SASO 2682

DUCTED AIR-CONDITIONERS AND AIR-TO-AIR HEAT PUMPS – TESTING AND RATING FOR PERFORMANCE

DUCTED AIR-CONDITIONERS AND AIR-TO-AIR HEAT PUMPS – TESTING AND RATING FOR PERFORMANCE

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FOREWORD

The Saudi Arabian Standards Organization (SASO) has adopted the International standard (ISO 13253:1995) "Ducted air-conditioners and air-to-air 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 4.2.5.4, 4.2.5.5, 5.2.5.4, 5.2.5.5 and 5.2.5.6) to suit local requirements.

DUCTED AIR-CONDITIONERS AND AIR-TO-AIR HEAT PUMPS – TESTING AND RATING FOR PERFORMANCE

1- SCOPE

1.1 This SASO Standard establishes performance testing and rating criteria for factory-made residential, commercial and industrial, electrically driven, mechanical-compression, ducted air-conditioners using air- and water-cooled condensers and ducted air-to-air heat pumps. The requirements of testing and rating contained in this SASO Standard are based on the use of matched assemblies.

This SASO Standard is limited to systems which use a single refrigeration circuit and have one evaporator and one condenser.

1.2 This SASO Standard does not apply to the testing and rating of

a) individual assemblies for separate use,

b) equipment using the absorption refrigeration cycle,

c) non-ducted air-conditioners or non-ducted heat pumps, or

d) water-source heat pumps.

1.3 It does not cover the determination of either seasonal efficiencies or part-load performances which may be required in some countries because they provide a better indication of efficiency under actual operating conditions.

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

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. SASO maintain registers of currently valid SASO Standards.

The standard to be approved by SASO concerned with “*Refrigerants — Number designation*”[1].

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[1] This standard will be based on ISO 817:1974.

3- DEFINITIONS

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

3.1 **standard air:** Dry air at 20.0 °C, and at a standard barometric pressure of 101,325 kPa, having a mass density of 1,204 kg/m^3.

3.2 **heating capacity:** Amount of heat that the equipment can add to the conditioned space in a defined interval of time. It is expressed in watts.

3.3 **latent cooling capacity:** Amount of latent heat that the equipment can remove from the conditioned space in a defined interval of time. It is expressed in watts.

3.4 **sensible cooling capacity:** Amount of sensible heat that the equipment can remove from the conditioned space in a defined interval of time. It is expressed in watts.

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

3.6 **energy efficiency ratio** (EER): Ratio of the total cooling capacity to the effective power input at any given set of rating conditions. (Where EER is stated with units Btu/hr. watt, it shall be understood that it will be dimensionless if it is derived from watts/watt.)

3.7 **coefficient of performance (COP):** Ratio of the heating capacity to the effective power input of the equipment at any given set of rating conditions. (Where COP is stated without an indication of units, it shall be understood that it is derived from watts/watt.)

3.8 **ducted air-conditioner:** An encased, factory-made assembly or assemblies designed to be used as permanently installed equipment to provide conditioned air to enclosed space(s) through a duct. It includes a prime source of refrigeration for cooling and dehumidification and may optionally include other means for heating, humidifying, ventilating, exhausting and cleaning the air. It normally includes an evaporator, compressor and condenser. Such equipment may be provided in more than one assembly, the separated assemblies of which are designed to be used together.

3.9 **ducted heat pump:** An encased, factory-made assembly or assemblies designed to be used as permanently installed equipment to take heat from a heat source and deliver it to the conditioned space through a duct when heating is desired. 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 normally includes an indoor conditioning coil, a compressor and an outdoor coil. Such equipment may be provided in more than one assembly, the separated assemblies of which are designed to be used together. The equipment may also provide the functions of air cleaning, circulating and humidifying.

3.10 **air-to-air heat pump:** Heat pump which takes heat from outside air and delivers it to the conditioned space when heating is desired, or takes heat from the conditioned air and delivers it to the outside air when cooling is desired.

3.11 **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), or the power allowance for equipment supplied without indoor fans (see 7.1.5).

It is expressed in watts.

3.12 **total power input,** P_t **:** Power input to all components of the equipment as delivered. It is expressed in watts or Kw.

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.

Table 1 — Cooling capacity test conditions

Parameter	Standard test conditions		
	T1	T2	T3
Temperature of air entering indoor side (°C) dry-bulb wet-bulb	 27 19	 21 15	 29 19
Temperature of air entering outdoor side (°C) dry-bulb wet-bulb [1)]	 35 24	 27 19	 46 24
Condenser water temperature [2)] (°C) Inlet outlet	 30 35	 22 27	 30 35
Test frequency	Rated frequency [3)] (60 Hz)		
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 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 50 and 60 Hz 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.			

4.1.2.3 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 the rating determined by test for each of the specified conditions for which they have been designated and tested.

4.1.3 Airflow conditions

4.1.3.1 Indoor-side air quantity

4.1.3.1.1 All standard ratings shall be determined at an indoor-side air volume flow rate as established below. All air quantities shall be expressed as cubic metres per second of standard air as defined in 3.1 and as recommended by the test methods described in annex E.

4.1.3.1.2 Equipment with indoor fans intended for use with field-installed duct systems shall be rated at the indoor-side air volume flow rate delivered when operating against the minimum external resistance specified by the manufacturer.

4.1.3.1.3 For equipment supplied without indoor fans and which are rated for general use to be applied to a variety of heating equipment, the indoor-side air volume flow rate shall be specified by the manufacturer in the published standard ratings. However, the pressure drop across the indoor coil assembly and the recommended enclosures and attachment means shall not exceed 75 Pa.

4.1.3.1.4 Indoor-side air quantities and pressures referred to herein apply to the air quantity experienced when the equipment is cooling and dehumidifying under the conditions specified in this section. This air quantity, except as noted in 4.3.3 and 4.4.3, shall be employed in all other tests specified herein without regard to the resulting external static pressure.

4.1.3.2 Outdoor-side air quantity

All standard ratings shall be determined at the outdoor-side air quantity specified by the manufacturer when the fan drive is adjustable. When the fan is non-adjustable, they shall be determined at the outdoor-side air volume flow rate inherent in the equipment when operated with all of the resistance elements associated with inlets, louvres, and any ductwork and attachments considered by the manufacturer as normal installation practice. Once established, the outdoor-side air circuit of the equipment shall remain unchanged throughout all tests specified herein.

4.1.4 Test conditions

4.1.4.1 Preconditions

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 capacity test data are recorded.

4.1.4.2 Duration of test

The data shall be recorded for 30 min at 5-min intervals until seven consecutive sets of readings within the tolerance presented in 6.5 have been attained.

4.2 Maximum cooling test

4.2.1 General conditions

The electrical 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 most stringent 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.

Table 2 — Maximum cooling test conditions

Parameter	Standard test conditions		
	T1	T2	T3
Temperature of air entering indoor side (°C) dry-bulb wet-bulb	 32 23	 27 19	 32 23
Temperature of air entering outdoor side (°C) dry-bulb wet-bulb [1)]	 43 26	 35 24	 52 31
Condenser water temperature (°C) inlet[2)]	 34	 27	 34
Test frequency	Rated frequency [3)] (60 Hz)		
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 flowrate 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 50 and 60 Hz shall be tested at each frequency.

4.2.3 Airflow conditions

The maximum cooling test shall be conducted with an indoor-side air volume flow rate as determined under 4.1.3.1.

4.2.4 Test conditions

4.2.4.1 Preconditions

The equipment shall be operated continuously for 1h 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 Air conditioners and heat pumps shall meet the following requirements when operating under the conditions specified in table 2:

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

4.2.5.2 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.

4.2.5.3 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.

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

4.2.5.5 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 electrical 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.

Table 3 — Minimum cooling test conditions

Parameter	Standard test conditions	
	T1 and T3	T2
Temperature of air entering indoor side (°C)		
dry-bulb	21[1)]	21
wet-bulb	15	15
Temperature of air entering outdoor side (°C)		
dry-bulb	21	10
wet-bulb	–	–
Condenser water temperature (°C) inlet	10	10
Water flow rate	As specified by the manufacturer	
Test frequency	Rated frequency[2)] (60 Hz)	
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 50 and 60 Hz shall be tested at each frequency.

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

4.3.3 Airflow 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 10 min, no safety element shall cut off during the 4 h of operation under the test conditions specified in table 3.

4.3.5.2 At the end of 4 h, any accumulation of ice or frost on the evaporator shall not reduce the airflow by more than 25 % of that determined at the start of operation.

4.4 Enclosure sweat and condensate disposal test

4.4.1 General conditions

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 Airflow 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.

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 (°C) dry-bulb wet-bulb[1)]	 27 24
Condenser water temperature (°C) outlet	27
Test frequency	Rated frequency[2)] (60 Hz)
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 50 and 60 Hz shall be tested at each frequency. 3) Equipment with dual-rated voltages shall be tested at the higher voltage.	

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 of all condensate and there shall be no dripping or blowing-off of water from the equipment such that the building or surroundings become wet.

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 5. 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 5 shall be considered standard rating conditions for the determination of heating capacity.

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 5.

5.1.3 Airflow conditions

5.1.3.1 Heating-only equipment shall use the airflow 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 airflow rate as for the cooling capacity rating test.

5.1.4 Test conditions

5.1.4.1 Preconditions

5.1.4.1.1 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.

Table 5 — Heating capacity test conditions

Parameter	Standard test conditions
Temperature of air entering indoor side (°C)	
dry-bulb	20
wet-bulb (maximum)	15
Temperature of air entering outdoor side (high[1]) (°C)	
dry-bulb	7
wet-bulb	6
Temperature of air entering outdoor side (low[1])) (°C)	
dry-bulb	2
wet-bulb	1
Temperature of air entering outdoor side (extra-low[1)2)])(°C)	
dry-bulb	-7
wet-bulb	-8
Test frequency	Rated frequency[3)] (60 Hz)
Test voltage	Rated voltage[4)]

1) If defrosting occurs during the high, low, or extra-low heating capacity tests, testing under these conditions shall be accomplished using the indoor air-enthalpy method (see annex B).
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 50 and 60 Hz 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 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 10. When the leaving air temperature tolerances exceed the permitted range because of frost, the procedure for the heating capacity test in the defrost region shall be used.

