This British Standard is the UK implementation of EN 14511-3:2011. It supersedes BS EN 14511-3:2007, which is withdrawn.

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.

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Climatiseurs, groupes refroidisseurs de liquide et pompes à chaleur avec compresseur entraîné par moteur électrique pour le chauffage et la réfrigération des locaux - Partie 3: Méthodes d'essai

Luftkonditionierer, Flüssigkeitskühlsätze und Wärmepumpen mit elektrisch angetriebenen Verdichtern für die Raumbeheizung und Kühlung - Teil 3: Prüfverfahren

This European Standard was approved by CEN on 20 August 2011.

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Foreword

This document (EN 14511-3:2011) 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of an identical text or by endorsement, at the latest by April 2012, and conflicting national standards shall be withdrawn at the latest by April 2012.

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 14511-3:2007.

This document has been prepared under a mandate given to CEN by the European Commission and the European Free Trade Association.

EN 14511 comprises the following parts under the general title *Air conditioners, liquid chilling packages and heat pumps with electrically driven compressors for space heating and cooling*:

— *Part 1: Terms and definitions*,

— *Part 2: Test conditions*,

— *Part 3: Test methods*,

— *Part 4: Requirements*.

According to the CEN/CENELEC Internal Regulations, the national standards organizations of the following countries are bound to implement this European Standard: Austria, Belgium, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, Switzerland and the United Kingdom.

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1 Scope

1.1 The scope of EN 14511-1:2011 is applicable.

1.2 This European Standard specifies the test methods for the rating and performance of air conditioners, liquid chilling packages and heat pumps using either air, water or brine as heat transfer media, with electrically driven compressors when used for space heating and cooling.

It also specifies the method of testing and reporting for heat recovery capacities, system reduced capacities and the capacity of individual indoor units of multisplit systems, where applicable.

2 Normative references

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

EN 14511-1:2011, *Air conditioners, liquid chilling packages and heat pumps with electrically driven compressors for space heating and cooling — Part 1: Terms and definitions*

EN 14511-2:2011, *Air conditioners, liquid chilling packages and heat pumps with electrically driven compressors for space heating and cooling — Part 2: Test conditions*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in EN 14511-1:2011 apply.

4 Rating capacity test

4.1 Basic principles Method of calculation for the determination of capacities

4.1.1 Heating capacity

The heating capacity of air conditioners and of air-to-air or water-to-air heat pumps shall be determined by measurements in a calorimeter room (see Annex A) or by the air enthalpy method (see Annex B).

The heating capacity of air-to-water, water-to-water heat pumps and liquid chilling packages shall be determined in accordance with the direct method at the water or brine heat exchanger, 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.

For steady state operation, the heating capacity shall be determined using the following formula:

$$P_H = q \times \rho \times c_p \times \Delta t \qquad (1)$$

where

P_H is the heat capacity, expressed in Watts;

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

ρ is the density, expressed in kilograms per cubic metre;

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

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

NOTE 1 The mass flow rate can be determined directly instead of the term (q x ρ).

NOTE 2 The enthalpy change ΔH can be directly measured instead of the term (c_p x Δt).

For the heating capacity calculation in transient operation, refer to 4.5.3.2.

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

a) If the fan or pump at the indoor heat exchanger is an integral part of the unit, the same power (calculated in 4.1.5.2 or 4.1.6.3) which is excluded from the total power input shall be also subtracted from the heating capacity;

b) If the fan or pump at the indoor heat exchanger is not an integral part of the unit, the same power (calculated in 4.1.5.3 or 4.1.6.4) which is included in the effective power input shall be also added to the heating capacity.

4.1.2 Cooling capacity

The cooling capacity of air conditioners and of air-to-air or water-to-air heat pumps shall be determined by measurements in a calorimeter room (see Annex A) or by the air enthalpy method (see Annex B).

The cooling capacity of air-to-water, water-to-water heat pumps and liquid chilling packages shall be determined in accordance with the direct method at the water or brine heat exchanger, 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:

$$P_C = q \times \rho \times c_p \times \Delta t \qquad (2)$$

where

P_C is the cooling capacity, expressed in watts;

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

ρ is the density, expressed in kilograms per cubic metre;

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

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

NOTE 1 The mass flow rate can be determined directly instead of the term (q x ρ).

