SASO 2681

NON-DUCTED AIR CONDITIONERS AND HEAT PUMPS – TESTING AND RATING PERFORMANCE

NON-DUCTED AIR CONDITIONERS AND HEAT PUMPS – TESTING AND RATING PERFORMANCE

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Annexes

FOREWORD

The Saudi Arabian Standards Organization (SASO) has adopted the international standard (ISO 5151:1994) “Non-ducted air conditioners and heat pumps – Testing and rating for performance” issued by the International Organization for Standardization. It has been prepared to be approved as a Saudi standard after introducing few additions (see clauses 4.2.5.5, 4.2.5.6, 5.2.5.4, 5.2.5.5 and 5.2.5.6) to suit local requirements.

NON-DUCTED AIR CONDITIONERS AND HEAT PUMPS – TESTING AND RATING PERFORMANCE

1- SCOPE

1.1 This SASO Standard specifies the standard conditions on which the ratings of single-package and split-system non-ducted air conditioners employing air- and water-cooled condensers and heat pumps employing air-cooled condensers are based, and the test methods to be applied for determination of the various ratings. This SASO Standard is limited to systems utilizing a single refrigeration circuit and having one evaporator and one condenser.

NOTE 1 For the purposes of this SASO Standard, the term "equipment" will be used to mean "non-ducted air conditioners and/or non-ducted heat pumps".

1.2 This SASO Standard also specifies the test conditions and the corresponding test procedures for determining various performance characteristics of these non-ducted air conditioners and heat pumps.

1.3 It does not apply to the testing and rating of:

a) water-source heat pumps;

b) multiple split-system[1] air conditioners and heat pumps;

c) units designed for use with additional ducting; or

d) mobile (windowless) units having a condenser exhaust duct.

1.4 Clause 4 of this SASO Standard covers the rating and testing conditions for non-ducted air conditioners and heat pumps when used for cooling.

1.5 Clause 5 of this SASO Standard covers the rating and testing conditions for non-ducted air conditioners and heat pumps when used for heating. The means for heating may be the heat pump refrigeration cycle or electrical resistance.

1.6 Annex A establishes testing procedures. Annex B describes the test facilities for the calorimeter method. Annex C provides formulae for the calculation of heating and cooling capacities. Annex D describes instruments which can be used in making measurements, and annex E describes methods for measuring air-flow. Annex F describes the outdoor air-enthalpy test method. Annex G gives a list of symbols used in the annexes.

[1] A unit having two or more indoor units connected to a single outdoor unit.

2- NORMATIVE REFERENCE

The following standard contains provisions which, through reference in this text, constitute provisions of this SASO Standard. At the time of publication, the edition indicated was valid. All standards are subject to revision, and parties to agreements based on this SASO Standard are encouraged to investigate the possibility of applying the most recent edition of the standard indicated below. Members of IEC and ISO maintain registers of currently valid SASO Standards.

ISO 817:—[1] , *Refrigerants — Number designation.*

3- DEFINITIONS

For the purposes of this SASO Standard, the following definitions apply. Annex G lists the symbols used to identify the terms contained in this SASO Standard.

3.1 **non-ducted air conditioner:** An encased assembly or assemblies designed as a unit, primarily for mounting in a window, or through a wail, or as a console. It is designed primarily to provide free delivery of conditioned air to an enclosed space, room or zone (conditioned space). It includes a prime source of refrigeration for cooling and dehumidification and may also include means for heating other than a heat pump, and means for the circulation and the cleaning of air. It may also include means for heating, humidifying, ventilating or exhausting air. Where such equipment is provided in more than one assembly, the separated assemblies (split-systems) are to be designed to be used together, and the requirements of rating outlined in this SASO Standard are based on the use of matched assemblies.

3.2 **non-ducted heat pump:** An encased assembly or assemblies designed as a unit, primarily for mounting in a window, or through a wall, or as a console. It is designed primarily to provide free delivery of conditioned air to an enclosed space, room or zone (conditioned space). It includes a prime source of refrigeration for heating which takes heat from a heat source. It may be constructed to remove heat from the conditioned space and discharge it to a heat sink if cooling and dehumidification are desired from the same equipment. It may also include means for the circulation and the cleaning of air, humidifying, ventilating or exhausting air.

3.3 **standard air:** Dry air at 20,0 °C, and at a standard barometric pressure of 101,325kPa, having a mass density of 1,204 kg/m^3.

NOTE 2 The definitions given in 3.4 to 3.13 relating to air-flow are illustrated in figure 1.

[1] To be published. (Revision of ISO 817:1974)

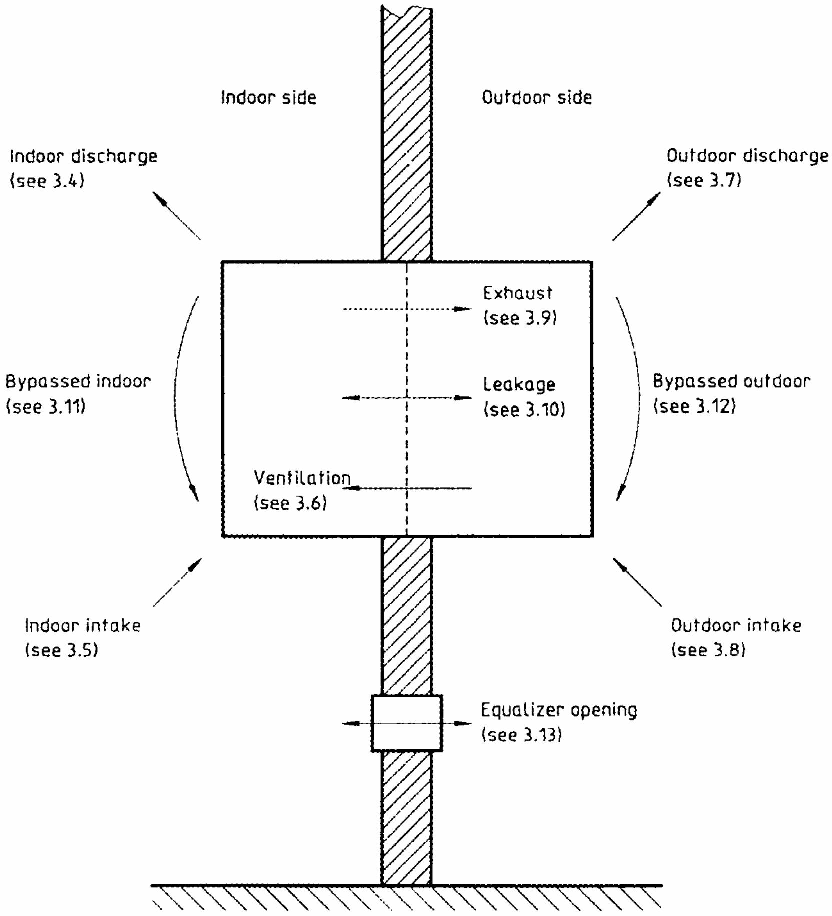


Figure 1 - Air-flow diagram illustrating definitions given in 3.4 to 3.13

3.4 **indoor discharge air-flow:** Rate of flow of air from the indoor-side outlet of the equipment into the conditioned space.

3.5 **indoor intake air-flow:** Rate of flow of air into the equipment from the conditioned space.

3.6 **ventilation air-flow:** Rate of flow of air introduced to the conditioned space through the equipment from the outside.

3.7 **outdoor discharge air-flow:** Discharge rate of flow of air from the outdoor side of the equipment to the outdoors.

3.8 **outdoor intake air-flow:** Rate of flow of air into the equipment from the outdoor side.

3.9 **exhaust air-flow:** Rate of flow of air from the indoor side through the equipment to the outdoor side.

3.10 **leakage air-flow:** Rate of flow of air interchanged between the indoor side and outdoor side through the equipment as a result of its construction features and sealing techniques.

3.11 **bypassed indoor air-flow:** Flow of conditioned air directly from the indoor-side outlet to the indoor-side inlet of the equipment.

3.12 **bypassed outdoor air-flow:** Flow of air directly from the outdoor-side outlet to the outdoor-side inlet of the equipment.

3.13 **equalizer opening air-flow:** Rate of flow of air through the equalizer opening in the partition wall of a calorimeter.

3.14 **total cooling capacity:** Amount of sensible and latent heat that the equipment can remove from the conditioned space in a defined interval of time.

3.15 **heating capacity:** Amount of heat that the equipment can add to the conditioned space in a defined interval of time.

3.16 **latent cooling capacity; room dehumidifying capacity:** Amount of latent heat that the equipment can remove from the conditioned space in a defined interval of time.

3.17 **sensible cooling capacity:** Amount of sensible heat that the equipment can remove from the conditioned space in a defined interval of time.

3.18 **sensible heat ratio:** Ratio of the sensible cooling capacity to the total cooling capacity.

3.19 **rated voltage(s):** Voltage(s) shown on the nameplate of the equipment.

3.20 **rated frequency(ies):** Frequency(ies) shown on the nameplate of the equipment.

3.21 **energy efficiency ratio (EER):** Ratio of the total cooling capacity to the effective power input at any given set of rating conditions. (Where the EER is stated without an indication of units, it shall be understood that it is derived from watts/watt.)

3.22 **coefficient of performance (COP):** Ratio of the heating capacity to the effective power input of the device at any given set of rating conditions.

3.23 **effective power input** (P_E): Average electrical power input to the equipment within a defined interval of time, obtained from:

- the power input for operation of the compressor and any power input for defrosting, excluding additional electrical heating devices not used for defrosting;
- the power input of all control and safety devices of the equipment; and
- the power input of the conveying devices within the equipment for heat transport media (e.g. fan, pump).

3.24 **total power input** (P_t)*:* Power input to all components of the equipment as delivered.

4- COOLING TESTS

4.1 Cooling capacity ratings

4.1.1 General conditions

All equipment within the scope of this SASO Standard shall have the cooling capacities and energy efficiency ratios determined in accordance with the provisions of this SASO Standard and rated at the cooling conditions specified in table 1.

4.1.2 Temperature conditions

4.1.2.1 Test conditions stated in table 1, columns T1, T2 and T3, shall be considered standard rating conditions.

4.1.2.2 Equipment manufactured for use in a moderate climate similar to that specified in table 1, column T1 only, shall have a nameplate rating determined by tests conducted at these specified conditions and shall be designated type T1 units.

4.1.2.3 Equipment manufactured for use in a cool climate similar to that specified in table 1, column T2 only, shall have a nameplate rating determined by tests conducted at these specified conditions and shall be designated type T2 units.

4.1.2.4 Equipment manufactured for use in a hot climate similar to that specified in table 1, column T3 only, shall have a nameplate rating determined by tests conducted at these specified conditions and shall be designated type T3 units.

4.1.2.5 Equipment manufactured for use in more than one of the types of climate defined in table 1, columns T1, T2 and T3, shall have marked on the nameplate the designated type and rating determined by tests for each of the specified conditions for which they have been designated and tested.

4.1.3 Air-flow conditions

When determining air-flow quantities for rating purposes, tests shall be conducted at standard rating conditions (see table 1) with 0 Pa static maintained at the air discharge of the equipment and with the refrigeration means in operation and after condensate equilibrium has been obtained. All air quantities shall be expressed as metre cubed per second (m^3/s) of standard air as defined in 3.3.

Table 1 — Test conditions for the determination of cooling capacity

Parameter	Standard test conditions		
	T1	T2	T3
Temperature of air entering indoor side (°C)			
dry-bulb	27	21	29
wet-bulb	19	15	19
Temperature of air entering outdoor side (°C)			
dry-bulb	35	27	46
wet-bulb 1)	24	19	24
Condenser water temperature 2) (°C)			
inlet	30	22	30
outlet	35	27	35
Test frequency	Rated frequency 3)		
Test voltage	Rated voltage 4)		
T1 = Standard cooling capacity rating conditions for moderate climates			
T2 = Standard cooling capacity rating conditions for cool climates			
T3 = Standard cooling capacity rating conditions for hot climates			
1) The wet-bulb temperature condition is not required when testing air-cooled condensers which do not evaporate the condensate.			
2) Representative of equipment working with cooling towers. For equipment designed for other uses, the manufacturer shall designate the condenser water inlet and outlet temperatures or the water flow rates and the inlet water temperature in the ratings.			
3) Equipment with dual-rated frequencies shall be tested at each frequency.			
4) The test voltage on dual-rated voltage equipment shall be performed at both voltages or at the lower of the two voltages if only a single rating is published.			

4.1.4 Test conditions

4.1.4.1 Preconditions

a) When using the calorimeter method, two simultaneous methods of determining capacities shall be used. One method determines the capacity on the indoor side, the other measures the capacity on the outdoor side. These two simultaneous determinations shall agree within 4 % of the value obtained on the indoor side for the test to be valid. In the case of non-ducted air conditioners with water-cooled condensers, the heat-flow rejected via the cooling water is measured instead of the measurement in the outdoor-side compartment.

b) The test capacity shall include the determination of the sensible, latent or total cooling capacity as determined in the indoor-side compartment.

c) Tests shall be conducted under the selected conditions with no changes made in fan speed or system resistance to correct for variations from the standard barometric pressure (see 3.3).

d) Grille positions, damper positions, fan speeds, etc. shall be set to result in maximum cooling capacity unless this is contrary to the manufacturer's instructions. When tests are made at other settings, these shall be noted together with the cooling capacity ratings.

e) Test conditions shall be maintained for not less than 1 h before recording data for the capacity test.