5.1.4.1.3 During the test in the defrost region, any apparatus disturbing normal outdoor airflow on the equipment shall not be connected. The indoor airflow is to be allowed to continue with no changes in the airflow 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 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.

5.1.4.1.4 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 equipment defrost controls may occur. Under defrost conditions the normal functioning of the test room reconditioning apparatus may be disturbed. Because of this, the maximum allowable deviation of air temperature readings shall be three times those specified in table 10.

5.1.4.2 Duration

Data shall be recorded for 30 min at 5-min intervals until seven consecutive sets of readings within the tolerances specified in 6.5 have been attained. 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.

5.2 Maximum heating test

5.2.1 General conditions

The electrical conditions given in table 6 shall be used during the maximum heating test. The test voltages shall be maintained at the specified percentages under running conditions.

5.2.2 Temperature conditions

The temperature conditions given in table 6 shall be used during these tests unless the manufacturer specifies other conditions in the manufacturer's equipment specification sheets.

5.2.3 Airflow 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 6 — 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)] (60 Hz)
Test voltage	a) 90 % and 110 % of rated voltage 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 50 and 60 Hz shall be tested at each frequency.	

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 6:

– 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 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.

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 6, 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 7 shall be used for this test.

5.3.2 Temperature conditions

The temperature conditions for this test shall be as given in table 7, unless the manufacturer specifies other conditions in the manufacturer's equipment specification sheets.

5.3.3 Airflow conditions

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

5.3.4 Test conditions

5.3.4.1 Preconditions

The equipment shall be operated for a sufficient period of time to reach stable operating conditions.

5.3.4.2 Duration

After the equipment has reached stable operating conditions, these conditions shall be maintained for 1 h.

5.3.5 Performance requirements

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

Table 7 — 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 (60 Hz)
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 50 and 60 Hz shall be tested at each frequency.

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

5.4 Automatic defrost test

5.4.1 General conditions

The electrical conditions given in table 5 shall be used during the automatic defrost test for heat pumps.

5.4.2 Temperature conditions

The outdoor air temperature conditions given in table 5 for low outdoor-side entering air temperatures shall be used during the automatic defrost test for heat pumps.

5.4.3 Airflow conditions

Unless prohibited by the manufacturer, the indoor-side fan is to be adjusted to the highest speed and the 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 5 have been stabilized.

5.4.4.2 Duration

The equipment 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 coil 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 by the manufacturer.

6- TEST METHODS AND UNCERTAINTIES OF MEASUREMENTS

6.1 Test methods

The following test methods are specified in this SASO Standard and are described in the annexes:

a) air-enthalpy method, indoor-side (see annex B);
b) compressor calibration method (see annex C);
c) refrigerant enthalpy method (see annex D);
d) airflow measurement method (see annex E);
e) cooling condensate measurement method (see annex F);
f) air-enthalpy method, outdoor-side (see annex G).

6.2 Applicability of test methods

6.2.1 Equipment shall be rated for capacity by the indoor air-enthalpy test method (see annex B).

6.2.2 Additional capacity tests, for example those identified in 6.1 b) to f), may be used for confirmation purposes.

6.3 Uncertainties of measurement

The uncertainties of measurement shall not exceed the values specified in table 8.

6.4 Variations in individual readings

The maximum allowable variations of individual readings from stated conditions in the performance tests shall be as shown in table 9. The maximum permissible variation of any observation during the capacity test shall be as shown in table 10.

6.5 Test tolerances

6.5.1 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.

6.5.2 The maximum permissible variations of the mean of the test observations from the standard or desired test conditions are shown in table 10.

Table 8 — Uncertainties of measurement of indicated values

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

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.

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).

Table 9 — 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 10 — 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	 ± 0.3 °C ± 0.2 °C	 ± 1.0 °C ± 0.5 °C
Temperature of air leaving indoor side	—	±1.0°C
Temperature of air entering outdoor side dry-bulb wet-bulb	 ± 0.3 °C ± 0.2 °C	 ± 1.0 °C ± 0.5 "C
Temperature of air leaving outdoor side dry-bulb		 ± 1.0 °C
Air volume flow rate	± 5%	± 10%
Voltage	± 1 %	± 2%
Water temperature inlet outlet	 ± 0.1 °C ± 0.1 °C	 ± 0.2 °C ± 0.2 °C
Water volume flow rate	± 1 %	± 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 being 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 airflow rate, in cubic metres per second of standard air;

f) external resistance to indoor airflow, 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.

7.1.3 Cooling capacity calculations

Standard ratings of capacities shall include the effects of circulating-fan heat, but shall not include supplementary heat.

7.1.3.1 If the fan at the evaporator is an integral part of the equipment, the heat from this should not affect the cooling capacity by a factor greater than the declared value of uncertainty. If it does, then the same power which is excluded from the input shall also be added to the cooling capacity.

7.1.3.2 If the fan at the evaporator is not an integral part of the equipment, the heat from this should also not affect the cooling capacity by a factor greater than the declared value of uncertainty. If it does, then the same power which is included in the input shall also be subtracted from the cooling capacity.

7.1.3.3 Determination of capacities is not required at performance test conditions.

7.1.4 Heating capacity calculations

7.1.4.1 Heating capacity is to be based on airflow and the indoor air temperature rise (or drop when defrosting), averaged with respect to time over the entire test period.

7.1.4.2 In the event that the indoor air fan stops during defrosting, the capacity during this interval is considered to be zero, but this elapsed period of time shall be included in the total test period for obtaining the average temperature rise for the indoor air stream. The net result for equipment in which no defrosting occurs is the integrated capacity for the total test period.

7.1.4.3 For equipment in which defrosting occurs, the net result is the integrated capacity for the total number of complete cycles during the test period. A complete cycle consists of a heating period and a defrosting period from defrost termination to defrost termination.

7.1.4.4 Electrical input to the equipment shall be based on the total electrical input obtained for the entire test period.

7.1.4.5 Determination of capacities is not required at performance test conditions.

7.1.5 Power input of fans

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

$$\frac{q_v \Delta p_e}{\eta}$$

where

η = 0,3 by convention;

Δp_e is the external static pressure difference, in pascals;

q_v is the rated airflow, in cubic metres per second.

7.1.5.2 If no fan is provided with the equipment, the power input, in watts, to overcome the pressure drop of the equipment shall be included in the effective power absorbed by the equipment, using the following formula:

$$\frac{q_v \Delta p_i}{\eta}$$

where

η = 0,3 by convention;

Δp_i is the internal static pressure difference, in pascals;

q_v is the rated airflow, in cubic metres per second.

7.1.5.3 The values obtained are representative of equipment with zero external static pressure. Additional calculations may be needed to derive the performance of specific applications where no fans are provided with the cooling coils (e.g. for residential applications), by considering a factor of 775 W/(m^3/s) for adjusting the heating and cooling capacities and the effective power input.

7.2 Data to be recorded

The data to be recorded during the tests include:

a) date;

b) observer(s);

c) barometric pressure, in kilopascals;

d) equipment nameplate data;

e) times;

f) power input to equipment[1], in watts;

g) energy input to equipment[2], in watt hours;

h) applied voltage(s), in volts;

i) frequency, in hertz;

j) external resistance to airflow, in pascals;

k) fan speed(s), if adjustable, in revolutions per minute;

l) dry-bulb temperature of air entering equipment, in degrees Celsius;

m) wet-bulb temperature of air entering equipment, in degrees Celsius:

n) dry-bulb temperature of air leaving equipment, in degrees Celsius;

o) wet-bulb temperature[3] of air leaving equipment, in degrees Celsius;

p) volume flow rate of air and all relevant measurements for its calculation, in cubic metres per second.

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 for confirmation;

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

[1] Total power input and where required, input to equipment components.
[2] Energy input to equipment is required only during defrost operations.
[3] Required only during cooling capacity test.

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

8- MARKING PROVISIONS

8.1 Nameplate requirements

Each air-conditioner, heat pump, single package and split system assembly 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[4];

b) distinctive type or model designation and serial number;

c) rated voltage(s);

d) rated frequency(ies);

e) climate application type(s) (see 4.1.2.1);

f) total cooling capacity[5];

g) heating capacity[6];

h) refrigerant designation and refrigerant mass charge.

8.3 Refrigerant designation

Refrigerant designation shall be in accordance with the relevant SASO standard*.

8.4 Split systems

The information in a), b), c) and d) in 8.2 and the refrigerant designation 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.

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[4] The manufacturer is considered to be the firm whose name is on the nameplate.
[5] For each rated voltage and frequency.
* This standard will be based on ISO 817.

9.1.3 The values of energy efficiency ratios and coefficients of performance shall be rounded to 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.

Annex A

(normative)

Test requirements

A.1 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 airflow 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 lines shall be installed with not more than a 2 m difference in elevation. 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 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.

Annex B

(normative)

Indoor air-enthalpy test method

B.1 General

In the air-enthalpy method, capacities are determined from measurements of entering and leaving wet- and dry-bulb temperatures and the associated airflow rate.

B.2 Applications

This method shall be used for the indoor-side tests of all equipment. Subject to the additional conditions given in annex H, this method may be used for the outdoor-side tests.

B.3 Calculation of cooling capacities

Total, sensible and latent indoor cooling capacities based on the indoor-side test data are calculated by the following equations:[6]

$$\phi_{tci} = q_{mi}(h_{a1} - h_{a2})/[v_n^{'}(1 + w_n)] \quad \ldots\text{(B.1)}$$

$$\phi_{sci} = q_{mi}c_{pa}(t_{a1} - t_{a2})/[v_n^{'}(1 + w_n)] \quad \ldots\text{(B.2)}$$

$$c_{pa} = 1006 + 1860w_n \quad \ldots\text{(B.3)}$$

$$\phi_{lci} = 2.47 \times 10^6[q_{mi}(w_{i1} - w_{i2})/[v_n^{'}(1 + w_n)] \quad \ldots\text{(B.4)}$$

$$\phi_{lci} = \phi_{tci} - \phi_{sci} \quad \ldots\text{(B.5)}$$

where:

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

q_{mi} is the indoor airflow rate, as measured in cubic metres per second;

h_{a1} is the specific enthalpy of air entering indoor-side compartment, in joules per kilogram of dry air;

h_{a2} is the specific enthalpy of air leaving indoor-side compartment, in joules per kilogram of dry air;

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

w_n *is* the specific humidity at the nozzle inlet, in kilograms per kilogram;

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

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[6] Equations (B.1), (B.2), (B.6) and (B.7) do not provide allowances for heat or air leakage in the test equipment. In equation (B.4) the latent heat of vaporization of water is 2,47 x 10^6 J/kg at 15 °C ± 1 °C.