NOTE 2 The enthalpy change ΔH can be directly measured instead of the term (c_p x Δt)"

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

a) If the fan or pump at the evaporator is an integral part of the unit, the same power (calculated in 4.1.5.2 or 4.1.6.3) which is excluded from the total power input is also added to the cooling capacity.

b) If the fan or pump at the evaporator is not an integral part of the unit, the same power (calculated in 4.1.5.3 or 4.1.6.4) which is included in the effective power input is also subtracted from the cooling capacity.

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4.1.3 Heat recovery capacity

The heat recovery capacity of air-to-water and water-to-water heat pumps and liquid chilling packages shall be determined in accordance with the direct method at the water or brine heat exchanger, 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 heat recovery capacity shall be determined using the following formula:

$$P_{HR} = q \times \rho \times c_p \times \Delta t \qquad (3)$$

where

P_{HR} is the heat recovery capacity, expressed in Watts;

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

ρ is the density, expressed in kilograms per cubic metre;

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

Δt is the difference between inlet and outlet temperatures expressed in kelvin.

NOTE The mass flow rate can be determined directly instead of the term (q x ρ). The enthalpy change ΔH can be directly measured instead of the term (c_p x Δt).

4.1.4 Power input of fans for units without duct connection

In the case of units which are not designed for duct connection, i.e. which do not permit any external pressure differences, and which are equipped with an integral fan, the power absorbed by the fan shall be included in the effective power absorbed by the unit.

4.1.5 Power input of fans for units with duct connection

4.1.5.1 The following corrections of the power input of fans shall be made to both indoor and outdoor fans, where applicable.

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

$$\frac{q \times \Delta p_e}{\eta} \qquad (4)$$

where

η is 0,3 by convention;

Δp_e is the measured available external static pressure difference, expressed in pascal, as defined in 2.52 of EN 14511-1:2011;

q is the nominal air flow rate, expressed in cubic meters per second.

4.1.5.3 If no fan 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:

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$$\frac{q \times (-\Delta p_i)}{\eta} \tag{5}$$

where

η is 0,3 by convention;

Δp_i is the measured internal static pressure difference, expressed in pascal, as defined in 2.53 of EN 14511-1:2011;

q is the nominal air flow rate, expressed in cubic meters per second.

4.1.6 Power input of liquid pumps

4.1.6.1 The following corrections of the power input of liquid pumps shall be made to both indoor and outdoor liquid pumps, where applicable.

4.1.6.2 When the liquid pump is integrated into 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 then considered as an integral part of the unit.

4.1.6.3 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 using the following formula:

$$\frac{q \times \Delta p_e}{\eta} \tag{6}$$

where

η is the efficiency of the pump calculated according to Annex H;

Δp_e is the measured available external static pressure difference, expressed in Pascal, as defined in 2.52 of EN 14511-1:2011;

q is the nominal liquid flow rate, expressed in cubic meters per second.

4.1.6.4 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:

$$\frac{q \times (-\Delta p_i)}{\eta} \tag{7}$$

where

η is the efficiency of the pump calculated according to Annex H;

Δp_i is the measured internal static pressure difference, expressed in pascal, as defined in 2.53 of EN 14511-1:2011;

q is the nominal liquid flow rate, expressed in cubic meters per second.

4.1.6.5 In the case of appliances designed especially to operate on a distributing network of pressurised water without water-pump, no correction is to be applied to the power input.

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4.1.7 Units for use with remote condenser

The power from the auxiliary liquid pump of the remote condenser shall not be taken into account in the effective power input.

4.2 Test apparatus

4.2.1 Arrangement of the test apparatus

4.2.1.1 General requirements

The test apparatus shall be designed in such a way that all requirements on adjustment of set values, stability criteria and uncertainties of measurement according to this European Standard can be fulfilled.

4.2.1.2 Test room for the air side

The size of the test room shall be selected such that any resistance to air flow at the air inlet and air outlet orifices of the test object is avoided. The air flow through the room shall not be capable of initiating any short circuit between these two orifices, and therefore the velocity of the air flows through the room at these two locations shall not exceed 1,5 m/s when the test object is switched off. The air velocity in the room shall also not be greater than the mean velocity through the unit inlet. Unless otherwise stated by the manufacturer, the air inlet or air outlet orifices shall be not less than 1 m distant from the surfaces of the test room.

Any direct heat radiation by heating units in the test room onto the unit or onto the temperature measuring points shall be avoided.