4.1.4.2 Duration of test

The test shall then be run for 30 min, recording data every 5 min, providing seven sets of readings. Variations allowed in capacity test readings shall be in accordance with table 12.

4.2 Maximum cooling test

4.2.1 General conditions

The conditions which shall be used during the maximum cooling test are given in table 2.

4.2.2 Temperature conditions

Tests shall be carried out under the conditions given in column T1, T2 or T3 of table 2, based on the intended use, as determined in 4.1.2. Equipment intended for use under more than one set of operating conditions shall have the highest relevant set of the intended operating conditions applied for test purposes. If maximum operating temperature conditions for cooling are specified in the manufacturer's equipment specification sheets, they shall be used in lieu of those in table 2.

4.2.3 Air-flow conditions

The maximum cooling test shall be conducted with an indoor-side air volume flow rate as determined under 4.1.3.

4.2.4 Test conditions

4.2.4.1 Preconditions

The controls of the equipment shall be set for maximum cooling and all ventilating air dampers and exhaust air dampers shall be closed. The equipment shall be operated continuously for 1 h after the specified air temperatures and the equilibrium condensate level have been established.

4.2.4.2 Duration of test

All power to the equipment shall be cut off for 3 min and then restored for 1 h.

4.2.5 Performance requirements

4.2.5.1 During one entire test, the equipment shall operate without any indication of damage.

4.2.5.2 The motors of the equipment shall operate continuously for the first hour of the test without tripping of the motor-overload protective devices.

4.2.5.3 The motor-overload protective device may trip only during the first 5 min of operation after the shutdown period of 3 min. During the remainder of that 1-h test period, no motor-overload protective device shall trip.

4.2.5.4 For those models so designed that resumption of operation does not occur after the initial trip within the first 5 min, the equipment may remain out of operation for not longer than 30 min. It shall then operate continuously for 1 h.

Table 2 — Maximum cooling test conditions

Parameter	**Standard test conditions**		
	T1	**T2**	**T3**
Temperature of air entering indoor side (°C)			
dry-bulb	32	27	32
wet-bulb	23	19	23
Temperature of air entering outdoor side (°C)			
dry-bulb	43	35	52
wet-bulb [1)]	26	24	31
Condenser water temperature (°C)			
inlet	34	27	34
Test frequency	Rated frequency [3)]		
Test voltage	1) 90 % and 110 % of rated voltage with a single nameplate rating 2) 90 % of minimum voltage and 110 % of maximum voltage for units with a dual nameplate voltage		

1)	The wet-bulb temperature condition is not required when testing air-cooled condensers which do not evaporate the condensate.
2)	For equipment with water-cooled condensers, the water flow rate shall be the same as that used in cooling capacity test (minimum flow rate for equipment with multiple cooling capacity rating). For equipment incorporating a condenser water control valve, it shall be allowed to operate normally.
3)	Equipment with dual-rated frequencies shall be tested at each frequency.

4.2.5.5 The equipment measured total cooling capacity shall not be less than 95% of the declared nameplate value.

4.2.5.6 The equipment measured EER shall not be less than 95% of the declared rated value.

4.3 Minimum cooling test

4.3.1 General conditions

The conditions which shall be used during the minimum cooling test are given in table 3.

4.3.2 Temperature conditions

If minimum operating temperature conditions are specified in the manufacturer's equipment specification sheets, they shall be used in lieu of those given in table 3.

4.3.3 Air-flow conditions

The controls, fan speeds, dampers and grilles of the equipment shall be set to produce the maximum tendency to frost or ice the evaporator, providing such settings are not contrary to the manufacturer's operating instructions.

4.3.4 Test conditions

4.3.4.1 Preconditions

The equipment shall be started and operated until the operating conditions have stabilized.

4.3.4.2 Duration of test

After the operating conditions have stabilized, the equipment shall be operated for a period of 4 h.

4.3.5 Performance requirements

4.3.5.1 After the end of the starting period of l0 min, no safety element shall cut off during the 4 h of operation.

4.3.5.2 At the end of 4 h, any accumulation of ice or frost on the evaporator shall not cover more than 50 % of the indoor-side face area of the evaporator coil.

Table 3 — Minimum cooling test conditions

Parameter	Standard test conditions
Temperature of air entering indoor side (°C) dry-bulb wet-bulb	 21 [1)] 15
Temperature of air entering outdoor side (°C)	Lowest limit recommended by manufacturer
Water temperature (°C) inlet	 10
Water flow rate	As specified by the manufacturer
Test frequency	Rated frequency [2)]
Test voltage	Rated voltage [3)]

1) 21 °C or the lowest temperature above 21 °C at which the regulating (control) device will allow the equipment to operate.

2) Equipment with dual-rated frequencies shall be tested at each frequency.

3) Equipment with dual-rated voltages shall be tested at the higher voltage.

4.4 Enclosure sweat and condensate disposal test

4.4.1 General conditions

Air-cooled equipment which rejects condensate to the condenser air shall meet the requirements of this test. The electrical conditions which shall be used during the enclosure sweat and condensate disposal test are given in table 4.

4.4.2 Temperature conditions

The temperature conditions which shall be used during this test are given in table 4.

4.4.3 Air-flow conditions

The controls, fans, dampers and grilles of the equipment shall be set to produce the maximum tendency to sweat, provided such settings are not contrary to the manufacturer's operating instructions.

4.4.4 Test conditions

4.4.4.1 Preconditions

After establishment of the specified temperature conditions, the equipment shall be started with its condensate collection pan filled to the overflowing point, and the equipment shall be run until the condensate flow has become uniform.

4.4.4.2 Duration of test

The equipment shall be operated for a period of 4 h.

4.4.5 Performance requirements

4.4.5.1 When operating under the test conditions specified in table 4, no condensed water shall drip, run or blow from the equipment.

4.4.5.2 Equipment which rejects condensate to the condenser air shall dispose all condensate and there shall be no dripping or blowing-off of water from the equipment such that the building or surroundings become wet.

4.5 Freeze-up test

4.5.1 General conditions

The freeze-up tests (air blockage test and drip test) may be conducted simultaneously with the minimum cooling test. The electrical conditions shall be those specified in table 5.

4.5.2 Temperature conditions

The temperature conditions for the freeze-up tests are given in table 5.

Table 4 — Enclosure sweat and condensate disposal test conditions

Parameter	Standard test conditions
Temperature of air entering indoor side (°C) dry-bulb wet-bulb	 27 24
Temperature of air entering outdoor side	Lowest limit recommended by manufacturer
Water temperature (°C) dry-bulb wet-bulb	 27 24
Condenser water temperature (°C) outlet	27
Test frequency	Rated frequency 2)
Test voltage	Rated voltage 3)

1) The wet-bulb temperature condition is not required when testing air-cooled condensers which do not evaporate the condensate.

2) Equipment with dual-rated frequencies shall be tested at each frequency.

3) Equipment with dual-rated voltages shall be tested at the higher voltage.

Table 5 — Freeze-up test conditions

Parameter	Standard test conditions	
	T1 and T3	T2
Temperature of air entering indoor side (°C)		
dry-bulb	21 [1)]	21 [1)]
wet-bulb	15	15
Temperature of air entering outdoor side		
dry-bulb	21	10
wet-bulb	--	--
Condenser water temperature (°C)		
Outlet [2)]	21	10
Condenser water temperature (°C) outlet		
Water flow rate	As specified by the manufacturer	
Test frequency	Rated frequency [2)]	
Test voltage	Rated voltage [3)]	

1) 21 °C or the lowest temperature above 21 °C at which the regulating (control) device will allow the equipment to operate.

2) For equipment with water-cooled condensers, the condenser water flow rate shall be maintained at that established in table 1 except that, if more than one rating is provided, then the highest flow rate shall be used.

3) Equipment with dual-rated frequencies shall be tested at each frequency.

4) Equipment with dual-rated voltages shall be tested at the higher voltage.

4.5.3 Air-flow conditions

4.5.3.1 Air blockage test

The controls of the equipment shall be set for maximum cooling and the fan speeds, dampers and grilles shall be set to produce the maximum tendency to frost or ice the evaporator, provided such settings are not contrary to the manufacturer's operating instructions.

4.5.3.2 Drip test

The air inlet shall be covered to block completely the passage of air, so as to attempt to achieve complete blockage of the evaporator coil by frost.

4.5.4 Test conditions

4.5.4.1 Air blockage test

The test shall be continuous, with the equipment operating on the cooling cycle for 4 h after establishment of the specified temperature conditions.

4.5.4.2 Drip test

The equipment shall be operated for 6 h after which the equipment shall be stopped and the air-inlet covering removed until the accumulation of ice or frost has melted. The equipment shall then be turned on again, with the fans operating at the highest speed, for 5 min.

4.5.5 Performance requirements

4.5.5.1 Air blockage test

At the end of 4 h of operation, any accumulation of ice or frost on the evaporator shall not cover more than 50 % of the indoor-side face area of the evaporator coil.

4.5.5.2 Drip test

During the test, no ice shall drip from the coil and no water shall drip or blow off the equipment on the indoor side.

5- HEATING TESTS

5.1 Heating capacity ratings

5.1.1 General conditions

All equipment within the scope of this SASO Standard shall have the heating capacities and coefficients of performance determined in accordance with the provisions of this SASO Standard and rated at the conditions specified in table 6. The electrical input values used for rating purposes shall be measured during the heating capacity test.

5.1.2 Temperature conditions

5.1.2.1 Test conditions stated in table 6 shall be considered standard rating conditions.

5.1.2.2 If a manufacturer specifies that the equipment is not suitable for operation under the extra-low temperature test conditions, tests shall be made only at the high and low temperatures specified in table 6.

5.1.3 Air-flow conditions

5.1.3.1 Heating-only equipment shall use the air-flow quantity specified by the manufacturer.

5.1.3.2 For equipment which provides both heating and cooling, the test shall be conducted at the same air-flow rate as for the cooling capacity rating test.

5.1.3.3 When determining air-flow quantities for rating purposes, tests shall be conducted under standard rating conditions (see table 6) with the heating means in operation with 0 Pa static maintained in the air discharge of the equipment.

5.1.4 Test conditions

5.1.4.1 Preconditions

5.1.4.1.1 When using the calorimeter method, two simultaneous methods of determining capacities shall be used. One method determines the capacity on the indoor side, the other measures the capacity on the outdoor side. These two simultaneous determinations shall agree within 4 % of the value obtained on the indoor side for the test to be valid.

Table 6 — Test conditions for determination of heating capacity

Parameter	Standard test conditions
Temperature of air entering indoor side (°C) dry-bulb wet-bulb (maximum)	 20 15
Temperature of air entering outdoor side (high[1])(°C) dry-bulb wet-bulb	 7 6
Temperature of air entering outdoor side (low[1]) (°C) dry-bulb wet-bulb	 2 1
Temperature of air entering outdoor side (extra-low[1)2)]) (°C) dry-bulb wet-bulb	 -7 -8
Test frequency	Rated frequency[3)]
Test voltage	Rated voltage[4)]

1) If defrosting occurs during the high, low, or extra-tow heating capacity tests, testing under these conditions shall be accomplished using the indoor air-enthalpy method (see B.2 and C.3.3).

2) Test is to be conducted only if the manufacturer specifies that the equipment is suitable for operation under these conditions.

3) Equipment with dual-rated frequencies shall be tested at each frequency.

4) The test voltage on dual-rated voltage equipment shall be performed at both voltages or at the lower of the two voltages if only a single rating is published.

5.1.4.1.2 Tests shall be conducted at the selected conditions with no changes in fan speed or system resistance made to correct for variations from the standard barometric pressure (see 3.3).

5.1.4.1.3 The test room reconditioning apparatus and the equipment under test shall be operated until equilibrium conditions are attained, but for not less than 1 h, before test data are recorded.

5.1.4.2 Duration

Data shall then be recorded for 30 min at 5-min intervals until seven consecutive sets of readings within the tolerances specified in table 12 have been attained.

5.1.4.3 Frosting conditions

5.1.4.3.1 Under some conditions of heating, a small amount of frost may accumulate on the outdoor coil and a distinction needs to be made between non-frosting and frosting operations for the test as a whole. For the purposes of this SASO Standard, the test is to be considered non-frosting provided the effect is such that the indoor and outdoor leaving air temperatures remain within the operating tolerances for non-frosting operation specified in table 12. When the leaving air temperature exceeds the permitted range because of frost, the procedure for the heating capacity test in the defrost region described in A.4 of annex A shall be used.

5.1.4.3.2 If, under test conditions, defrost action is experienced within a 3-h period, or the test tolerances of table 12 are exceeded, then the procedure for transient heating capacity tests (see B.2) shall be used.