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

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

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

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

w_{i1} is the specific humidity of air entering 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.

B.4 Calculation of heating capacities

B.4.1 Total heating capacity based on indoor-side data is calculated by the following equation:[7]

$$\phi_{thi} = q_{mi} c_{pa} (t_{a2} - t_{a1}) / [v_n^{'} (1 + w_n)] \qquad \text{. . . (B.6)}$$

where ϕ_{thi} is the total heating capacity, indoor-side data, in watts, and the other symbols are as defined above.

B.4.2 Total heating capacity based on outdoor-side data is calculated by the following equation:[7]

$$\phi_{tho} = q_{mo} (h_{a3} - h_{a4}) / [v_n^{'} (1 + w_n)] + P_k \qquad \text{... (B.7)}$$

where:

ϕ_{tho} is the total heating capacity, outdoor-side data, in watts;

q_{mo} is the outdoor airflow rate, as measured in cubic metres per second;

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

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

P_k is the power input to compressor, in watts.

B.4.3 If line loss corrections are to be made, they shall be included in the capacity calculations (see G.4.2).;

Annex C

(informative)

Compressor calibration method

C.1 General description

C.1.1 In this method, total cooling or heating capacity is determined as follows.

a) From measurements of properties of the refrigerant entering and leaving the indoor side of the equipment and the associated refrigerant flow rate as determined by subsequent calibration of the compressor under identical operating conditions. Direct capacity measurements should be used when the superheat of the refrigerant leaving the evaporator is less than 2.8 °C.

b) By measuring capacity directly with a calorimeter when the compressor is operating under conditions identical to those encountered during the equipment test.

C.1.2 When the compressor calibration method is used, the requirements in B.4.1 and B.4.2 apply to both the equipment test and the compressor calibration test.

C.2 Measurement of refrigerant properties

C.2.1 The equipment should be operated under the desired test conditions, and measurements of the temperature and pressure of the refrigerant entering and leaving the indoor side, and entering and leaving the compressor should be taken at 10-min intervals until four sets of readings within the tolerances specified in 6.5.1 and 6.5.2 are obtained. When an indoor air-enthalpy test is required, these readings should be obtained during this test.

C.2.2 On equipment not sensitive to refrigerant charge, pressure gauges may be tapped into the refrigerant lines.

C.2.3 On equipment sensitive to refrigerant charge, it is necessary to determine refrigerant pressures after this test because the connection of pressure gauges might result in a loss of charge. To accomplish this, measure temperatures during the test by means of thermocouples soldered to return bends at the midpoints of each indoor and outdoor coil circuit or at points not affected by vapour superheat or liquid subcooling. Following the test, connect the gauges to the lines and evacuate the equipment and charge it with the type and quantity of refrigerant specified on the nameplate. Then operate the equipment again under test conditions and, if necessary, add or remove refrigerant charge until the coil thermocouple measurements are within ± 0.3 °C of their original values, the temperatures of the refrigerant vapour entering and leaving the compressor are within ± 1.7 °C of their original values, and the temperature of the liquid entering the expansion device is reproduced within ± 0.6 °C. The operating pressures should then be noted.

C.2.4 Refrigerant temperatures should be measured by means of thermocouples soldered to the lines at appropriate locations.

C.2.5 No thermocouples should be removed, replaced or otherwise disturbed during any portion of a complete capacity test.

C.2.6 Temperatures and pressures of the refrigerant vapour entering and leaving the compressor should be measured in the refrigerant lines approximately 25 cm from the compressor shell. If the reversing valve is included in the calibration, these data should be taken on the lines to the coils and approximately 25 cm from the valve.

C.3 Compressor calibration

C.3.1 The refrigerant flow rate should then be determined from the calibration of the compressor at the predetermined refrigerant pressures and temperatures entering and leaving the compressor by one of the primary test methods described in the relevant SASO standard*.

C.3.2 Calibration tests should be performed with the compressor and reversing valve (where used) at the same ambient temperature and air pattern as in the tested equipment.

C.3.3 For the methods listed, i.e.

a) secondary refrigerant calorimeter method,

b) flooded-system primary refrigerant calorimeter method,

c) dry-system primary refrigerant calorimeter method, and

d) concentric-tube calorimeter method,

the refrigerant flow rate is calculated as follows:

$$q_r = \phi_{tci} / (h_{g1} - h_{f1})$$

where:

q_r is the refrigerant flow rate, in kilograms per second;

ϕ_{tci} is the total cooling capacity, in watts;

h_{g1} is the enthalpy of refrigerant vapour entering the compressor, in joules per kilogram;

h_{f1} is the enthalpy of refrigerant liquid at saturation temperature corresponding to the pressure of the refrigerant vapour leaving the compressor, in joules per kilogram.

C.3.4 The gaseous refrigerant flowmeter method gives refrigerant flow directly.

C.3.5 Total cooling capacity is calculated as specified in C.3.7 . Total heating capacity is calculated as specified in C.3.8.

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* This standard will be based on ISO 917.

C.3.6 Heating capacity is measured directly as given in C.3.6.1 to C.3.6.4 .

C.3.6.1 For compressor calibration tests, when the evaporator superheat on the heating cycle is less than 2.8 °C, it is necessary to determine the refrigerant flow rate using the heat rejection from the calorimeter condenser. A water-cooled condenser, insulated against heat leakage, is required. The condenser may be used with any of the calorimeter arrangements specified in C.3.3.

C.3.6.2 This method may be used only when the calculated heat leakage from the condenser to the ambient is less than 2 % of the refrigerating effect of the compressor.

C.3.6.3 The calibration test should be run as specified in C.3.2. Additional data required are:

a) refrigerant pressure and temperature entering the condenser;

b) refrigerant pressure and temperature leaving the condenser;

c) water temperatures entering and leaving the condenser;

d) ambient temperature surrounding the condenser;

e) quantity of condenser cooling water;

f) average temperature of the condenser jacket surface exposed to the ambient.

C.3.6.4 The refrigerant flow rate, q_r is calculated as follows:

$$q_r = [q_W c_{pW} (t_{W1} - t_{W2}) + U(t_c - t_a)] / (h_{g2} - h_{f2})$$

where:

q_W is the condenser water flow rate, in kilograms per second;

c_{pW} is the specific heat of water, in joules per kilogram kelvin;

t_{W1} is the temperature of water entering the calorimeter, in degrees Celsius;

t_{W2} is the temperature of water leaving the calorimeter, in degrees Celsius;

U is the heat leakage coefficient, in joules per second kelvin;

t_c is the temperature of the surface of the calorimeter, in degrees Celsius;

t_a is the ambient temperature, in degrees Celsius;

h_{g2} is the enthalpy of refrigerant vapour entering the condenser, in joules per kilogram;

h_{f2} is the enthalpy of refrigerant liquid leaving the condenser, in joules per kilogram.

C.3.7 Cooling capacities are calculated as given in C.3.7.1 or C.3.7.2.

C.3.7.1 For tests in which the evaporator superheat is 2.8 °C or more, the total cooling capacity, ϕ_{tci} based on compressor calibration data is calculated from the refrigerant flow rate as follows:

$$\phi_{tci} = q_r (h_{r2} - h_{r1}) - P_i$$

where:

h_{r2} is the enthalpy of refrigerant leaving the indoor-side compartment, in joules per kilogram;

h_{r1} is the enthalpy of refrigerant entering the indoor-side compartment, in joules per kilogram;

P_i is the power input, indoor-side, in watts.

C.3.7.2 For tests in which the evaporator superheat is less than 2.8 °C, the total cooling capacity, ϕ_{tci} . is calculated as follows:

$$\phi_{tci} = \phi_e + U(t_a - t_c) - P_i$$

where:

ϕ_e is the heat input to the calorimeter evaporator, in watts;

U , t_a and P_i are as defined above.

C.3.8 Total heating capacity, ϕ_{thi} based on compressor calibration data is calculated from the refrigerant flow rate as follows:

$$\phi_{thi} = q_r (h_{r1} - h_{r2}) - P_i$$

Annex D

(informative)

Refrigerant-enthalpy method

D.1 General description

D.1.1 In this method, capacity is determined from the enthalpy change and flow rate of the refrigerant. Enthalpy changes are determined from measurements of entering and leaving pressures and temperatures of the refrigerant, and the flow rate is determined by a suitable flowmeter placed in the liquid line.

D.1.2 This method may be used for tests of equipment in which the refrigerant charge is not critical and where normal installation procedures involve the field connection of refrigerant lines.

D.1.3 This method should not be used for tests in which the refrigerant liquid leaving the flowmeter is subcooled less than 1.7 °C nor for tests in which the superheat of the vapour leaving the indoor-side compartment is less than 2.8 °C.

D.2 Measurement of refrigerant flow

D.2.1 The refrigerant flow rate should be measured with an integrating-type flowmeter connected in the liquid line upstream of the refrigerant control device. This meter should be sized so that its pressure drop does not exceed the vapour pressure change that a 1.7 °C temperature change would produce.

D.2.2 Temperature and pressure measuring instruments and a sight glass should be installed immediately downstream of the meter to determine if the refrigerant liquid is adequately subcooled. Subcooling of 1.7 °C and the absence of any vapour bubbles in the liquid leaving the meter are considered adequate. It is recommended that the meter be installed at the bottom of a vertical downward loop in the liquid line to take advantage of the static head of the liquid thus provided.