4.2.1.3 Appliances with duct connection

The connections of a ducted air unit to the test facility shall be sufficiently air tight to ensure that the measured results are not significantly influenced by exchange of air with the surroundings.

4.2.1.4 Appliances with integral pumps

For appliances with integral and adjustable water or brine pumps, the external static pressure shall be set at the same time as the temperature difference.

4.2.1.5 Liquid chilling package for use with remote condenser

Units for use with remote condenser are tested by using a water-cooled condenser, the characteristics of which shall enable the intended operating conditions to be achieved.

4.2.2 Installation and connection of the test object

4.2.2.1 General

The test object shall be installed and connected for the test as recommended by the manufacturer in the installation and operation manual. The accessories provided by option are not included in the test. If a back-up heater is provided in option or not, it shall be switched off or disconnected to be excluded from the testing.

For single ducts, regardless of the manufacturer’s instructions, the discharge duct shall be as short and straight as possible compatibly with minimum distance between the unit and the wall for correct air inlet but not less than 50 cm. No accessory shall be connected to the discharge end of the duct.

For double duct units, the same requirements apply to both suction and discharge ducts, unless the appliance is designed to be installed directly on the wall. For multisplit systems, the test shall be performed with the system operating at a capacity ratio of 1, or as close as possible.

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When the liquid pump is an integral part of the unit and the external static pressure setting possible, the setting shall be made in order to reduce this external pressure to approach zero.

When performing measures in heating mode, set the highest room temperature on the unit/system control device; when performing measures in cooling mode, set the lowest room temperature on the unit/system control device. If in the instructions, the manufacturer indicates a value for the temperature set on the control device for a given rating condition, then this value shall be used.

For unit with open-type compressor the electric motor shall be supplied or specified by the manufacturer. The compressor shall be operated at the rotational speed specified by the manufacturer.

For inverter type control units, the setting of the frequency shall be done for each rating condition. The manufacturer shall provide in the documentation information about how to obtain the necessary data to set the required frequencies.

NOTE If a skilled personnel with knowledge of control software is required for the start of the system, the manufacturer or the nominated agent should be in attendance when the system is being installed and prepared for tests.

4.2.2.2 Installation of unit consisting of several parts

In the case of a unit consisting of several parts, the following installation conditions shall be complied for the test.

a) The refrigerant lines shall be installed in accordance with the manufacturer's instructions. The length of the lines shall be 5 m except if the constraints of the test installation make 5 m not possible, in which case a greater length may be used, with a maximum of 7,5 m.

b) The lines shall be installed so that the difference in elevation does not exceed 2,5 m.

c) The thermal insulation of the lines shall be applied in accordance with the manufacturer's instructions.

d) Unless constrained by the design, at least half of the connecting lines shall be exposed to the outside conditions, with the rest of the lines exposed to the inside conditions.

4.2.2.3 Indoor units of multisplit systems

When testing a multisplit system in a calorimeter room, the air flow rate and the external static pressure shall be adjusted separately for each one of the ducted indoor units.

When testing a multisplit system using the air enthalpy method, the air flow rate and the external static pressure shall be adjusted separately for each indoor unit, ducted or not.

In case of equipment with non ducted indoor units tested using the air enthalpy method, the above requirement on ducted indoor units shall apply.

4.2.2.4 Measuring points

Temperature and pressure measuring points shall be arranged in order to obtain mean significant values.

For free air intake temperature measurements, it is required:

— either to have at least one sensor per square meter, with not less than four measuring points and by restricting to 20 the number of sensors equally distributed on the free air surface;

— or to use a sampling device. It shall be completed by four sensors for checking uniformity if the surface area is greater than 1 m².

Air temperature sensors shall be placed at a maximum distance of 0,25 m from the free air surface.

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For control cabinet air conditioners, the inlet temperature at the evaporator is measured instead of the temperature inside the control cabinet.

For units consisting of a heat pump and a storage tank as a factory made unit, water inlet and outlet temperature measurements shall be taken at the inlet and outlet of the tank respectively.

For water and brine, the density in formulae (1), (2) and (3) shall be determined in the temperature conditions measured near the volume flow measuring device.

4.3 Uncertainties of measurement

The uncertainties of measurement shall not exceed the values specified in Table 1.