5.2 Maximum heating test

5.2.1 General conditions

The electrical conditions given in table 7 shall be used during the maximum heating test. The determination of maximum heating is not required under performance test conditions. The test voltages shall be maintained at the specified percentages under running conditions.

5.2.2 Temperature conditions

The temperature conditions given in table 7 shall be used during these tests unless the manufacturer specifies other conditions in the manufacturer's equipment specification sheets.

5.2.3 Air-flow conditions

The controls of the equipment shall be set for maximum heating and all ventilating air dampers and exhaust air dampers shall be closed.

5.2.4 Test conditions

5.2.4.1 Preconditions

The equipment shall be operated continuously for 1 h after the specified air temperatures and the equilibrium condensate level have been established.

5.2.4.2 Duration

All power to the equipment shall then be cut off for 3 min and then restored for 1 h.

5.2.5 Performance requirements

5.2.5.1 Heat pumps shall meet the following requirements when operating under the conditions specified in table 7:

- during one entire test, the heat pump shall operate without indication of damage;
- the heat pump motors shall operate continuously for the first hour of the test without tripping of the motor-overload protective devices.

5.2.5.2 The motor-overload protective device may trip only during the first 5 min following the 3-min cutoff of power, During the remainder of that 1-h test period, no motor-overload protective device shall trip.

5.2.5.3 For equipment that is so designed that resumption of operation does not occur after the initial trip within the first 5 min, the equipment may remain out of operation for not longer than 30 mm. It shall then operate continuously for 1 h.

5.2.5.4 The equipment measured total heating capacity shall not be less than 95% of the declared nameplate value.

5.2.5.5 The equipment measured COP shall not be less than 95% of the declared rated value.

5.2.5.6 At the standard conditions given in Table 7, the COP shall not be less than 3.0.

5.3 Minimum heating test

5.3.1 General conditions

The electrical conditions given in table 8 shall be used for this test. The voltages shall be maintained at the specified percentages under running conditions.

5.3.2 Temperature conditions

The temperature conditions for this test shall be as given in table 8, unless the manufacturer specifies other conditions in the manufacturer's equipment specification sheets.

5.3.3 Air-flow conditions

The controls of the equipment shall be set for maximum heating, and all ventilating air dampers and exhaust air dampers shall be closed.

Table 7 — Maximum heating test conditions

Parameter	Standard test conditions
Temperature of air entering indoor side (°C) dry-bulb	 27
Temperature of air entering outdoor side (°C) dry-bulb wet-bulb	 24 18
Test frequency	Rated frequency[1)]
Test voltage	a) 90 % and 110 % of rated voltage for equipment with a single nameplate rating b) 90 % of minimum voltage and 110 % of maximum voltage for equipment with a dual nameplate voltage
1) Equipment with dual-rated frequencies shall be tested at each frequency.	

5.3.4 Test conditions

5.3.4.1 Preconditions

The equipment shall be operated for 1 h under the temperature conditions and voltage specified in table 8.

5.3.4.2 Duration

After the equipment has reached stable operating conditions, these conditions shall be maintained for 4 h.

5.3.5 Performance requirements

The heat pump shall operate throughout the test without a cutoff by any safety control.

5.4 Automatic defrost test

5.4.1 General conditions

The electrical conditions given in table 9 shall be used during the automatic defrost test for heat pumps.

5.4.2 Temperature conditions

The temperature conditions given in table 9 shall be used during the automatic defrost test for heat pumps.

5.4.3 Air-flow conditions

Unless prohibited by the manufacturer, the indoor-side fan is to be adjusted to the highest speed and the unit outdoor-side fan to the lowest speed, if separately adjustable.

5.4.4 Test conditions

5.4.4.1 Preconditions

The equipment shall be operated until the temperatures specified in table 9 have been stabilized.

5.4.4.2 Duration

The heat pump shall remain in operation for two complete defrosting periods or for 3 h, whichever is the longer.

5.4.5 Performance requirements

During and directly after the defrosting periods, the air temperature to the outdoor side shall not rise by more than 5 °C. During the defrosting period, the temperature of the air from the indoor side of the equipment shall not be lower than 18 °C for longer than 1 min. This may be accomplished, if necessary, by using additional heating, provided and mounted in the equipment, or specified for use by the manufacturer.

Table 8 — Minimum heating test conditions

Parameter	Standard test conditions
Temperature of air entering indoor side (°C) dry-bulb	 20
Temperature of air entering outdoor side[1)] (°C) dry-bulb wet-bulb	 -5 -6
Test frequency[2)]	Rated frequency
Test voltage[3)]	Rated voltage

1) If the equipment can be operated under the "extra-low" temperature condition, - 7 °C dry-bulb and - 8 °C wet-bulb temperatures shall be used.

2) Equipment with dual-rated frequencies shall be tested at each frequency. 3) Equipment with dual-rated voltages shall be tested at the higher voltage.

Table 9 — Automatic defrost test conditions

Parameter	Standard test conditions
Temperature of air entering indoor side (°C) dry-bulb wet-bulb (maximum)	 20 12
Temperature of air entering outdoor side (°C) dry-bulb wet-bulb	 2 1
Test frequency	Rated frequency[1)]
Test voltage	Rated voltage[2)]

1) 1) Equipment with dual-rated frequencies shall be tested at each frequency.
2) The test voltage on dual-rated voltage equipment shall be performed at both voltages or at the higher of the two voltages if only a single rating is published.

6- TEST METHODS AND UNCERTAINTIES OF MEASUREMENTS

6.1 Test methods

6.1.1 Capacity and performance tests of non-ducted air conditioners and heat pumps are conducted using either the room calorimeter method or the indoor air-enthalpy method. Both methods are permitted subject to the provision that the results are within the limits of the uncertainties of measurement established in 6.2.

6.1.2 The room calorimeter can be of either the calibrated type or the balanced ambient type, as described in annex B.

6.1.3 In the air-enthalpy method, heating or cooling capacities are determined from measurements of entering and leaving wet- and dry-bulb temperatures and the associated air-flow rate. This method can be employed for the indoor-side tests of all equipment. Subject to the additional requirements of annex F, this method may be used for the outdoor-side tests. This method can be applied to water-cooled condensing equipment for which a second determination of the cooling capacity from measurements on the water-side is possible.

6.2 Uncertainties of measurement

The uncertainties of measurement shall not exceed the values specified in table 10.

6.3 Variations in individual readings

The maximum allowable variations of individual readings from stated conditions in the performance tests shall be as shown in table 11. The maximum permissible variation of any observation during the capacity test shall be as shown in table 12.

6.4 Test tolerances

6.4.1 The maximum permissible variation of any observation represents the greatest permissible difference between maximum and minimum instrument observations during the test. When expressed as a percentage, the maximum allowable variation is the specified percentage of the arithmetical mean of the observations.

6.4.2 The maximum permissible variations of the mean of the test observations from the standard or desired test conditions are shown in table 12.

Table 10 — Uncertainties of measurement of indicated values

Measured quantity	Uncertainty of measurement[1)]
Water temperature temperature difference volume flow static pressure difference	 ± 0.1 °C ± 0.1 °C ± 5% ± 5 Pa
Air dry-bulb temperature wet-bulb temperature volume flow static pressure difference	 ± 0.2 °C ± 0.2 °C ± 5% ± 5 Pa for pressure <= 100 Pa ± 5 % for pressure > 100 Pa
Electrical inputs	± 0.5 %
Time	± 0.2 %
Mass	± 1.0 %
Speed	± 1.0%

1) Uncertainty of measurement is an estimate characterizing the range of values within which the true value of a measurand lies (measurand is a quantity subject to measurement).

NOTE — Uncertainty of measurement comprises, in general, many components. Some of these components may be estimated on the basis of the statistical distribution of the results of series of measurements and can be characterized by experimental standard deviations. Estimates of other components can be based on experience or other information.

Table 11 — Variations allowed in performance test readings

Quantity measured	Maximum allowable variations in individual readings from stated performance test conditions
For minimum operating conditions test air temperatures water temperatures	 +1 °C + 0.6 °C
For maximum operating conditions test air temperatures water temperatures	 -1 °C - 0.6 °C
For other tests air temperatures water temperatures	 ± 1 °C ± 0.6 °C

Table 12 — Variations allowed in capacity test readings

Readings	Variations of arithmetical mean values from specified test conditions	Maximum variation of individual reading from rating conditions
Temperature of air entering indoor side dry-bulb wet-bulb Temperature of air entering outdoor side dry-bulb wet-bulb Temperature of air leaving outdoor side dry-bulb Air volume flow rate Voltage	 ± 0.3 °C ± 0.2 °C ± 0.3 °C ± 0.2 °C ±5% ± 1 %	 ± 1,0 °C ± 0.5 °C ± 1.0 °C ± 0.5 °C ± 1.0 °C ± 10% ± 2%
Water temperature inlet outlet Water volume flow rate	 ± 0,1 °C ± 0,1 °C ± 1 %	 ± 0.2 °C ± 0,2 °C ±2%
External resistance to air-flow	±5 Pa	± 10 Pa

7- TEST RESULTS

7.1 Capacity calculations

7.1.1 General

The results of a capacity test shall express quantitatively the effects produced upon air by the equipment tested. For given test conditions, the capacity test results shall include such of the following quantities as are applicable to cooling or heating and to the type of equipment tested:

a) total cooling capacity, in watts;

b) sensible cooling capacity, in watts;

c) latent cooling capacity, in watts;

d) heating capacity, in watts;

e) indoor-side air-flow rate, in cubic metres per second of standard air;

f) external resistance to indoor air-flow, in pascals;

g) effective power input to the equipment or individual power inputs to each of the electrical equipment components, in watts.

7.1.2 Adjustments

Test results shall be used to determine capacities without adjustment for permissible variations in test conditions, except that air enthalpies, specific volumes and isobaric specific heat capacities shall be corrected for deviations from saturation temperature and standard barometric pressure.

7.2 Data to be recorded

The data to be recorded for the capacity tests are given in tables 13 and 14 for the calorimeter test method and in table 15 for the indoor air-enthalpy test method. The tables identify the general information required but are not intended to limit the data to be obtained. Electrical input values used for rating purposes shall be those measured during the capacity tests.

7.3 Test report

7.3.1 General information

As a minimum, the test report shall contain the following general information:

a) date;

b) test institute;

c} test location;

d) test method used (calorimeter or air enthalpy);

e) test supervisor;

f) test objective, type designation;

g) reference to this SASO Standard.

7.3.2 Additional information

The information given **on the nameplate should be** noted on the test report.

7.3.3 Rating test results

The values given shall be the mean of the values taken over the test period.

Table 13 - Data to be recorded for calorimeter cooling capacity tests

No.	Data
1	Date
2	Observers
3	Barometric pressure
4	Speed of equipment cooling fan(s)
5	Applied voltage
6	Frequency
7	Total power input to equipment[1)]
8	Total current input to equipment
9	Control dry-bulb and wet-bulb temperature of air (indoor-side calorimeter compartment)[2)]
10	Control dry-bulb and wet-bulb temperature of air (outdoor-side calorimeter compartment)[2)]
11	Average air temperature outside the calorimeter (calibrated room-type; see figure B.4)
12	Total power input to indoor-side and outdoor-side compartments
13	Quantity of water evaporated in humidifier
14	Temperature of humidifier water entering indoor-side and outdoor-side (if used) compartments or in humidifier tank
15	Cooling water flow rate through outdoor-side compartment heat-rejection coil
16	Temperature of cooling water entering outdoor-side compartment, for heat-rejection coil
17	Temperature of cooling water leaving outdoor-side compartment, from heat-rejection coil
18	Cooling water flow rate through equipment condenser (water-cooled units only)
19	Temperature of water entering equipment condenser (water-cooled units only)
20	Temperature of water leaving equipment condenser (water-cooled units only)
21	Mass of water from equipment which is condensed in the reconditioning equipment[3)]
22	Temperature of condensed water leaving outdoor-side compartment
23	Volume of air-flow through measuring nozzle of separating partition
24	Air-static pressure difference across separating partition of calorimeter compartments

1) Total power input to the equipment, except if more than one external power connection is provided on the equipment; record input to each connection separately.
2) See B.1.7.
3) For equipment which evaporates condensate on the outdoor coil

Table 14 — Data to be recorded for calorimeter heating capacity tests

No.	Data
1	Date
2	Observers
3	Barometric pressure
4	Speed of equipment heating fan(s)
5	Applied voltage
6	Frequency
7	Total power input to equipment[1)]
8	Total current input to equipment
9	Control dry-bulb and wet-bulb temperature of air (indoor-side calorimeter compartment)[2)]
10	Control dry-bulb and wet-bulb temperature of air (outdoor-side calorimeter compartment)[2)]
11	Average air temperature outside the calorimeter (calibrated room-type; see figure B.4)
12	Total power input to indoor-side and outdoor-side compartments
13	Quantity of water evaporated in humidifier
14	Temperature of humidifier water entering indoor-side and outdoor-side (if used) compartments or in humidifier tank
15	Cooling water flow rate through outdoor-side compartment heat-rejection coil
16	Temperature of cooling water entering outdoor-side compartment, for heat-rejection coil
17	Temperature of cooling water leaving outdoor-side compartment, from heat-rejection coil
18	Water condensed in indoor-side or outdoor-side compartment
19	Temperature of condensed water leaving indoor-side compartment
20	Volume of air-flow through measuring nozzle of separating partition
21	Air-static pressure difference across separating partition of calorimeter compartments

1) Total power input to the equipment, except if more than one external power connection is provided on the equipment; record input to each connection separately.
2) SeeB.1.7.