D.2.3 At the end of the test, a sample of the circulating refrigerant and oil mixture may be taken from the equipment and its percentage of oil calculated from:

$$x_0 = \frac{m_5 - m_1}{m_3 - m_1}$$

where:

x_0 is the concentration of oil based on the mass of refrigerant and oil in the sample;

m_1 is the mass of the cylinder and bleeder assembly when empty;

m_3 is the mass of the cylinder and bleeder assembly with sample;

m_5 is the mass of the cylinder and bleeder assembly with residual oil from the sample.

The total indicated flow rate should be corrected for the amount of oil circulating.

D.3 Refrigerant temperature and pressure measurement

The temperature and pressure of the refrigerant entering and leaving the indoor-side of the equipment should be measured with instruments in accordance with annexes G and H.

D.4 Calculation of cooling capacity

Total cooling capacity based on volatile refrigerant flow data is calculated as follows:

$$\phi_{tci} = x_r q_{ro}(h_{r2} - h_{r1}) - P_i$$

where:

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

x_r is the mass ratio of refrigerant to refrigerant-oil mixture;

q_{ro} is the flow rate of refrigerant-oil mixture, in cubic metres per second;

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.

D.5 Calculation of heating capacity

Total heating capacity based on volatile refrigerant flow data is calculated as follows:

$$\phi_{thi} = x_r q_{ro}(h_{r1} - h_{r2}) - P_i$$

where:

ϕ_{thi} is the total heating capacity, indoor-side data, in watts.

Annex E

(informative)

Airflow measurements

E.1 General

E.1.1 Airflow measurements should be made in accordance with the provisions specified in the relevant SASO standards* as appropriate (see annex K) and the provisions of this annex.

E.1.2 Indoor airflow rates for equipment rated 117 kW and lower should be measured in accordance with the methods specified in H.3 if the indoor air-enthalpy method is used. The nozzle apparatus described in H.8 is recommended when direct airflow measurement is not employed. The indoor airflow rate should be determined indirectly as specified in E.1.3.

E.1.3 Indoor airflow rates of equipment rated above 117 kW should be determined by one of the methods given in E.1.1 or by the modified method given in E.2.4.

E.2 Calculations

E.2.1 The airflow rate through a single nozzle is calculated by the following equations:

$$q_i = 1.414 C_d A_n (1000 p_v v_n^{'})^{0.5}$$

$$v_n^{'} = 101 v_n / [p_n (1 + w_n)]$$

where:

q_i is the airflow rate, indoor, calculated in cubic metres per second;

C_d is the nozzle discharge coefficient;

A_n is the area of nozzle, in square metres;

p_v is the velocity pressure at nozzle throat or static pressure difference across nozzle, in pascals;

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

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

p_n is the pressure at nozzle throat, in kilopascals;

w_n is the specific humidity at nozzle throat, in kilograms per kilogram.

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* This standards will be based on ISO 5221, 3966 and 5167-1.

E.2.2 When more than one nozzle is used, the total airflow rate is the sum of the flow rates of the individual nozzles calculated in accordance with E.2.1.

E.2.3 The flow rate of standard air is calculated as follows:

$$q_s = q_{vi} /(1.2v_n^{'})$$

where:

q_s is the airflow rate, standard air, in cubic metres per second;

q_{vi} if the volume airflow, indoors, measured, in cubic metres per second.

E.2.4 Calculations for the modified airflow measurement method are given in E.2.4.1 and E.2.4.2.

E.2.4.1 If the modified airflow method is selected (see figure E.1 for apparatus), low-side air quantity should be determined from the following equations:

$$q_i = \phi_{sri} /1006 + 1860 w_{i2} (t_{a5} - t_{a1})$$

ϕ_{sri} is the sensible reheat capacity (indoor-side data), in watts;

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

t_{a5} is the temperature of air leaving reheat coil, in degrees Celsius;

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

The heat line loss in the interconnecting tubing, ϕ_L in watts, is given by:

$$\phi_L = q_i v_{a1}$$

where v_{a1} is the specific volume of air leaving indoor-side compartment, in cubic metres per kilogram of dry air.

The airflow rate, standard air, q_s in cubic metres per second, is given by:

$$q_s = \phi_{sri} /1.204(t_{a5} - t_{a1})$$

E.2.4.2 Sensible reheat capacity (indoor-side data) is determined as follows.

a) If electric reheat is used, ϕ_{sri} is the watts input to the heater.

b) If steam coil reheat is used:

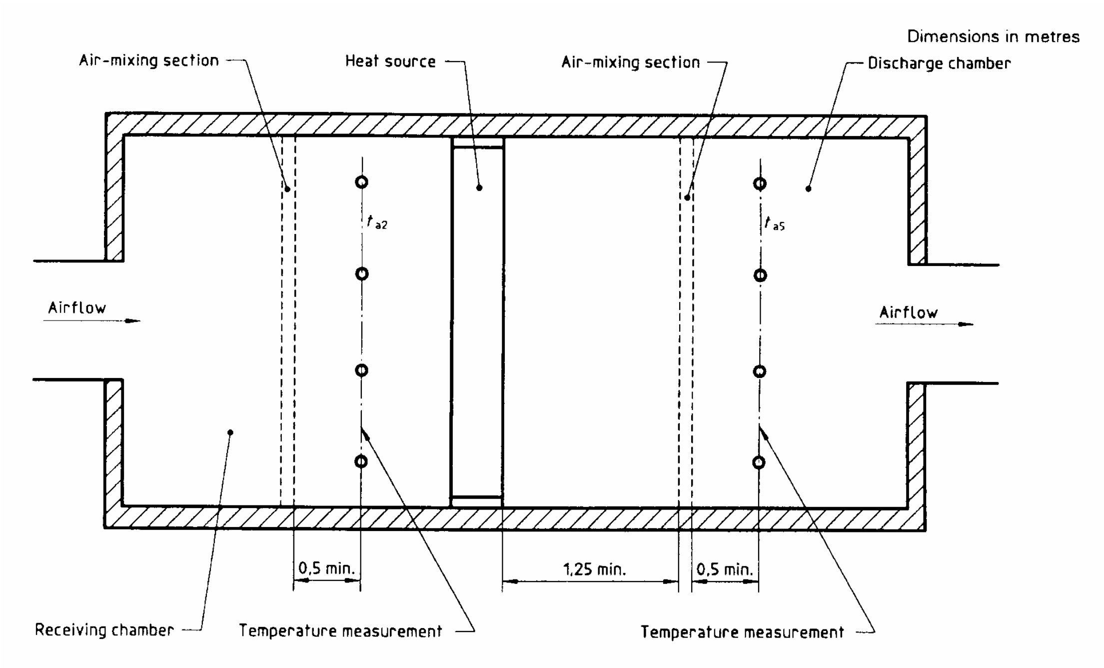
$$\phi_{sri} = q_k (h_{k1} - h_{k2})$$

where:

q_k is the flow rate of fluid condensate (steam), in kilograms per second;

h_{k1} is the enthalpy of steam entering calorimeter evaporator, in joules per kilogram;

h_{k2} is the enthalpy of fluid leaving calorimeter evaporator, in joules per kilogram.



NOTES

1 Heat loss from the enclosure should be less than 1 % of the heat input to the heat source.

2 Minimum temperature rise across the heat source should be 10 °C.

Figure E.1 — Alternative airflow measurement apparatus

Annex F

(informative)

Cooling condensate measurements

F.1 General

The latent cooling capacity should be determined from measurements of the condensate flow rate. The drain connection should be trapped to stabilize the condensate flow.

F.2 Calculations

F.2.1 The latent cooling capacity is calculated as follows:

$$\phi_{lci} = 0.134\ q_c$$

where:

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

q_c is the flow rate, indoor coil condensate, in kilograms per second.

F.2.2 The sensible cooling capacity is then calculated as follows

$$\phi_{sc} = \phi_{tci} - \phi_{lci}$$

where:

ϕ_{sc} is the sensible cooling capacity, in watts;

ϕ_{tci} is the tota1 cooling capacity, indoor-side data, in watts.

Annex G

(informative)

Outdoor air-enthalpy test method

G.1 General

G.1.1 In the air-enthalpy method, capacities are determined from measurements of entering and leaving wet- and dry-bulb temperatures and the associated airflow rate.

G.1.2 Outdoor air-enthalpy tests are subject to the apparatus arrangement limitations specified in G.2.1 if the compressor is independently ventilated, and to the line loss adjustment permitted by B.4.3 and G.4.2 if the equipment has remote outdoor coils.

G.2 Test room requirements

G.2.1 When the air-enthalpy method is used for outdoor-side tests, it is necessary to ascertain whether the attachment of the airflow 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 10-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 within ± 0.3 °C or its pressure equivalent of the averages observed during the preliminary test, the outdoor airflow 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 within ± 2.0 % with the results obtained during the preliminary test period. This applies for both the cooling and the heating cycle, but needs to be carried out at any one condition for each.

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

G.2.3 When the outdoor airflow is adjusted as described in G.2.1, the adjusted airflow 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.

G.3 Test conditions

When the outdoor air-enthalpy method is used, the requirements given in 5.1.4.1.3 and 5.1.4.1.4 apply to both the preliminary test (see G.2) and the regular equipment test.

G.4 Calculations

G.4.1 Total indoor cooling capacity based on outdoor-side date is calculated by one of the equations (G.1) or (G.2):[7]

$$\phi_{tci} = q_{mo}(h_{a4} - h_{a3})/[v_n^{'}(1 + w_n)] - P_t \qquad \ldots(G.1)$$

where:

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

q_{mo} is the outdoor-side airflow rate, measured in cubic metres per second;

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

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

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

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

P_t is the total power input to equipment, in watts.

or, for air-cooled equipment which does not re-evaporate:[8]

$$\phi_{tci} = q_{mo}c_{pa}(t_{a4} - t_{a3})/[v_n^{'}(1 + w_n)] - P_t \qquad \ldots(G.2)$$

where:

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

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

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

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[7] Equations (G.1) and (G.2) do not provide allowances for heat leakage in the test equipment.