Table 1 — Uncertainties of measurement for indicated values

Measured quantity	Unit	Uncertainty of measurement
Liquid		
- temperature difference	K	± 0,15 K
- temperature inlet/outlet	K	± 0,15 K
- volume flow	m^3/s	± 1 %
- static pressure difference	kPa	± 5 %
Air		
- dry bulb temperature	°C	± 0,2 K
- wet bulb temperature	°C	± 0,4K
- volume flow	m^3/s	± 5 %
- static pressure difference	Pa	± 5 Pa ($\Delta p \leq 100$ Pa) or ± 5 %($\Delta p > 100$ Pa)
Refrigerant		
- pressure at compressor outlet	kPa	± 1 %
- temperature	°C	± 0,5 K
Concentration		
- Heat transfer medium	%	± 2
Electrical quantities		
- electric power	W	± 1 %
- voltage	V	± 0,5 %
- current	A	± 0,5 %
- electrical energy	kWh	± 1 %
Compressor rotational speed	min^{-1}	± 0,5 %

The heating or cooling capacities measured on the liquid side shall be determined within a maximum uncertainty of 5 % independent of the individual uncertainties of measurement including the uncertainties on the properties of fluids.

The steady state heating or cooling capacities determined using the calorimeter method shall be determined with a maximum uncertainty of 5 %, independent of the individual uncertainties of measurement including the uncertainties on the properties of fluids; this maximum uncertainty is extended to 10% for single duct units due to the air exchange between the two compartments of the calorimeter room.

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Heating capacity determined during transient operation (defrost cycles) using the calorimeter method shall be determined with a maximum uncertainty of 10 %, independent of the individual uncertainties of measurement including the uncertainties on the properties of fluids.

The heating and cooling capacities measured on the air side using the air enthalpy method shall be determined with a maximum uncertainty of 10 %, independent of the individual uncertainties of measurement including the uncertainties on the properties of fluids.

4.4 Test procedure

4.4.1 General

4.4.1.1 All units

The test conditions are given in EN 14511-2:2011.

If liquid heat transfer media other than water are used, the specific heat capacity and density of such heat transfer media shall be determined and taken into consideration in the evaluation.

Table 4 states permissible deviations of the measured values from the test conditions.

4.4.1.2 Non ducted units

For non-ducted units, the adjustable settings such as louvers and fan speed shall be set for maximum steady-state air flow.

For inverter type control units, if the manufacturer indicates a speed of the fan different from the maximum one to set on the control device for a given rating condition, then this speed shall be used.

4.4.1.3 Units ducted on the indoor heat exchanger

The volume flow and the pressure difference shall be related to standard air and with dry heat exchanger.

If the airflow rate is given by the manufacturer with no atmospheric pressure, temperature and humidity conditions, it shall be considered as given for standard air conditions.

The airflow rate given by the manufacturer shall be converted into standard air conditions. The setting of this airflow rate shall be made when the fan only is operating.

The rated air flow rate given by the manufacturer shall be set and the resulting external static pressure (ESP) measured.

If the ESP is lower than the minimum value given in Table 2 (or Table 3), the air flow rate is decreased to reach this minimum value.

If the ESP is greater than twice the minimum value given in Table 2 (or Table 3), the air low rate is increased to reach twice this minimum value.

If the ESP is greater than the minimum value given in Table 2 (or Table 3) but not greater than twice this minimum value, then keep this ESP.

The apparatus used for setting the ESP shall be maintained in the same position during all the tests.

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Table 2 — Pressure requirement for comfort air conditioners

Standard capacity ratings kW	**Minimum external static pressure** [a b] Pa
$0 < Q < 8$	25
$8 \leq Q < 12$	37
$12 \leq Q < 20$	50
$20 \leq Q < 30$	62
$30 \leq Q < 45$	75
$45 \leq Q < 82$	100
$82 \leq Q < 117$	125
$117 \leq Q < 147$	150
$Q \geq 147$	175

[a] For equipment tested without an air filter installed, the minimum external static pressure shall be increased by 10 Pa.

[b] If the manufacturer's installation instructions state that the maximum allowable discharge duct length is less than 1m, then the unit can be considered as a free delivery unit and be tested as a non ducted indoor unit with an ESP of 0 Pa.

Table 3 — Pressure requirement for close control air conditioners

Capacity kW	**Pressure** Pa	
	For down-flow discharge into double floor	For up-flow discharge into duct all units
< 30	50	-
≥ 30	75	-
All	-	50

4.4.1.4 Units ducted on the outdoor heat exchanger

The volume flow and the pressure difference shall be related to standard air and with dry heat exchanger.