Table 15 — Data to be recorded during the indoor air-enthalpy capacity tests

No.	Data
1	Date
2	Observers
3	Barometric pressure
4	Time of test
5	Power input[1)]
6	Applied voltage(s)
7	Current
8	Frequency
9	External resistance to air-flow
10	Fan speed(s) (if adjustable)
11	Dry-bulb temperature of air entering equipment
12	Wet-bulb temperature of air entering equipment
13	Dry-bulb temperature of air leaving equipment
14	Wet-bulb temperature of air leaving equipment
15	Volume flow rate of air and all relevant measurements for its calculation
1) Total power input and, where required, input to equipment components.	

8- MARKING PROVISIONS

8.1 Nameplate requirements

Each non-ducted air conditioner and heat pump shall have a nameplate, firmly attached and in a location accessible for reading.

8.2 Nameplate information

The nameplate shall carry the following minimum information in addition to the information required by SASO safety standards:

a) manufacturer's name or trademark [1];

b) distinctive type or model designation and serial number;

c) rated voltage(s);

d) rated frequency (ies);

e) climate application type(s) (see 4.1);

f) total cooling capacity [2];

g) heating capacity [4];

h) refrigerant designation and refrigerant mass charge.

8.3 Refrigerant designation

Refrigerant designation shall be in accordance with ISO 817.

[1] The manufacturer is considered to be the firm whose name is on the nameplate.
[2] For each rated voltage and frequency.

8.4 Split systems

The information in a), b), c), d) and h) in 8.2 shall be provided on each element of a split system.

9- PUBLICATION OF RATINGS

9.1 Standard ratings

9.1.1 Standard ratings shall be published for cooling capacities (sensible, latent and total), heating capacity, energy efficiency ratio and coefficient of performance, as appropriate, for each unit produced in conformance to this SASO Standard. These ratings shall be based on data obtained at the established rating conditions in accordance with the provisions of this SASO Standard.

9.1.2 The values of the standard capacities shall be expressed in kilowatts, rounded to the nearest 0,1 kW.

9.1.3 The values of energy efficiency ratios and coefficients of performance shall be expressed in multiples of the nearest 0,05.

9.1.4 Each capacity rating shall be followed by the corresponding voltage and frequency rating.

9.2 Other ratings

Additional ratings may be published based on conditions other than those specified as standard rating conditions if they are clearly specified and the data are determined by the methods specified in this SASO Standard, or by analytical methods which are verifiable by the test methods specified in this SASO Standard.

[3] The manufacturer is considered to be the firm whose name is on the nameplate.
[4] For each rated voltage and frequency.

Annex A

(normative)

Test Procedures

A.I General test room requirements

A.1.1 If an indoor-condition test room is required, it shall be a room or space in which the desired test conditions can be maintained within the specified tolerances. It is recommended that air velocities in the vicinity of the equipment under test do not exceed 2,5 m/s.

A.1.2 If an outdoor-condition test room or space is required, it shall be of sufficient volume and shall circulate air in a manner such that it does not change the normal air-circulating pattern of the equipment under test. It shall be of dimensions such that the distance from any room surface to any equipment surface from which air is discharged is not less than 1,8 m and the distance from any other room surface to any other equipment surface is not less than 0,9 m, except for floor or wall relationships required for normal equipment installation. The room conditioning apparatus should handle air at a rate not less than the outdoor air-flow rate, and preferably should take this air from the direction of the equipment air discharge and return it at the desired conditions uniformly and at low velocities.

A.2 Equipment installation

A.2.1 The equipment to be tested shall be installed in accordance with the manufacturer's installation instructions, using recommended installation procedures and accessories. If the equipment can be installed in several locations, the tests shall be conducted using the worst location. In all cases, the manufacturer's recommendations with respect to distances from adjacent walls, amount of extensions through walls, etc., shall be followed.

A.2.2 No alterations to the equipment shall be made except for the attachment of required test apparatus and instruments in the specified manner.

A.2.3 Where necessary, the equipment shall be evacuated and charged with the type and amount of refrigerant specified in the manufacturer's instructions.

A.2.4 All standard ratings for equipment in which the condenser and the evaporator are two separate assemblies shall be determined with the maximum length of refrigerant tubing on each line, of a length specified by the manufacturer, or 7,5 m, whichever is the shorter. Such equipment in which the interconnecting tubing is furnished as an integral part of the unit and not recommended for cutting to length should be tested with the complete length of tubing furnished. Unless constrained by the design, at least half of the interconnecting tubing shall be exposed to the outdoor conditions with the rest of the tubing exposed to indoor conditions. The line diameters, insulation, details of installation, evacuation and charging shall be in accordance with the manufacturer's published recommendations.

A.3 Electrical supply requirements

The voltages specified shall be maintained within the specified percentages under running conditions. The electrical service supplied to the equipment's service connection shall be such that the voltage will not rise more than 3 % when the equipment is stopped. After the service has been adjusted to accomplish this result, no subsequent adjustment shall be made during the test.

A.4 Heating capacity test in the defrost region

A.4.1 During the tests, a capacity determination based only on indoor air-circuit measurements is permissible. During this test, any apparatus disturbing normal outdoor air-flow through the equipment shall not be connected. The indoor air-flow is to be allowed to continue with no changes in the air-flow settings for the test equipment or for the associated test apparatus, except that if the defrost controls provide for stopping the indoor fan, provision shall be made to shut off the flow of air through the indoor coil from the test apparatus while the indoor fan is stopped. An integrating watt-hour meter shall be used for obtaining electrical input to the equipment.

A.4.2 The test room reconditioning apparatus and the equipment under test shall be operated until equilibrium conditions are attained, but for not less than 1 h, except that normal variations due to operation of the defrost controls of the equipment may occur. Under defrost conditions, the normal functioning of the test room reconditioning apparatus may be disturbed. Because of this, the operational tolerances shall be three times those specified in table 12.

A.4.3 The equipment shall be operated for a test period of 3 h. If the equipment is in defrost at the end of this test period, the cycle shall be completed. Data shall be recorded at normal 5-min intervals except that, during the defrost cycle, data shall be recorded at least every 10 s to establish accurately the start and completion of the defrost cycle, the time-temperature pattern of the indoor air stream (if the indoor fan is running), and the electrical input to the equipment.

A.4.4 Transient conditions and internal losses make it impractical in many cases to obtain accurate simultaneous checks of measured heating capacity. Hence, the accuracy of the primary measurement equipment is verified by means of a qualification test procedure, as described in E.6 of annex E.

Annex B

(normative)

Calorimeter test method

B.1 General

B.1.1 The calorimeter provides a method for determining capacity simultaneously on both the indoor side and the outdoor side. In the cooling mode, the indoor-side capacity determination is made by balancing the cooling and dehumidifying effects with measured heat and water inputs. The outdoor-side capacity provides a confirming test of the cooling and de-humidifying effect by balancing the heat and water rejection on the condenser side with a measured amount of cooling.

B.1.2 The two calorimeter compartments, indoor side and outdoor side, are separated by an insulated partition having an opening into which the non-ducted equipment is mounted. The equipment shall be installed in a manner similar to a normal installation. No effort shall be made to seal the internal construction of the equipment to prevent air leakage from the condenser side to the evaporator side or vice versa. No connections or alterations shall be made to the equipment which might in any way alter its normal operation.

B.1.3 A pressure-equalizing device as illustrated in figure B.1 shall be provided in the partition wall between the indoor-side and the outdoor-side compartments to maintain a balanced pressure between these compartments and also to permit measurement of leakage, exhaust and ventilation air. This device consists of one or more nozzles of the type shown in figure B.2, a discharge chamber equipped with an exhaust fan, and manometers for measuring compartment and air-flow pressures. A suggested arrangement of components is shown in figure B.3.

Since the air-flow from one compartment to the other may be in either direction, two such devices mounted in opposite directions, or a reversible device, shall be used.

The manometer pressure pickup tubes shall be so located as to be unaffected by air discharged from the equipment or by the exhaust from the pressure-equalizing device. The fan or blower which exhausts air from the discharge chamber shall permit variation of its air-flow by any suitable means, such as a variable speed drive, or a damper as shown in figure B.3. The exhaust from this fan or blower shall be such that it will not affect the inlet air to the equipment.

The equalizing device shall be adjusted during calorimeter tests or air-flow measurements so that the static pressure difference between the indoor-side and outdoor-side compartments is not greater than 1,25 Pa.

B.1.4 The size of the calorimeter shall be sufficient to avoid any restriction to the intake or discharge openings of the equipment. Perforated plates or other suitable grilles shall be provided at the discharge opening from the reconditioning equipment to avoid face velocities exceeding 0,5 m/s. Sufficient space shall be allowed in front of any inlet or discharge grilles of the air conditioner to avoid interference with the air-flow. Minimum distance from the equipment to side walls or ceiling of the compartment(s) shall be 1 m, except for the back of console-type equipment, which shall be in a normal relationship to the wall. Table B.1 gives the suggested dimensions for the calorimeter. To accommodate peculiar sizes of equipment, it may be necessary to alter the suggested dimensions to comply with the space requirements.

B.I.5 Each compartment shall be provided with reconditioning equipment to maintain specified air-flow and specified conditions. Reconditioning apparatus for the indoor-side compartment shall consist of heaters to supply sensible heat and a humidifier to supply moisture. Reconditioning apparatus for the outdoor-side compartment shall provide cooling, dehumidification and humidification. The energy should be controlled and measured.

When calorimeters are used for heat pumps, they shall have heating, humidifying and cooling capabilities for both rooms (see figures B.4 and B.5) or other means, such as rotating the equipment, may be used as long as the rating conditions are maintained.