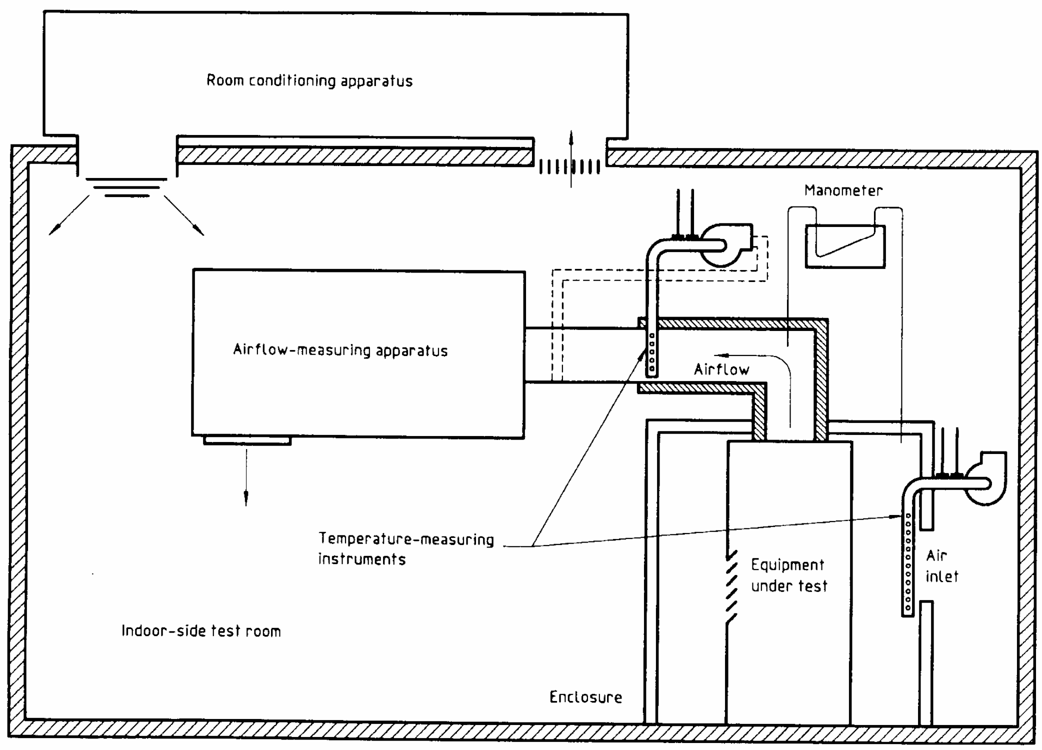


Figure G.1 — Arrangement for calorimeter air-enthalpy test method

G.4.2 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:

$$\phi_L = 0.6057 + 0.005316(D_t)^{0.75}(\Delta t)^{1.25} + 79.8D_t.\Delta t.L \qquad \text{... (G.3)}$$

where:

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

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

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

L is the length of refrigerant tubing, in metres.

b) For insulated lines:

$$\phi_L = 0.6154 + 0.3092(T)^{-0.33}(D_t)^{0.75}(\Delta t)^{1.25}L \qquad \text{... (G.4)}$$

where T is the thickness of insulation on interconnecting tubing, in millimetres.

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

Annex H
(informative)
Instrumentation and measurements

H.1 Temperature measurements

H.1.1 Temperatures should be measured using liquid-in-glass thermometers, thermocouples or electric resistance thermometers, including thermistors. In general, the response time of liquid-in-glass thermometers is too large to be used in transient testing. For transient testing, the instrument characteristics given in table H.1 should be met.

H.1.2 In-duct temperature measurements should be taken at not less than three locations at the centres of equal segments of the cross-sectional area, or suitable sampling or mixing devices giving equivalent results should be provided. Connections to the equipment should be insulated between the place of measurement and the equipment so that heat leakage through the connections does not exceed 1.0% of the capacity.

H.1.3 Indoor inlet air temperature should be measured at not less than three positions equally spaced over the equipment inlet area, or equivalent sampling means should be provided. For equipment without duct connections or enclosure, the temperature-measuring instruments or sampling devices should be located approximately 15 cm from the equipment inlet opening or openings.

Table H.1 — Instrument tolerances for temperature measurement

Values in degrees Celsius

Item measured	Instrument accuracy	Instrument precision	Usual range of measurements
Air dry-bulb temperature[1)]	±0.1	±0.05	- 29 to 60
Air wet-bulb temperature[1)]	±0.1	±0.05	- 18 to 32
Non-volatile refrigerant temperature[1)]	±0.1	±0.05	- 1 to 43
Non-volatile refrigerant temperature difference[2)]	±0.1	±0.05	3 to 14
Volatile refrigerant temperature difference[3)]	±0.6	±0.3	-34 to 121
Other temperatures required for other purposes[4)]	—	—	-18 to 149

1) Items are used to determine fluid temperature change and, in conjunction with flow rate, the cooling or heating flow rates.
2) Applicable where the temperature difference is measured with a single instrument.
3) Includes refrigerant tube temperatures where acceptable in lieu of immersion of instrument within refrigerant stream.
4) Other temperatures taken for other purposes; for example, refrigerant system component temperatures, motor winding temperatures or electrical component temperatures.

H.1.4 Outdoor inlet air temperatures should be measured at locations such that the following conditions are fulfilled.

a) The measured temperatures should be representative of the temperature surrounding the outdoor side and simulate the conditions encountered in an actual application.

b) At the point of measurement, the temperature of the air should not be affected by the air discharged from the outdoor side. This suggests that the temperatures be measured upstream of any recirculation produced.

It is intended that the specified test temperatures surrounding the outdoor side under test should simulate as nearly as possible a normal installation operating at ambient air conditions identical to the specified test temperatures.

H.1.5 Air velocities over the wet-bulb temperature-measuring instruments should be approximately 5 m/s. It is recommended that the same air velocity be used for inlet and outlet measurements.

H.1.6 In no case should the smallest scale division of the temperature-measuring instrument 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.

H.1.7 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 laboratory.

H.1.8 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.

H.1.9 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.

H.1.10 Temperature-measuring instruments should be adequately shielded from radiation from any adjacent heat sources.

H.1.11 Air temperature measurements are to be taken upstream of static pressure taps on the inlet, and downstream of the static pressure taps on the outlet.

H.2 Pressure measurements

H.2.1 Pressure measurements should be made with one or more of the following instruments;

a) mercury columns;

b) bourdon tube gauges, or

c) electronic pressure transducers.

H.2.2 The accuracy of the pressure-measuring instruments should be within ± 2.0 % of the indicated value.

H.2.3 In no case should the smallest scale division of the pressure-measuring instrument exceed 2.5 times the specified accuracy

H.3 Airflow and static pressure measurements

H.3.1 Static pressure across nozzles and velocity pressures at nozzle throats should be measured with manometers which have been calibrated against a standard manometer to ± 1.0 % of the reading. The smallest manometer scale reading should not exceed 2.0 % of the reading.

H.3.2 Duct static pressure should be measured with manometers having an accuracy of ± 2.5 Pa.

H.3.3 Areas of nozzles should be determined by measuring their diameters to an accuracy of ± 0.2 % in four locations approximately 45° apart around the nozzle in each of two places through the nozzle throat, one at the outlet and the other in the straight section near the radius.

H.4 Electrical measurements

H.4.1 Electrical measurements should be made with indicating or integrating instruments.

H.4.2 Instruments used for measuring the electrical input to heaters or other apparatus furnishing heat loads should be accurate to ± 1.0 % of the quantity measured. Instruments used for measuring electrical input to fan motors, compressor motors or other equipment accessories should be accurate to ± 2.0 % of the indicated value.

H.4.3 Voltages should be measured at the equipment terminals.

H.5 Flow measurements

H.5.1 Volatile refrigerant flow should be measured with an integrating-type flowmeter having an accuracy of ± 1.0 % of the indicated value.

H.5.2 Water and brine flow rates should be measured with a liquid flowmeter or quantity meter having an accuracy of ± 1.0 % of the indicated value.

H.5.3 Condensate collection rates should be measured with a liquid quantity meter measuring either mass or volume and having an accuracy of ± 1.0 % of the indicated value.

H.6 Time, mass and speed measurements

H.6.1 Time measurements should be made with instruments having an accuracy of ± 0.2 %.

H.6.2 Mass measurements should be made with apparatus having an accuracy of ± 0.2 %.

H.6.3 Speed measurements should be made with a revolution counter tachometer, stroboscope or oscilloscope having an accuracy of ± 1.0 %.

H.7 Airflow enthalpy measurements

The following test apparatus arrangements are recommended.

H.7.1 Tunnel air-enthalpy method (see figure H.1)

The equipment to be tested is typically located in a test room or rooms. An air-measuring device is attached to the equipment air discharge (indoor or outdoor, or both, as applicable). This device discharges directly into the test room or space, which is provided with suitable means for maintaining the air entering the equipment at the desired wet- and dry-bulb temperatures. Suitable means for measuring the wet- and dry-bulb temperatures of the air entering and leaving the equipment and the external resistance should be provided.

H.7.2 Loop air-enthalpy method (see figure H. 2)

This arrangement differs from the tunnel arrangement in that the air-measuring device discharge is connected to suitable reconditioning equipment which is, in turn, connected to the equipment inlet. The resulting test "loop" should be sealed so that air leakage at places that would influence capacity measurements does not exceed 1.0 % of the test airflow rate. The dry-bulb temperature of the air surrounding the equipment should be maintained within ± 3.0 °C of the desired test inlet dry-bulb temperature. Wet- and dry-bulb temperatures and external resistance are measured by suitable means.

H.7.3 Calorimeter air-enthalpy method (see figure H.3)

In this arrangement, an enclosure is placed over the equipment under test, or the applicable part of the equipment. This enclosure may be constructed of any suitable material, but should be non-hydroscopic, airtight and preferably insulated. It should be large enough to permit inlet air to circulate freely between the equipment and the enclosures, and in no case should the enclosure be closer than 15 cm to any part of the equipment. The inlet to the enclosure should be remotely located from the equipment inlet so as to cause circulation throughout the entire enclosed space. An air-measuring device is connected to the equipment discharge. This device should be well insulated where it passes through the enclosed space. Wet- and dry-bulb temperatures of the air entering the equipment are measured at the enclosure inlet. Temperature and external resistance measurements are made by suitable means.