If the air flow rate is given by the manufacturer with no atmospheric pressure, temperature and humidity conditions, it shall be considered as given for standard air conditions.

The air flow rate given by the manufacturer shall be converted into standard air conditions. The air flow rate setting shall be made when the fan only is operating.

The rated air flow rate given by the manufacturer shall be set and the resulting external static pressure (ESP) measured.

If the ESP is lower than 30 Pa, the air flow rate is decrease to reach this minimum value.

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The apparatus used for setting the ESP shall be maintained in the same position during all the tests.

If the manufacturer's installation instructions state that the maximum allowable discharge duct length is less than 1m, then the unit can be considered as a free delivery unit and be tested as a non ducted outdoor unit with an ESP of 0 Pa.

Table 4 — Permissible deviations from set values

Measured quantity	Permissible deviation of the arithmetic mean values from set values	Permissible deviations of each of the individual measured values from set values
Liquid		
- inlet temperature	± 0,2 K	± 0,5 K
- outlet temperature	± 0,3 K	± 0,6 K
- volume flow	± 1 %	± 2,5 %
- static pressure difference	--	± 10 %
Air		
- inlet temperature (dry bulb/wet bulb)[a]	± 0,3 K	± 1 K
- volume flow	± 5 %	± 10 %
- static pressure difference	-	± 10 %
Refrigerant		
- liquid temperature	± 1 K	± 2 K
- saturated vapour/bubble point temperature	± 0,5 K	± 1 K
Voltage	± 4 %	± 4 %

[a] For units with outdoor heat exchanger surfaces greater than 5 m², the deviation on the air inlet dry bulb temperature is doubled.

NOTE When testing single duct units the arithmetic mean value of the difference between the dry bulb temperature of the indoor compartment and of the air introduced from the outdoor compartment should have a maximum permissible deviation of 0,3 K. This requirement also applies to the wet bulb temperature difference.

4.4.2 Output measurement for water (brine)-to-water (brine) and water (brine)-to-air units

4.4.2.1 Steady state conditions

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 h, with respect to the tolerances given in Table 4. Periodic fluctuations of measured quantities caused by the operation of regulation and control devices are permissible, on condition the mean value of such fluctuations does not exceed the permissible deviations listed in Table 4.

4.4.2.2 Measurement of heating capacity, cooling capacity and heat recovery capacity

For the output measurement, it is necessary to record all the 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 s.

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The output shall be measured in the steady state condition. The duration of measurement shall be not less than 35 min.

4.4.3 Output measurement for cooling capacity of air-to-water and air-to-air units

4.4.3.1 Steady state conditions

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 h, with respect to the tolerances given in Table 4. Periodic fluctuations of measured quantities caused by the operation of regulation and control devices are permissible, on condition the mean value of such fluctuations does not exceed the permissible deviations listed in Table 4.

4.4.3.2 Measurement of cooling capacity

For the output measurement it is necessary to record all the 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 s.

The output shall be measured in the steady state condition. The duration of measurement shall be not less than 35 min.

4.4.4 Output measurement for heating capacity of air-to-air units with the air enthalpy method and of air-to-water units

4.4.4.1 General

The test procedure consists of three periods: a preconditioning period, an equilibrium period, and a data collection period. The duration of the data collection differs depending upon whether the heat pump's operation is steady state or transient.

Annex C gives a flow chart of the procedure and schematically represents most of the different test sequences that are possible when conducting a heating capacity test.

4.4.4.2 Preconditioning period

The test room reconditioning apparatus and the heat pump under test shall be operated until the test tolerances specified in Table 4 are attained for at least 10 min.

A defrost cycle may end a preconditioning period. If a defrost cycle does end a preconditioning period, the heat pump shall operate in the heating mode for at least 10 min after defrost termination prior to beginning the equilibrium period.

It is recommended that the preconditioning period end with an automatic or manually induced defrost cycle when testing at application rating conditions for outdoor air stated in Table 3 and in Tables 18 to 21 of EN 14511-2:2011.

For units having defrost cycles at the standard rating condition, the water flow rate shall be set at the corresponding inlet/outlet water temperatures 20 minutes after the end of a defrost cycle, manually or automatically induced.

4.4.4.3 Equilibrium period

The equilibrium period immediately follows the preconditioning period or the defrost cycle and a recovery period of 10 min that ends a preconditioning period.

A complete equilibrium period is one hour in duration.

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