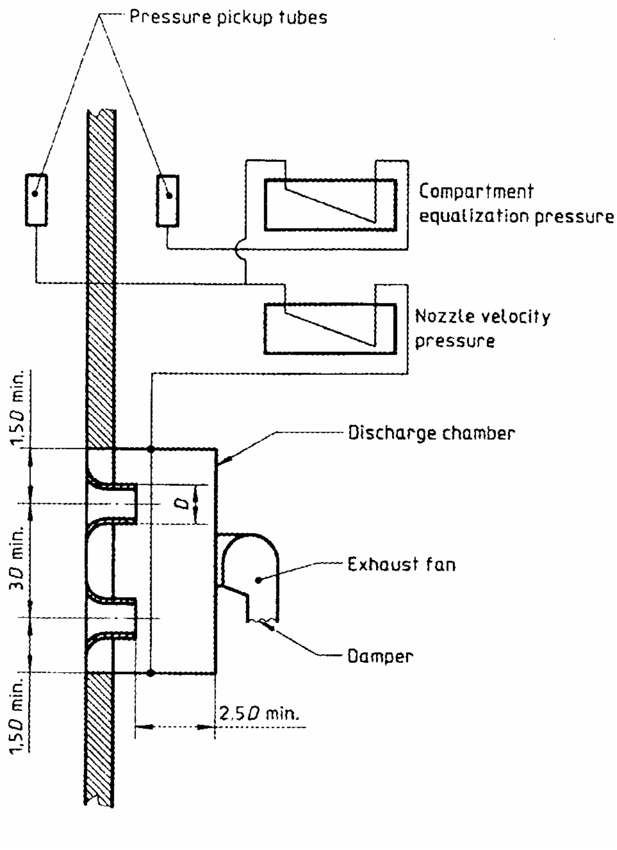


Figure B.l - Pressure-equalizing device

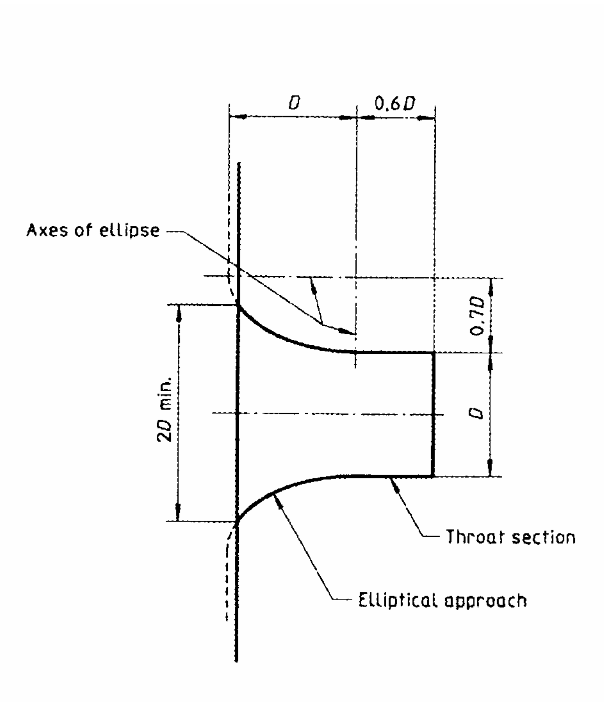


Figure B.2 - Air-flow measuring nozzle

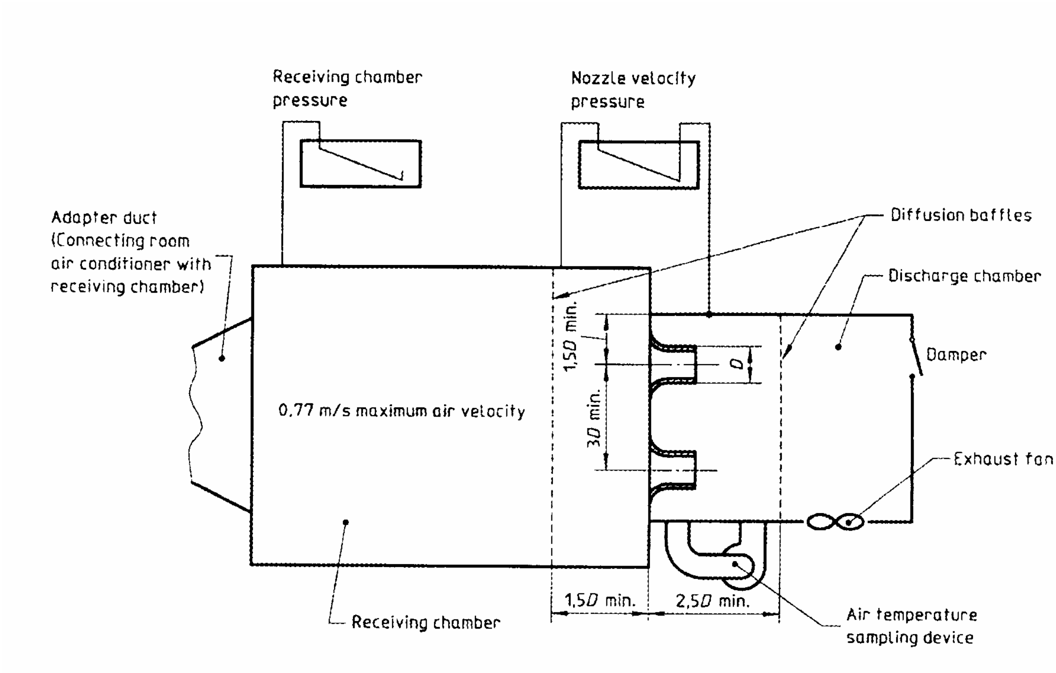


Figure B.3 - Air-flow measuring apparatus

Table B.1 — Sizes of calorimeter

Maximum rated cooling capacity of equipment[1)]	Suggested minimum inside dimensions of each room of calorimeter m		
W	Width	Height	Length
3 000	2,4	2,1	1,8
6000	2,4	2,1	2,4
9000	2,7	2,4	3,0
12000	3,0	2.4	3.7

1) All figures are round numbers.

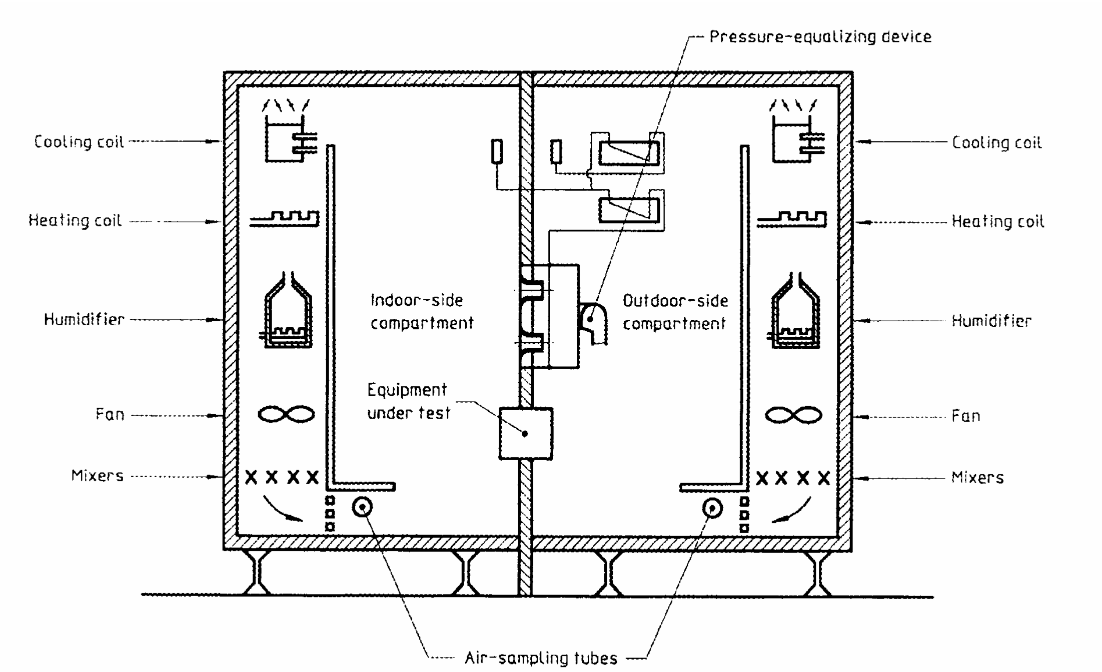


Figure B.4 - Typical calibrated room-type calorimeter

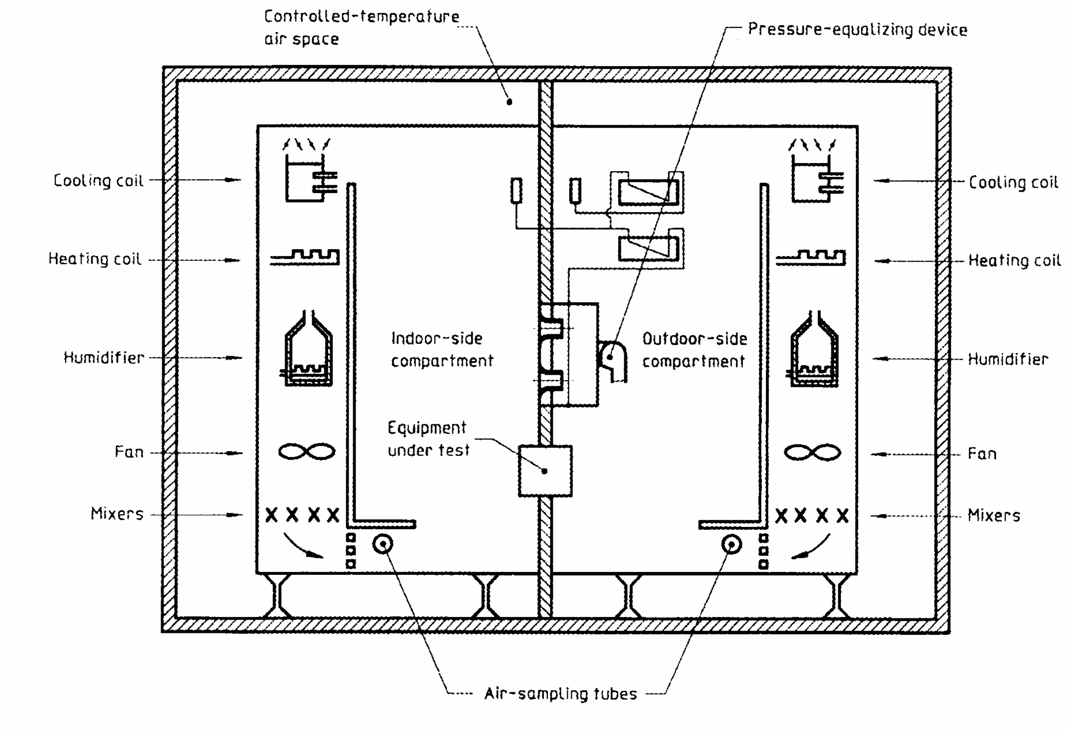


Figure B.5 — Typical balanced ambient room-type calorimeter

B.1.6 Reconditioning apparatus for both compartments shall be provided with fans of sufficient capacity to ensure air-flows of not less than twice the quantity of air discharged by the equipment under test in the calorimeter, and air velocities at the discharge of the reconditioning apparatus of less than 1 m/s. The calorimeter shall be equipped with means of measuring or determining specified wet- and dry-bulb temperatures in both calorimeter compartments.

B.1.7 It is recognized that in both the indoor-side and outdoor-side compartments, temperature gradients and air-flow patterns result from the interaction of the reconditioning equipment and test apparatus. Therefore, the resultant conditions are peculiar to and dependent upon a given combination of compartment size, arrangement and size of reconditioning apparatus, and the air discharge characteristics of the equipment under test.

The point of measurement of specified test temperatures, both wet- and dry-bulb, shall be such that the following conditions are fulfilled.

a) The measured temperatures shall be representative of the temperature surrounding the equipment, and shall simulate the conditions encountered in an actual application for both indoor and outdoor sides, as indicated above.

b) At the point of measurement, the temperature of the air shall not be affected by air discharged from the equipment. This makes it mandatory that the temperatures are measured upstream of any recirculation produced by the equipment.

B.1.8 Interior surfaces of the calorimeter compartments shall be of non-porous material with all joints sealed against air and moisture leakage. The access door shall be tightly sealed against air and moisture leakage by use of gaskets or other suitable means.

B.2 Transient heating capacity test

B.2.1 The test room reconditioning apparatus and the heat pump under test shall be operated under specified rating conditions until "equilibrium" conditions are attained, but for not less than 1 h, except that variations due to operation of defrost controls may occur. Under defrost conditions, the normal functioning of the test room reconditioning apparatus may be disturbed and the maximum allowable variation of air temperature readings from rating conditions shall be three times those shown in table 12.

B.2.2 If defrost controls on the heat pump provide for stopping the indoor air-flow, provision shall be made to stop the test apparatus air-flow to the equipment on both the indoor and outdoor sides during such a defrost period. If it is desirable to maintain operation of the reconditioning apparatus during the defrost period, provision may be made to bypass the conditioned air around the equipment as long as assurance is provided that the conditioned air does not aid in the defrosting. A watt-hour meter shall be used for obtaining the integrated electrical input to the equipment under test.

B.2.3 The equipment shall be operated for a minimum test period complying with one of the following:

a) a minimum of three complete defrost cycles;

b) a minimum of 3 h, including one complete defrost cycle:

c) 6 h, if no defrosting occurs.

B.2.4 If the equipment is in defrost at the end of this test period, the cycle shall be completed. A defrost cycle comprises one complete heating and defrosting interval. Data shall be recorded at not more than 5-min intervals except that, during the defrost cycle and recovery period, data shall be recorded at sufficient frequency to establish accurately the time-temperature pattern of the indoor air stream (if the indoor fan is running), and the electrical input to the equipment under test.

B.3 Calibrated room-type calorimeter

B.3.1 The calibrated room-type calorimeter is shown in figure B.4. Each calorimeter, including the separating partition, shall be insulated to prevent heat leakage (including radiation) in excess of 5 % of the capacity of the equipment. An air space permitting free circulation shall be provided under the calorimeter floor.

B.3.2 Heat leakage may be determined in either the indoor-side or outdoor-side compartment by the following method.

All openings shall be closed. Either compartment may be heated by electric heaters to a temperature of at least 11 °C above the surrounding ambient temperature. The ambient temperature shall be maintained constant within ± 1 °C outside all six enveloping surfaces of the compartment, including the separating partition. If the construction of the partition is identical with that of the other walls, the heat leakage through the partition may be determined on a proportional area basis.

B.3.3 For calibrating the heat leakage through the separating partition alone, the following procedure may be used.

A test is carried out as described above. Then the temperature of the adjoining area on the other side of the separating partition is raised to equal the temperature in the heated compartment, thus eliminating heat leakage through the partition, while the 11 °C differential is maintained between the heated compartment and the surrounding ambient temperature of the other five enveloping surfaces.

The difference in heat input between the first test and second test will permit determination of the leakage through the partition alone.

B.3.4 For the outdoor-side compartment equipped with means for cooling, an alternative means of calibration may be to cool the compartment to a temperature at least 11 °C below the ambient temperature (on six sides) and carry out a similar analysis.

B.3.5 As an alternative to the two-room simultaneous method of determining capacities, the performance of the indoor-side compartment shall be verified at least every 6 months using an industrial standard cooling capacity calibrating device. A calibrating device may also be another equipment whose performance has been measured by the simultaneous indoor and outdoor measurement method at an accredited national test laboratory as part of an industry-wide cooling capacity verification programme.

B.4 Balanced ambient room-type calorimeter

B.4.1 The balanced ambient room-type calorimeter is shown in figure B.5 and is based on the principle of maintaining the dry-bulb temperatures surrounding the particular compartment equal to the dry-bulb temperatures maintained within that compartment. If the ambient wet-bulb temperature is also maintained equal to that within the compartment, the vapour-proofing provisions of B.1.8 are not required.