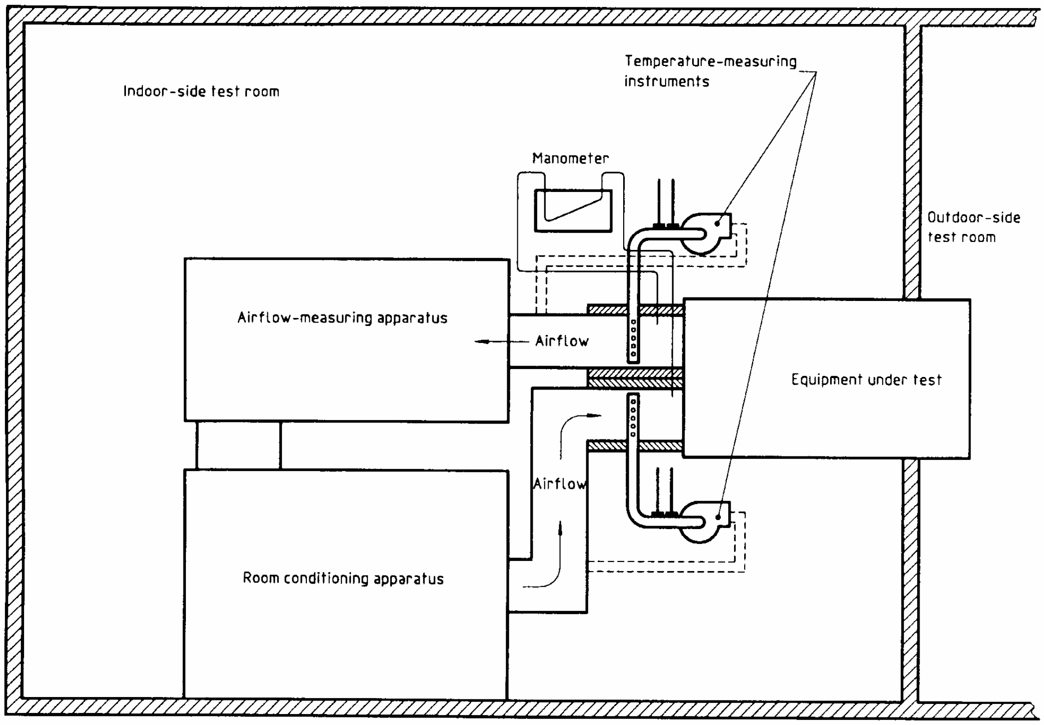


Figure H.1 - Arrangement for tunnel air-enthalpy test method

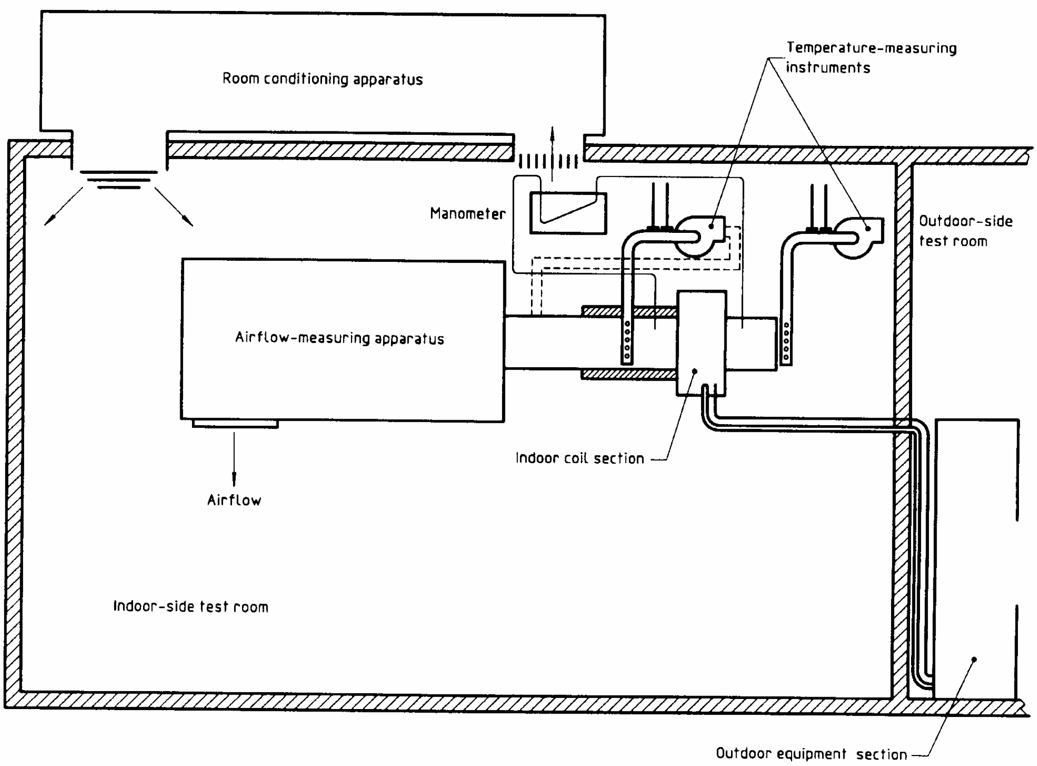


Figure H.2 - Arrangement for loop air-enthalpy test method

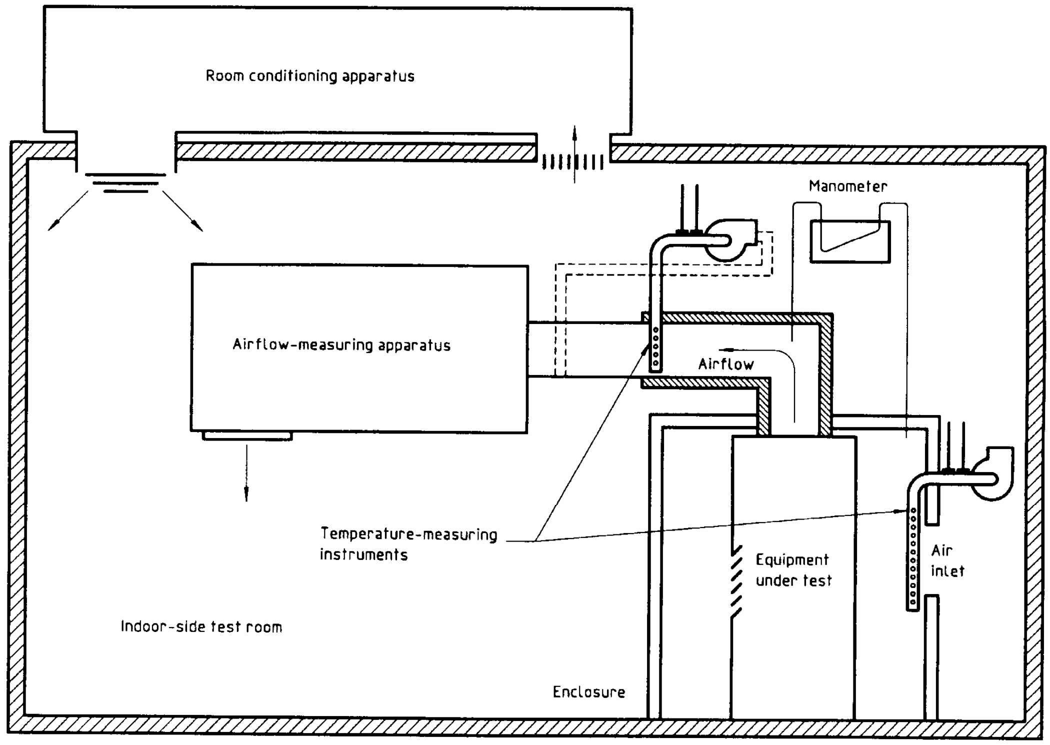


Figure H.3 - Arrangement for calorimeter air-enthalpy test method

H.7.4 Room air-enthalpy method (see figure H.4)

The equipment to be tested is typically located in the test rooms. An air-measuring device is attached to the air discharge (evaporator or condenser, as applicable), then, in turn, connected to suitable reconditioning apparatus. The discharge air from the reconditioning apparatus provides the desired wet- and dry-bulb temperature where air-sampling devices and manometers can measure wet- and dry-bulb temperatures and external resistance, as required.

H.7.5 General

The arrangements shown in figures H.1 to H.4 are intended to illustrate various possibilities available and should not be construed as applying specifically or solely to the types of equipment with which they are shown. However, an enclosure as shown in figure H.3 should be used when the compressor is in the indoor section and separately ventilated.

H.7.6 Alternatives

Other means of handling the air leaving the airflow-measuring device and supplying air at the proper conditions to the equipment inlet may be used provided that they do not interfere with the external resistance measurements or create abnormal conditions surrounding the equipment.

H.8 Nozzle apparatus

H.8.1 The nozzle apparatus consists of a receiving chamber and a discharge chamber separated by a partition in which one or more nozzles are located (see figure H.5). Air from the equipment under test is conveyed via a duct to the receiving chamber, passes through the nozzle or nozzles, and is then exhausted to the test room or channeled back to the equipment inlet.