B.4.2 The floor, ceiling and walls of the calorimeter compartments shall be spaced a sufficient distance away from the floor, ceiling and walls of the controlled areas in which the compartments are located in order to provide a uniform air temperature in the intervening space. It is recommended that this distance be at least 0,3 m. Means shall be provided to circulate the air within the surrounding space to prevent stratification.

B.4.3 Heat leakage through the separating partition shall be introduced into the heat balance calculation and may be calibrated in accordance with B.3.3, or may be calculated.

B.4.4 It is recommended that the floor, ceiling and walls of the calorimeter compartments be insulated so as to limit heat leakage (including radiation) to no more than 10% of the test equipment's capacity, with an 11 °C temperature difference, or 300 W for the same temperature difference, whichever is the greater, as tested using the procedure given in B.3.2.

B.5 Calorimeter and auxiliary equipment for water-cooled condenser tests

B.5.1 The indoor-side compartment of a room calorimeter of either the calibrated or the balanced ambient type shall be used.

B.5.2 Measurements shall be made for determining flow and temperature rise of the condenser cooling water. Water lines shall be insulated between the condenser and the temperature-measuring points.

Annex C

(normative)

Heating and cooling capacity calculations

C.1 Cooling capacity calculations (Calorimeter method)

C.1.1 The total room-cooling effect on the indoor side, as tested in either the calibrated or balanced-ambient room-type calorimeter (see figures B.4 and B.5) is calculated as follows:

$$\phi_{tci} = \sum \mathrm{P_r} + (h_{w1} - h_{w2})\ \mathrm{W_r} + \phi_{lp} + \phi_{lr} \qquad \ldots(\mathrm{C.1})$$

where:

ϕ_{tci} is the total cooling capacity, indoor-side data, in watts;

$\sum P_r$ is the sum of all power input to the indoor-side compartment, in watts;

h_{w1} is the specific enthalpy of water or steam supplied to maintain humidity; if no water is introduced during the test, h_{w1} is taken at the temperature of the water in the humidifier tank of the reconditioning apparatus, in kilojoules per kilogram;

h_{w2} is the specific enthalpy of condensed moisture leaving the indoor-side compartment, since transfer of condensed moisture from the indoor-side to the outdoor-side compartment usually takes place within the test equipment; when it is not practical to measure this temperature, the temperature of the condensate may be assumed to be at the measured, or estimated, wet-bulb temperature of the air leaving the test equipment, in kilojoules per kilogram;

w_r is the rate at which water vapour is condensed by the equipment under test, in grams per second; this is measured as the amount of water, in grams per second, evaporated into the indoor-side compartment by the reconditioning to maintain the required humidity;

ϕ_{lp} is the heat leakage rate into the indoor-side compartment through the partition separating the indoor-side and outdoor-side compartments, as determined from the calibrating test (or may be based on calculation in the case of a balanced-ambient room-type calorimeter), in watts;

ϕ_{lr} is the heat leakage rate into the indoor-side compartment through walls, floor and ceiling (but not including the separating partition) as determined from the calibrating test, in watts.

C.1.2 The total cooling capacity on the outdoor side, as tested in either the calibrated or balanced-ambient room-type calorimeter (see figures B.4 and B.5) is calculated as follows:

$$\phi_{tco} = \phi_c - \sum P_o - P_t + (h_{w3} - h_{w2})W_r + \phi_{lp} + \phi_{loo} \qquad \ldots\text{(C.2)}$$

where:

ϕ_{tco} is the total cooling capacity as determined on the outdoor-side compartment, in watts;

ϕ_C is the heat removed by the cooling coil in the outdoor-side compartment, in watts;

$\sum P_o$ is the sum of all power input to any equipment, such as reheaters, circulating fans, etc., in the outdoor-side compartment, in watts;

P_t is the total power input to the equipment under test, in watts;

h_{w2} is as defined in C. 1.1;

h_{w3} is the specific enthalpy of the condensed moisture removed by the air-treating coil in the outdoor-side compartment reconditioning apparatus, taken at the temperature at which the condensate leaves the compartment, in kilojoules per kilogram;

W_r is as defined in C. 1.1;

ϕ_{lp} is as defined in C. 1.1;

NOTE 3 This quantity will be numerically equal to that used in equation (C.1) (see C.1.1) if, but only if, the area of the separating partition exposed to the outdoor side is equal to the area exposed to the indoor-side compartment.

ϕ_{loo} is the heat leakage from the outdoor side (but not including heat leakage through the separating partition), as determined from the calibrating test, in watts.

C.1.3 The total cooling capacity of a liquid (water)-cooled equipment deducted from the condenser side is calculated as follows:

$$\phi_{tco} = \phi_{co} - \sum P_E \qquad \ldots\text{(C.3)}$$

where:

ϕ_{tco} is as defined in C.1.2;

ϕ_{co} is the heat removed by the condenser coil in the equipment, in watts;

$\sum P_E$ is the effective power input to the equipment, in watts.

C.1.4 The latent cooling capacity (room-dehumidifying capacity) is calculated as follows:

$$\phi_d = K_1 W_r \qquad \text{... (C.4)}$$

where:

ϕ_d is the latent cooling capacity, in watts;

K_1 is 2,460 kJ/kg;

w_r is as defined in C.1.1.

C.1.5 The sensible cooling capacity is calculated as follows:

$$\phi_s = \phi_{tci} - \phi_d \qquad \text{...(C.5)}$$

where:

ϕ_s is the sensible cooling capacity, in watts;

ϕ_{tci} is as defined in C.1.1;

ϕ_d is as defined in C.1.4.

C.1.6 The sensible heat ratio (SHR) is calculated as follows:

$$\text{SHR} = \phi_s / \phi_{tci} \qquad \text{... (C.6)}$$

Where:

ϕ_s is as defined in C.1.5;

ϕ_{tci} is as defined in C.1.1.

C.2 Heating capacity calculations (Calorimeter method)

C.2.1 Determination of the heating capacity by measurement in the indoor-side compartment is calculated as follows:

$$\phi_{hi} = \phi_{lci} + \phi_t + \phi_{li} - P_i \qquad \text{... (C.7)}$$

where (as also in the case of split-system equipment)

ϕ_{hi} is the heating capacity **as** determined in the indoor-side compartment, in watts;

ϕ_{lci} is the heat-flow removed from the indoor-side compartment, in watts;

ϕ_t is the heat-flow through the partition wall from the indoor-side to the outdoor-side compartment, in watts;

ϕ_{li} is the heat-flow through the remaining enveloping surfaces of the indoor-side compartment, in watts;

P_i is the other power input to the indoor-side compartment (e.g. illumination, electrical and thermal power input to the compensating device, heat balance of the humidification device), in watts.

NOTE 4 The transfer of energy by the equalizing air-flow and by the leakage air-flow of the unit is a function of the respective test equipment and is not to be taken into account when determining the capacity.

C.2.2 Determination of the heating capacity by measurement of the heat-absorbing side is calculated as follows for equipment where the evaporator takes the heat from an air-flow:

$$\phi_{ho} = P_o + P_t + q_{wo}(h_{w4} - h_{w5}) + \phi_t + \phi_{loo} \quad \text{... (C.8)}$$

where:

ϕ_{ho} is the heating capacity as determined in the outdoor-side compartment, in watts;

P_o is the total power input to the outdoor-side compartment with the exception of the power input to the equipment, in watts;

P_t is as defined in C.1.2;

q_{wo} is the mass flow rate of water supplied to the outside compartment to maintain the test conditions, in grams per second;

h_{w4} is the specific enthalpy of the water mass flow supplied to the outdoor-side compartment, in kilojoules per kilogram;

h_{w5} is the specific enthalpy of the condensed water (in the test condition, this is high) and frost, respectively (in the test condition, this is low or extra-low) in the equipment, in kilojoules per kilogram;

ϕ_t is as defined in C.2.1;

ϕ_{ioo} is the heat-flow through the remaining enveloping surfaces into the outdoor-side compartment, in watts.

NOTE 5 The transfer of energy by the equalizing air-flow and the leakage air-flow of the equipment is neglected.

C.3 Heating capacity calculations (Air-enthalpy method)

C.3.1 The results of the test shall express quantitatively the effect produced upon the air by the equipment tested. The test results shall include the heating capacity, recirculating air-flow, and the total energy input to the equipment.

C.3.2 During heating capacity and qualification tests, the measuring apparatus (figure C.I) permits some heat loss which must be determined by suitable calibration techniques and credited to the overall heating capacity,

C.3.3 The heating capacity based on indoor-side data is calculated by the following equation[3]:

$$\phi_{hi} = \frac{q_{mi} c_{pa} (t_{a2} - t_{a1})}{v_n^{'} (1 + w_n)} \quad . . . (C.9)$$

where:

ϕ_{hi} is as defined in C.2.1;

q_{mi} is the indoor air-flow rate at a measurement point, in cubic metres per second;

c_{pa} is the specific heat of dry air, in joules per kilogram kelvin;

t_{a2} is the temperature of air leaving the indoor side, in degrees Celsius;

t_{a1} is the temperature of air entering the indoor side, in degrees Celsius;

$v_n^{'}$ is the specific volume of air at point of measurement of air-water vapour mixture, in cubic metres per kilogram;

w_n is the specific humidity of air, in kilograms per kilogram of dry air.

If line loss corrections are to be made, they shall be included in the capacity calculations.

C.3.4 When moisture is deliberately added to the indoor air stream in order to provide humidification, there is a significant change in moisture content between the indoor air entering and leaving, and the following expression shall be used:

$$\phi_{hi} = \frac{q_{mi} (h_{a2} - h_{a1})}{v_n^{'} (1 + w_n)} \quad . . . (C.10)$$

where:

ϕ_{hi} is as defined in C.2.1;

q_{mi} is as defined in C.3.3;

h_{a1} is the enthalpy of air entering the indoor side, in kilojoules per kilogram of dry air;

h_{a2} is the enthalpy of air leaving the indoor side. in kilojoules per kilogram of dry air;

[3] Equation (C.9) does not provide allowances for heat leakage in the test equipment.

$v_n^{'}$ is as defined in C.3.3;

w_n is as defined in C.3.3.

C.3.5 The transient total heating capacity shall be calculated as shown in C.3.4 and averaged with respect to time for the entire test period. When the indoor air-flow of the equipment stops during defrosting, the capacity during this interval shall be considered to be zero, but the elapsed time must be included in the total test period for obtaining the mean heating capacity.

C.3.6 Test results shall be used to determine capacity without adjustment for permissible variations in test conditions.

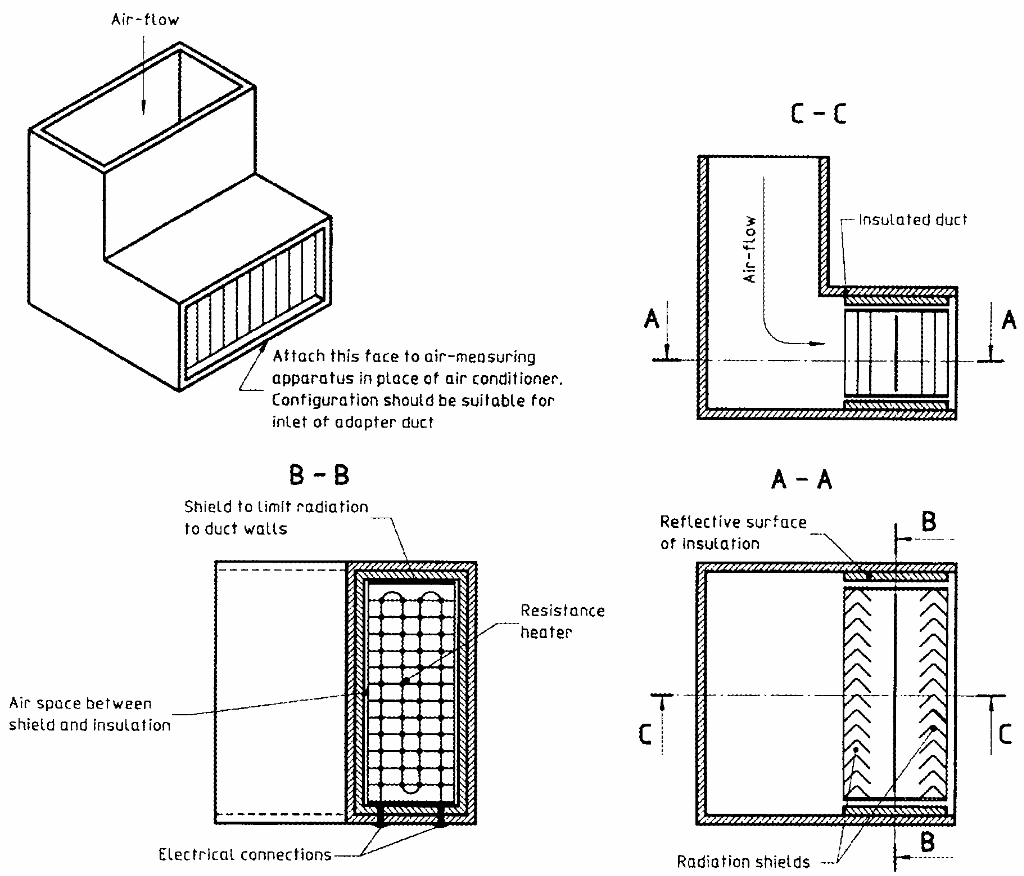


Figure C.l - Qualification test apparatus (suggested)

C.4 Cooling capacity calculations (Air-enthalpy method)

The total, sensible and latent indoor cooling capacities based on the indoor-side test data are calculated by the following equations[4]:

[4] Equations (C.11) and (C.12) do not provide allowances for heat leakage in the test equipment.

$$\phi_{tci} = \frac{q_{mi}(h_{a1} - h_{a2})}{v_n^{'}(1 + w_n)} \qquad \text{. . . (C.11)}$$

$$\phi_{sci} = \frac{q_{mi} c_{pa}(t_{a1} - t_{a2})}{v_n^{'}(1 + w_n)} \qquad \text{. . . (C.12)}$$

$$c_{pa} = 1005 + 1846 w_n$$

$$\phi_{lci} = \frac{2.47 \times 10^6 q_{mi}(w_{i1} - w_{i2})}{v_n^{'}(1 + w_n)} = \phi_{tci} - \phi_{sci} \qquad \text{. . . (C.13)}$$

where:

ϕ_{tci} is as defined in C.1.1;

q_{mi}, c_{pa}, t_{a1}, and t_{a2} are as defined in C.3.3;

h_{a1}, h_{a2}, $v_n^{'}$ and w_n are as defined in C.3.4 **;**

ϕ_{sci} is the sensible cooling capacity, indoor-side data, in watts;

ϕ_{lci} is the latent cooling capacity, indoor-side data, in watts;

w_{i1} is the specific humidity of air entering the indoor-side compartment, in kilograms per kilogram of dry air;

w_{i2} is the specific humidity of air leaving indoor-side compartment, in kilograms per kilogram of dry air;

2,47 x 10^6 in equation (C.13) is the latent heat of vaporization at 15 °C ± 1 °C, in joules per kilogram.

Annex D
(informative)
Instruments

D.1 Temperature-measuring instruments

D.1.1 The smallest scale division of the temperature-measuring instrument should not exceed twice the specified accuracy. For example, for the specified accuracy of ± 0,05 °C, the smallest scale division should not exceed ±0,1 °C.

D.1.2 Where an instrument accuracy of ± 0,05 °C is specified, the instrument should be calibrated by comparison with a thermometer certified by a recognized authority, such as a national standards authority.

D.1.3 In all measurements of wet-bulb temperature, sufficient wetting should be provided and sufficient time should be allowed for the state of evaporative equilibrium to be attained. For mercury-in-glass thermometers having a bulb diameter not over 6,5 mm, temperatures should be read under conditions which ensure a minimum air velocity of 5 m/s. For any other instrument, a sufficient air velocity should be provided to give the same equilibrium conditions as those defined above.

D.1.4 Wherever possible, temperature-measuring instruments used to measure the change in temperature should be arranged so that they can be readily interchanged between inlet and outlet positions to improve accuracy.

D.1.5 Temperatures of fluids within conduits should be measured by inserting the temperature-measuring instrument directly within the fluid, or within a well inserted into the fluid. If a glass thermometer is to be inserted directly into the fluid, it should be calibrated for the effect of pressure.

D.1.6 Temperature-measuring instruments should be adequately shielded from radiation from any adjacent heat sources.

D.1.7 The response time is the time required for the instrumentation to obtain 63 % of the final steady-state temperature difference when subjected to a step change in temperature difference of 7 °C or more.

D.2 Pressure-measuring instruments

D.2.1 The maximum scale interval should not be greater than that listed for the range of the manometer given in table D.1.

Table D.I — Range of manometer
Values in pascals

Range	Maximum scale interval
From 1,25 to 25	1.25
Over 25 to 250	2.5
Over 250 to 500	5.0
Over 500	25

D.2.2 For air-flow rate measurements, the minimum pressure differential should be:

a) 25 Pa with an inclined-tube manometer or micro-manometer;

b) 500 Pa with a vertical tube manometer.

D.2.3 Calibration standards should be;

a) for instruments with the range 1,25 Pa to 25 Pa, a micromanometer accurate to ± 0,25 Pa;

b) for instruments with the range 25 Pa to 500 Pa, a manometer accurate to ± 2,5 Pa (hook gauge or micromanometer);

c) for instruments with the range 500 Pa and upwards, a manometer accurate to ± 25 Pa (vertical-tube manometer).

D.2.4 Barometric pressure should be measured by a barometer having a scale marking permitting readings to an accuracy of within ± 0,1 %.

D.3 Electrical instruments

D.3.1 Electrical measurements should be made with either of the following instruments:

a) indicating;

b) integrating.

D.3.2 Instruments used for measuring all electrical inputs to the calorimeter compartments should be accurate to ± 0,5 % of the quantity measured.

D.4 Water-flow-measuring instruments

D.4.1 Water-flow measurements should be made with either of the following instruments having an accuracy of ± 1,0 % of the quantity measured:

a) liquid quantity meter, measuring either mass or volume;

b) liquid flowmeter.

D.4.2 The liquid quantity meter should employ a tank having a capacity sufficient to accumulate the flow for at least 2 min.

D.5 Other instruments

D.5.1 Time interval measurements should be made with instruments whose accuracy is ± 0,2 % of the quantity measured.

D.5.2 Mass measurement should be made with apparatus whose accuracy is ± 1,0 % of the quantity measured.

D.5.3 Instruments for measuring rotating speed should be of the remote-sensing type with an accuracy of ± 1,0 % of the quantity measured.

Annex E
(informative)
Air-flow measurement

E.1 Air-flow determination

E.1.1 The following air quantities may be measured using the apparatus and testing procedures given in this annex;

a) indoor-side discharge air-flow;

b) ventilation air-flow, if the non-ducted air conditioner or heat pump is equipped to provide same;

c) exhaust air-flow, if the non-ducted air conditioner or heat pump is equipped to provide same;

d) leakage air-flow.

E.1.2 Air-flow quantities are determined as mass flow rates. If air-flow quantities are to be expressed for rating purposes in volume flow rates, such ratings should state the conditions (pressure, temperature and humidity) at which the specific volume is determined.

E.2 **Nozzles**

E.2.1 Nozzles should be constructed in accordance with figure B.2, and installed in accordance with the provisions of E.2.2 and E.2.3.

E.2.2 Nozzle discharge coefficients for the construction shown in figure B.2 may be determined by use of the alignment chart (see figure E.1).

Figure E.1 is the solution of the following equations:

$$C_d = f(\mathrm{Re})$$

$$\mathrm{Re} = \frac{VD\rho}{\mu}$$

where:

C_d is the discharge coefficient;

Re is the Reynolds number;

D is the nozzle diameter;

V is the velocity;

ρ is the density;

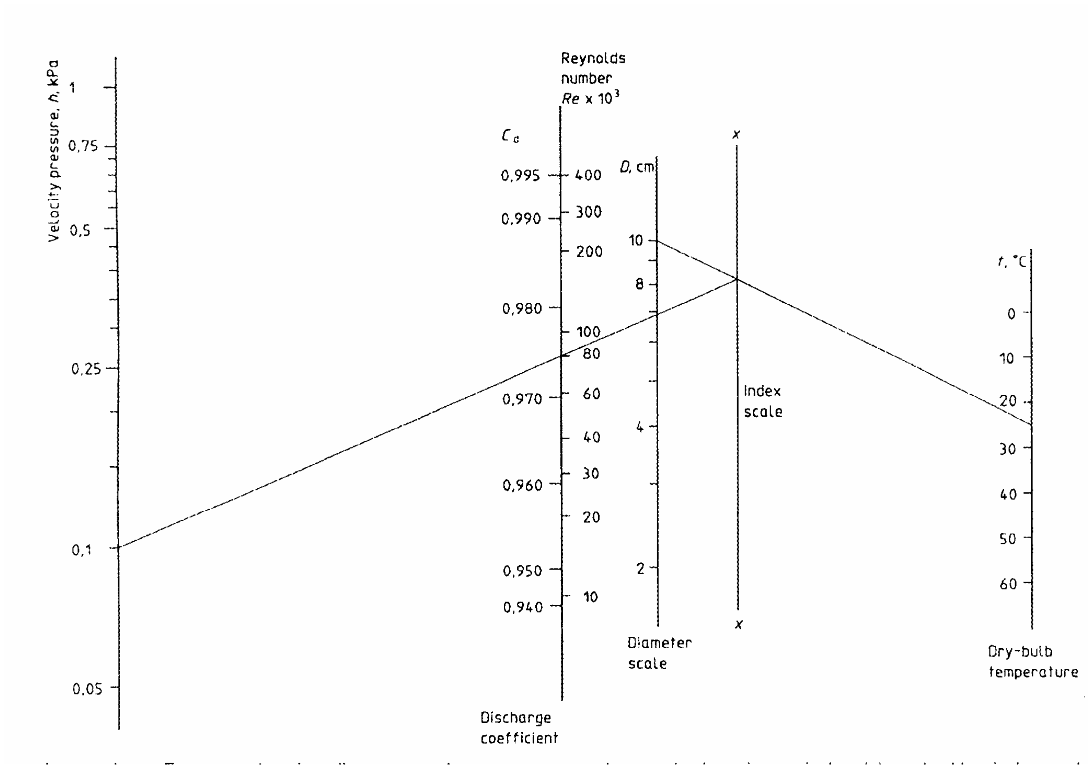
μ is the viscosity

and

$$V = \varphi(h)$$

$$\frac{\rho}{\mu} = \psi(t)$$

E.2.3 Nozzles may also be constructed in accordance with appropriate national standards, provided they can be used in the apparatus described in figures B.2 and B.3 and result in equivalent accuracy.



Instructions: Enter graph using diameter and temperature scales to obtain point on index (x) scale. Use index and pressure scales to obtain Reynolds number and discharge coefficient.

Figure E.1 — Determination of nozzle discharge coefficient

E.3 Apparatus for room discharge air-flow measurements

E.3.1 Room discharge air-flow measurements should be made with apparatus similar to that shown in figures B.1 and B.3.

E.3.2 One or more nozzles constructed in accordance with figures B.2 and B.3 should be fitted into one wall of the receiving chamber, discharging into the discharge chamber, and should be of such a size that the throat velocity is not less than 15 m/s. Centre distances between nozzles in use should not be less than three throat diameters, and the distance from the centre of any nozzle to any of the four adjacent side walls should be not less than 1,5 throat diameters.

If the nozzles are of different diameters, the distance between axes should be based upon the average diameter. Size and arrangement of the receiving chamber should be sufficient to provide uniform approach velocity to the nozzle(s) or have suitable diffusion baffles to accomplish this purpose. Nozzles so installed may be considered to require a negligible correction for approach velocity.

E.3.3 To establish a zero static pressure with respect to the test room at the discharge of the air conditioner or heat pump in the receiving chamber, a manometer should have one side connected to one or more static pressure connections located flush with the inner wall of the receiving chamber.

E.3.4 Size and arrangement of the discharge chamber should be such that the distance from the centre of any nozzle to the adjacent side wall is not less than 1,5 throat diameters and not less than 5 throat diameters to the next obstruction, unless suitable diffusion baffles are used.

E.3.5 An exhaust fan should be connected to the discharge chamber to overcome the resistance of the chamber, nozzle(s) and diffusion baffles.

E.3.6 The manometer(s) used to measure the pressure drop across the nozzle(s) should have one side connected to one or more static pressure connections located flush with the inner wall of the receiving chamber. The other side of the manometer(s) should be connected in a similar manner to one or more static pressure connections in the wall of the discharge chamber. Static pressure connections should be located so as not to be affected by air-flow. If desired, the velocity head of the air stream leaving the nozzle(s) may be measured by a pitot tube, but when more than one nozzle is in use, the pitot tube reading is determined for each nozzle. Temperature readings at the nozzle(s) should be used only for determining air density.

E.4 Indoor-side discharge air-flow measurement

E.4.1 Indoor-side discharge air-flow should be measured with apparatus similar to that illustrated in figure B.3.

E.4.2 The outlet or outlets of the equipment under test should be connected to the receiving chamber by adapter ducting of negligible air resistance.

E.4.3 The exhaust fan should be adjusted to give zero static pressure at the discharge of the equipment in the receiving chamber.

E.4.4 The following readings should be taken:

a) barometric pressure;

b) nozzle dry- and wet-bulb temperatures or dew point temperatures;

c) nozzle velocity pressure.