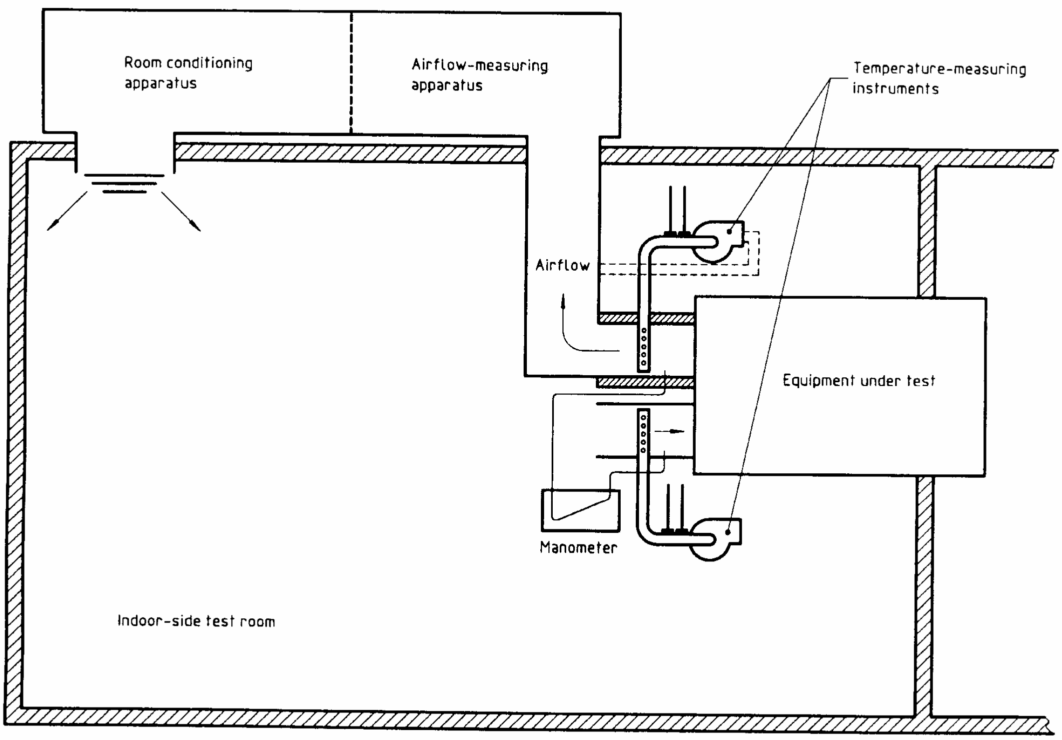
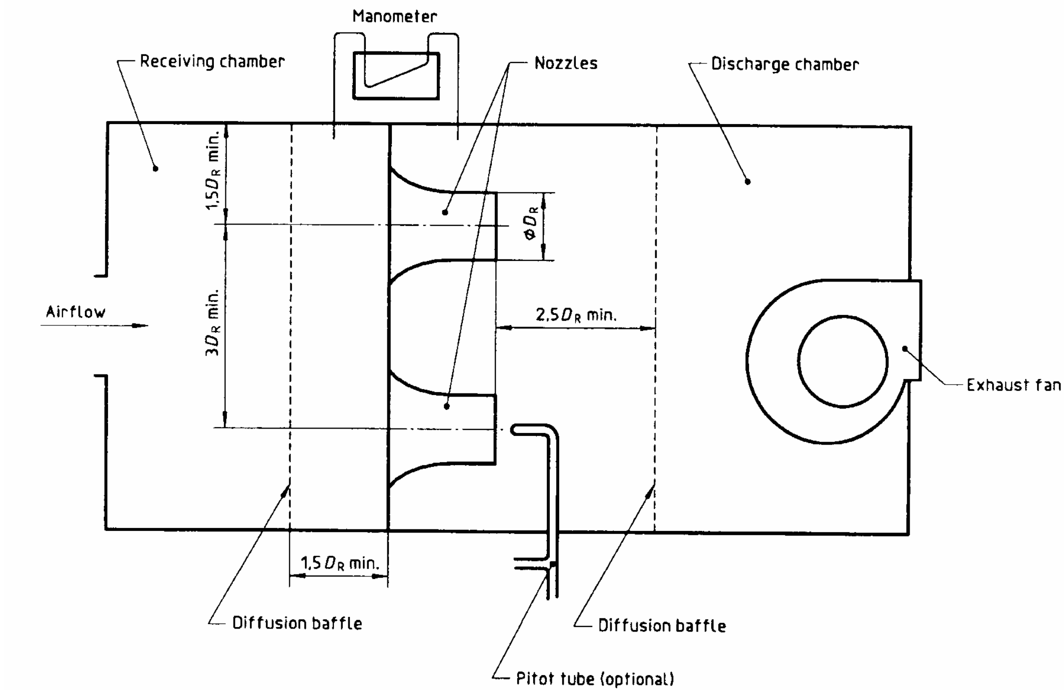


Figure H.4 — Arrangement for room air-enthalpy test method



NOTE — Diffusion baffles should have uniform perforations with approx. 40 % free area.

Figure H.5 — Airflow-measuring apparatus

H.8.2 The nozzle apparatus and its connections to the equipment inlet should be sealed so that air leakage does not exceed 1.0% of the airflow rate being measured.

H.8.3 The centre-to centre distance between nozzles in use should be not less than three times the throat diameter of the larger nozzle, and the distance from the centre of any nozzle to the nearest discharge or receiving chamber side wall should not be less than 1.5 times its throat diameter.

H.8.4 Diffusers should be installed in the receiving chamber (at a distance at least 1.5 times the largest nozzle throat diameter) upstream of the partition wall and in the discharge chamber (at a distance at least 2.5 times the nozzle throat diameter) downstream of the partition wall.

H.8.5 An exhaust fan, capable of providing the desired static pressure at the equipment outlet, should be installed in one wall of the discharge chamber, and means should be provided to vary the capacity of this fan.

H.8.6 The static pressure drop across the nozzle or nozzles should be measured with a manometer or manometers having an accuracy of ± 1.0% of the reading. One end of the manometer should be connected to a static pressure tap located flush with the inner wall of the receiving chamber and the other end to a static pressure tap located flush with the inner wall of the discharge chamber or, preferably, several taps in each chamber should be connected to several manometers in parallel or manifolded to a single manometer. Alternatively, the velocity head of the air stream leaving the nozzle or nozzles may be measured by a pitot tube as shown in figure H.5, but when more than one nozzle is in use, the pitot tube reading should be determined for each nozzle.

H.8.7 Means should be provided to determine the air density at the nozzle throat.

H.8.8 The throat velocity of any nozzle in use should be not less than 15 m/s, nor more than 35 m/s.

H.8.9 When nozzles are constructed in accordance with figure H. 6, and installed in accordance with the provisions of this annex, they may be used without calibration. If the throat diameter is 12.5 cm or larger, the coefficient may be assumed to be 0.99. For nozzles smaller than 12.5 cm in diameter, or where a more precise coefficient is desired, the following values may be used or, preferably, the nozzle should be calibrated.

Reynolds number, *Re*	**Discharge coefficient,** C_d
50000	0.97
100000	0.98
150000	0.98
200 000	0.99
250 000	0.99
300 000	0.99
400 000	0.99
500 000	0.99

Reynolds number. *Re***,** is calculated as follows:

$$Re = fV_n D_n$$

Where:

f is a factor, dependent on temperature, for the Reynolds number;

V_n is the velocity of air at nozzle, in metres per second;

D_n is the diameter of nozzle throat, in millimetres.

The temperature factor, f , is as follows:

Temperature, °C	*Factor,*
-6.5	78.2
+4.5	72.0
15.5	67.4
26.5	62.8
38	58.1
49	55.0
60	51.9
71	48.8

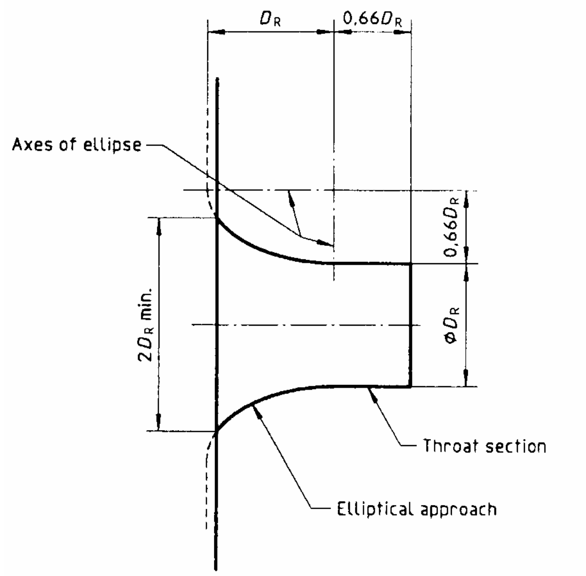


Figure H.6 — Airflow-measuring nozzle

H.9 Static pressure measurements

H.9.1 Equipment with a fan and a single outlet

H.9.1.1 As shown in figure H.7, a short plenum chamber should be attached to the outlet of the discharge-side of the equipment, where external static pressure measurements are required. This plenum should discharge into an air-measuring device (or a suitable dampening device when direct air measurement is not used), and should have cross-sectional dimensions equal to the dimensions of the equipment outlet.

H.9.1.2 External static pressure should be measured by a manometer. One side of the manometer should be connected to four externally manifolded pressure taps in the discharge plenum, these taps being centred in each plenum face at a distance of twice the mean cross-sectional dimension from the equipment outlet. If an inlet duct connection is used, the other side of the manometer should be connected to four externally manifolded pressure taps centred in each face of the inlet duct. If no inlet duct connection is used, the other side of the manometer should be open to the surrounding atmosphere. Inlet duct connections should have cross-section dimensions equal to those of the equipment (see figure H.8).