E.4.5 Air mass flow rate through a single nozzle is determined as follows:

$$q_m = K_2 C_d A \sqrt{\frac{p_v}{v_n'}} \qquad \text{...(E.1)}$$

Air volume flow rate through a single nozzle is determined as follows:

$$q_v = K_2 C_d A \sqrt{1000 p_v v_n^{'}} \qquad \text{...(E.2)}$$

$$v_n^{'} = \frac{p_A v_n}{p_n (1 + w_n)} \qquad \text{...(E.3)}$$

where:

q_m is the air mass flow rate, in kilograms per second;

q_v is the air volume flow rate, in cubic metres per second;

K_2 is 1 414;

C_d is the nozzle discharge coefficient (see E.2.2);

A is the nozzle area, in square metres;

p_v is the static pressure difference, in pascals, across the nozzle, or the velocity pressure of the nozzle throat, in pascals, the approach velocity being considered negligible;

$v_n^{'}$ is the specific volume of air at the nozzle inlet, in cubic metres per kilogram of the air-water vapour mixture;

p_A is the standard barometric pressure = 101,325 kPa;

p_n is the barometric pressure at nozzle inlet, in kilopascals;

w_n is the specific humidity at nozzle inlet, in kilograms per kilogram of dry air;

v_n is the specific volume of humid air at dry-and wet-bulb temperature conditions existing at the nozzle inlet but at standard barometric pressure, in cubic metres per kilogram.

NOTE 6 Where the barometric pressure deviates from the standard barometric pressure by not more than 3 kPa, $v_n^{'}$ may, for simplicity, be considered equal to v_n.

E.4.6 Air-flow through multiple nozzles may be calculated in accordance with E.4.5, except that the total flow rate will be the sum of the q_m values for each nozzle used.

E.5 Ventilation, exhaust and leakage air-flow measurements

E.5.1 Ventilation, exhaust and leakage air-flows should be measured using apparatus similar to that illustrated in figure B,3 with the refrigeration system in operation and after condensate equilibrium has been obtained.

E.5.2 With the equalizing device adjusted for a maximum static pressure differential between the indoor-side and outdoor-side compartments of 1 Pa, the following readings should be taken:

a) barometric pressure;

b) nozzle wet- and dry-bulb temperatures;

c) nozzle velocity pressure.

E.5.3 Air-flow values should be calculated in accordance with E.4.5.

E.6 Test apparatus calibration (Air-enthalpy method)

E.6.1 In order to fulfil the requirements of this SASO Standard, the test apparatus should be periodically calibrated under conditions similar to the equipment test conditions. The calibration test method involves the introduction of electric resistance heat into the measuring apparatus at a point as near as practical to the point of attachment of the equipment being tested (see figure C.1).

E.6.2 Calibration tests should be performed at least every 6 months and whenever changes are made to the test apparatus.

E.6.3 During the calibration test, the air-flow, the inlet temperature, and the outlet temperature should agree with the values measured during the test of the equipment, within the tolerances given in table 11. The electrical input to the resistance heater should be adjusted to provide the equivalent test conditions.

E.6.4 The heat input of the resistance heater is calculated as follows:

$$\phi_r = P_r \qquad \text{... (E.4)}$$

where:

ϕ_r is the total heating capacity of the resistance heater, in watts;

P_r is the power input to the resistance heater, in watts,

E.6.5 The net heating capacity output of the calibration apparatus is calculated as described in C.3.3.

E.6.6 The test apparatus is considered satisfactorily calibrated if the heat input of the qualification resistance heater (E.6.4) agrees with the measured heat output (E.6.5) to within 4 %.

Annex F

(informative)

Outdoor air-enthalpy test method

F.1 General

F.1.1 In the air-enthalpy method, capacities are determined from measurements of entering and leaving wet- and dry-buib temperatures and the associated air-flow rate.

F.1.2 Outdoor air-enthalpy tests are subject to the apparatus arrangement limitations specified in F.2.1, if the compressor is independently ventilated, and to the line loss adjustments permitted by C.3.3 and F.4.3, if the equipment employs remote outdoor coils.

F.2 Test room requirements

F.2.1 When the air-enthalpy method is employed for outdoor tests, it is necessary to ascertain whether the attachment of the air-flow measuring device changes the performance of the equipment being tested and, if so, to correct for this change. To accomplish this, the equipment should have thermocouples soldered to return bends at approximately the midpoints of each indoor coil and outdoor coil circuit. Equipment not sensitive to refrigerant charge may, alternatively, be provided with pressure gauges connected to access valves or tapped into the suction and discharge lines. The equipment should then be operated under the desired conditions, with the indoor-side test apparatus connected but not the outdoor-side apparatus. Data should be recorded at 5-min intervals for a period of not less than 30 min after equilibrium has been attained. The outdoor-side test apparatus should then be connected to the equipment and the pressure or temperatures indicated by the aforementioned gauges or thermocouples should be noted. If, after equilibrium is again attained, these do not average to within ± 0,3 °C or its pressure equivalent of the averages observed during the preliminary test, the outdoor air-flow rate should be adjusted until the specified agreement is attained. The test should be continued for a period of 30 min after attainment of equilibrium under the proper conditions with the outdoor-side test apparatus connected, and the indoor-side test results during this interval should agree to within ± 2,0 % of the results obtained during the preliminary test period. This applies for both the cooling and the heating cycle, but needs to be done under any one condition for each.

F.2.2 For equipment in which the compressor is ventilated independently of the outdoor air stream, the calorimeter air-enthalpy method arrangement should be employed to take into account compressor heat radiation (see figure F.1).

F.2.3 When the outdoor air-flow is adjusted as described in F.2.1, the adjusted air-flow rate is used in the capacity calculation. In such cases, however, the outdoor fan power input observed during the preliminary tests should be used for rating purposes.

F.3 Test conditions

When the outdoor air-enthalpy method is used, the requirements given in A.4.1 and A.4.2 apply to both the preliminary test (see F.2) and the regular equipment test.

F.4 Calculations

F.4.1 The total cooling capacity based on outdoor-side data is calculated by one of the following equations[5]:

$$\phi_{tco} = \frac{q_{mo}(h_{a4} - h_{a3})}{v_n^{'}(1 + w_n)} - P_t \qquad \text{... (F.1)}$$

or, for air-cooled equipment which does not re-evaporate:

$$\phi_{tco} = \frac{q_{mo} c_{pa}(t_{a4} - t_{a3})}{v_n^{'}(1 + w_n)} - P_t \qquad \text{... (F.2)}$$

where:

ϕ_{tco} is the total cooling capacity based on outdoor-side data, in watts;

q_{mo} is the air mass flow rate on the outdoor side, in cubic metres per second;

h_{a4} is the specific enthalpy of air leaving the outdoor side, in joules per kilogram of dry air;

h_{a3} is the specific enthalpy of air entering the outdoor side, in joules per kilogram of dry air;

c_{pa} is the specific heat of dry air, in joules per kilogram kelvin;

t_{a4} is the temperature of air leaving the outdoor side, in degrees Celsius;

t_{a3} is the temperature of air entering the outdoor side, in degrees Celsius;

$v_n^{'}$ is the specific volume of air at point of measurement, in cubic metres per kilogram of the air-water vapour mixture;

w_n is the specific humidity at the nozzle, in kilograms per kilogram of dry air;

P_t is the total power to equipment, in watts.

F.4.2 The total heating capacity based on outdoor-side data is calculated by one of the following equations[6]:

$$\phi_{tho} = \frac{q_{mo}(h_{a4} - h_{a3})}{v_n^{'}(1 + w_n)} - P_t \qquad \text{... (F.3)}$$

[5] Equations (F.1) and (F.2) do not provide allowances for heat leakage in the test equipment.
[6] Equations (F.3) and (F.4) do not provide allowances for heat leakage in the test equipment.

or, for air-cooled equipment which does not re-evaporate:

$$\phi_{tho} = \frac{q_{mo} c_{pa} (t_{a4} - t_{a3})}{v_n^{'} (1 + w_n)} - P_t \qquad \ldots\text{(F.4)}$$

where:

ϕ_{tho} is the total heating capacity based on outdoor-side data, in watts, and the other symbols are as defined in F.4.1.

F.4.3 If line loss corrections are to be made, they should be included in the capacity calculations. Allowance should be made as follows.

a) For bare copper tube

$$\phi_L = 0.6057 + 0.005316 (D_t)^{0.75} (\Delta t)^{1.25} + 79.8 D_t \Delta t L \qquad \text{... (F.5)}$$

b) For insulated lines

$$\phi_L = 0.6154 + 0.3092 (T)^{-0.33} (D_t)^{0.75} (\Delta t)^{1.25} L \qquad \text{... (F.6)}$$

where:

ϕ_L is the line heat loss in the interconnecting tubing, in watts;

D_t is the outside diameter of refrigerant tubing, in millimetres;

Δt is the average temperature difference, in degrees Celsius, between the refrigerant and the surrounding ambient;

L is the length of refrigerant tubing, in metres;

T is the insulation thickness, interconnecting tubing, in millimetres.

The line loss correction should be added algebraically to the outdoor-side capacity.

Annex G

(informative)

List of symbols

Symbol	Description	Unit
A	area of nozzle	m^2
C_d	nozzle discharge coefficient	—
c_{pa}	specific heat of dry air	kJ/kg.K
D_t	outside diameter of refrigerant tubing	mm
h_{a1}	specific enthalpy of wet air entering indoor-side compartment	kJ/kg of dry air
h_{a2}	specific enthalpy of air leaving indoor-side compartment	kJ/kg of dry air
h_{a3}	specific enthalpy of air entering outdoor-side compartment	J/kg of dry air
h_{a4}	specific enthalpy of air leaving outdoor-side compartment	J/kg of dry air
h_{w1}	specific enthalpy of water or steam supplied to indoor-side compartment	kJ/kg
h_{w2}	specific enthalpy of condenser moisture leaving indoor-side compartment	kJ/kg
h_{w3}	specific enthalpy of condensate removed by air-treating coil in the outdoor-side compartment reconditioning equipment	kJ/kg
h_{w4}	specific enthalpy of the water supplied to the outdoor-side compartment	kJ/kg
h_{w5}	specific enthalpy of the condensed water (in the test condition, this is high) and the frost, respectively (in the test condition, this is low or extra-low) in the equipment	J/kg
K_1	constant (= 2 460)	J/kg
K_2	constant (= 1 414)	—
L	length of refrigerant tubing	m
ϕ_{lp}	heat leakage into indoor side compartment through partition separating indoor side from outdoor side	W
ϕ_{lr}	heat leakage into indoor-side compartment through walls, floor and ceiling	W
ϕ_c	heat removed by cooling coil in the outdoor-side compartment	W
ϕ_{co}	heat removed by the condenser coil	W

Symbol	Description	Unit
ϕ_d	latent cooling capacity (dehumidifying)	W
ϕ_{hi}	heating capacity, indoor-side compartment	W
ϕ_{ho}	heating capacity, outdoor-side compartment	W
ϕ_L	line heat loss in interconnecting tubing	W
ϕ_{lci}	heat removed from indoor-side compartment	W
ϕ_{li}	heat flow through the remaining enveloping surfaces of the indoor-side compartment	W
ϕ_{loo}	heat leakage out of or into the outdoor-side compartment, not including the heat leakage through the partition	W
ϕ_r	total heating capacity of resistance heater	W
ϕ_s	sensible cooling capacity	W
ϕ_{sci}	sensible cooling capacity, indoor-side data	W
ϕ_t	heat flow through partition wall	W
ϕ_{tci}	total cooling capacity, indoor-side data	W
ϕ_{tco}	total cooling capacity, outdoor-side data	W
ϕ_{thi}	total heating capacity, indoor-side data	W
ϕ_{tho}	total heating capacity, outdoor-side data	W
p_A	standard barometric pressure (= 101,325)	kPa
p_n	barometric pressure at the nozzle inlet	kPa
p_v	static pressure deference across nozzle	Pa
P_E	effective power input	W
P_i	other power input to the indoor-side compartment (e.g., illumination, electrical and thermal power input to the compensating device, heat balance of the humidification device	W
P_o	total power input to the outdoor-side compartment with the exception of the power input to the equipment	W
P_r	power input to the resistance heater	W
P_t	total power input to equipment	W
$\sum P_o$	sum of all power input to any equipment in the outdoor-side compartment (e.g. re-heaters, fans, etc.)	W
$\sum P_r$	sum of all power input to indoor-side compartment	W
q_m	air mass flow rate	kg/s

Symbol	Description	Unit
q_{mi}	indoor air-flow rate	m^3/s
q_v	air volume flow rate	m^3/s
q_{wo}	mass flow rate of water supplied to the outside compartment to maintain test conditions	g/s
SHR	sensible heat ratio	-
t	Temperature	°C
t_{a1}	temperature of air entering indoor-side compartment	°C
t_{a2}	temperature of air leaving indoor-side compartment	°C
t_{a3}	temperature of air entering outdoor-side compartment	°C
t_{a4}	temperature of air leaving outdoor-side compartment	°C
T	insulation thickness, interconnecting tubing	mm
V_n	specific volume of air at wet- and dry-bulb temperature conditions existing at nozzle inlet but at standard barometric pressure	m^3/kg of dry air
$V_n^{'}$	specific volume of air at air-flow measuring device	m^3/kg of air-water vapour mixture
w_{i1}	specific humidity of air entering indoor-side compartment	kg/kg of dry air
w_{i2}	specific humidity of air leaving indoor-side compartment	kg/kg of dry air
w_n	specific humidity at the nozzle inlet	kg/kg
W_r	rate at which water vapour is condensed by the equipment	g/s