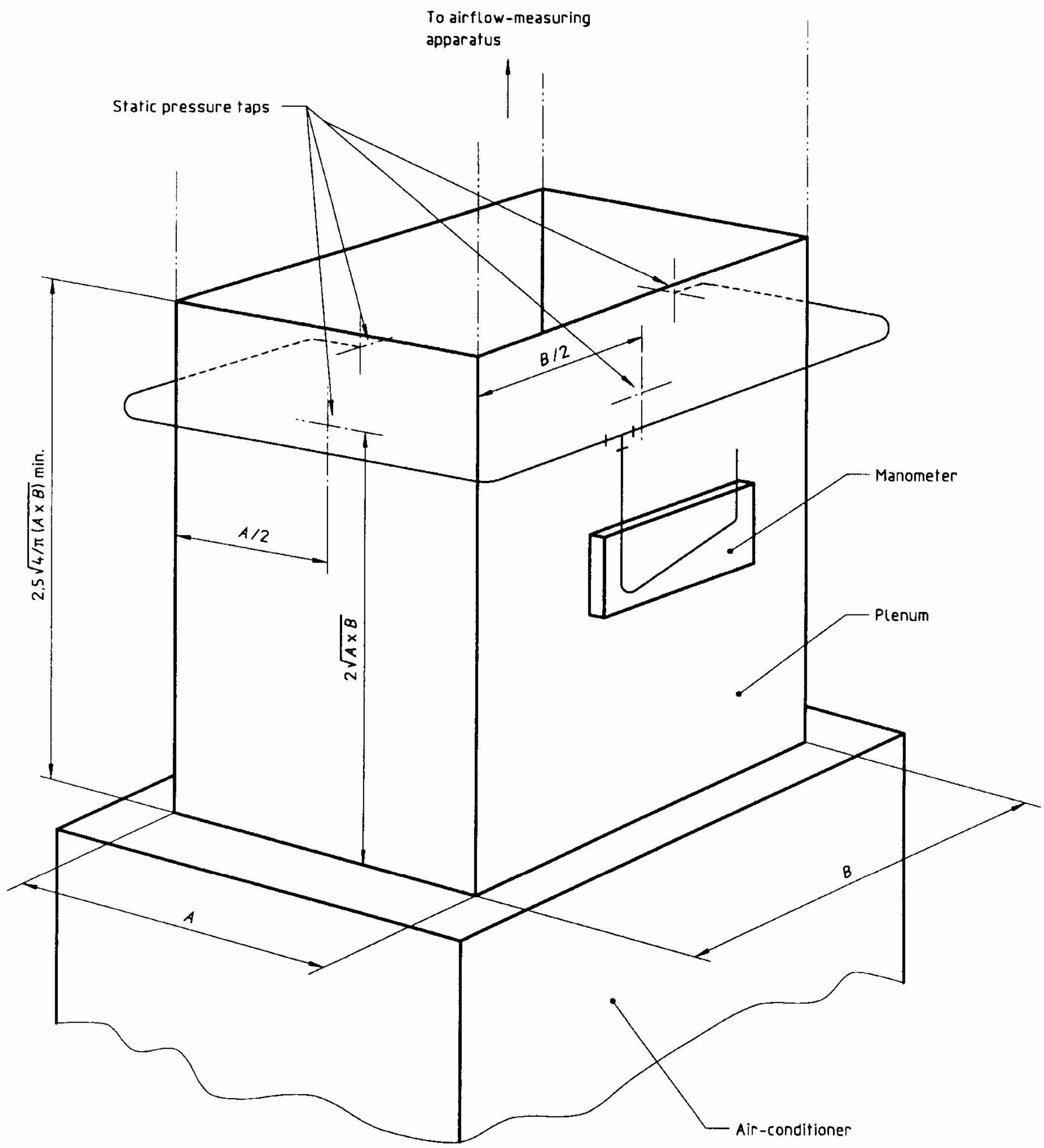


Figure H.7 - External static pressure measurement

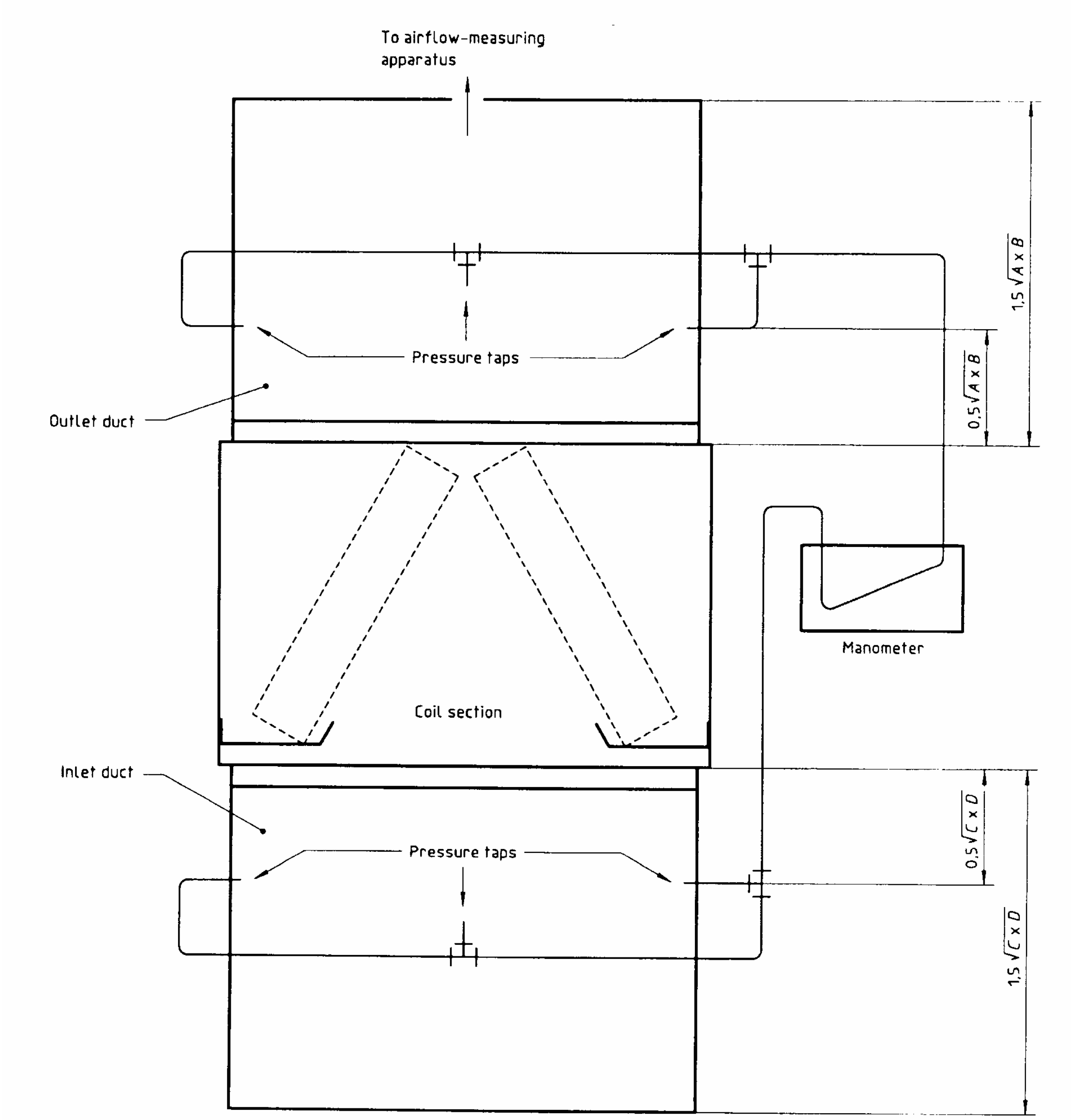


Figure H.8 - Static air pressure drop measurement for coil section without fan

H.9.2 Equipment with fans and multiple outlets

H.9.2.1 Equipment with multiple discharge outlet duct connections should have a short plenum and should discharge into a single common duct section, the duct section in turn discharging into the air-measuring device. Each plenum should have an adjustable restrictor located in the plane where the plenums enter the common duct section for the purpose of equalizing the static pressure in each plenum.

H.9.2.2 Equipment with multiple blowers using a single discharge duct connection flange should be tested with a single plenum in accordance with H.9.1.1. Any other test plenum arrangements should not be used except to simulate duct designs specifically recommended by the equipment manufacturer.

H.9.3 Equipment without fans

H.9.3.1 For indoor coil sections which do not incorporate a fan, the inlet and outlet duct connections should have cross-sectional dimensions equal to the duct flanges of the supplied or recommended coil enclosure.

H.9.3.2 The static air pressure drop should be measured by a manometer as shown in figure H.8. One side of the manometer should be connected to four externally manifolded pressure taps in the outlet duct, these taps being centred in each duct face located at the distance from the coil casing as shown. The other side of the manometer should be connected to four externally manifolded pressure taps centred in each inlet duct face located at the distance from the coil casing as shown.

H.9.4 General requirements for static pressure measurements

H.9.4.1 It is recommended that the pressure taps consist of 6.25 mm diameter nipples soldered to the outer plenum surfaces and centred over 1 mm diameter holes through the plenum. The edges of these holes should be free of burrs and other surface irregularities.

H.9.4.2 The plenum and duct section should be sealed to prevent air leakage, particularly at the connections to the equipment and the air-measuring device, and should be insulated to prevent heat leakage between the equipment outlet and the temperature-measuring instruments.

H.10 Test instrumentation for the high-temperature test

H.10.1 The indoor airflow rate should be determined as described in annex E. This requires the construction of an air-receiving chamber and discharge chamber separated by a partition in which one or more nozzles are located. The receiving chamber is connected to the indoor air discharge side of the equipment through a short plenum.

H.10.2 The exhaust side of the airflow rate measuring device contains an exhaust fan with some means to vary its capacity to obtain the desired external resistance to airflow. The exhaust side is then left open to the test room or is ducted through a conditioning apparatus and then back to the equipment inlet.

H.10.3 The static pressure across the nozzles, the velocity pressure and the static pressure measurements at the nozzle throat should be measured with manometers which will provide errors no greater than ± 1.0% of the indicated values and have minimum scale divisions not exceeding 2.0 % of the reading.

H.10.4 Static pressure and temperature measurements should be taken at the nozzle throat in order to obtain the density of the air. The area of the nozzle should be determined by measuring the diameter with an error not exceeding ± 0.2 % in four locations approximately 45° apart around the nozzle in each of two places through the nozzle throat, one at the outlet and the other in the straight section near the radius.

H.10.5 The energy usage of the compressor, the indoor and outdoor fans, and all other equipment components should be measured with a watt-hour meter which is accurate to within ± 0.5 % of the quantity measured.

H.10.6 Measurements of the air temperature entering and leaving the indoor coil or the difference between the two should be made in accordance with the requirements of H.9. These temperatures should be continuously recorded with instrumentation having a total system accuracy within ± 0.15 °C and a response time of 2.5 s or less, upstream of the static pressure tap on the inlet and downstream of the static pressure tap on the outlet.

H.10.7 The indoor and outdoor dry-bulb temperatures should be continuously recorded with instrumentation which will result in an error no greater than ± 0.15°C. The outdoor wet-bulb temperature should be continuously recorded.

H.10.8 Static pressure measurements in the ducts and across the equipment should be made in accordance with H.3 using airflow-measuring apparatus which will result in an error no greater than 0.25 mm of water. Static pressure measurements should be made and recorded at 5-min intervals. All other data not continuously recorded should be recorded at 10-min intervals.

H.11 Test instrumentation for the frost accumulation test

H.11.1 The airflow rate for the frost accumulation test should be the same as described in H.10. The indoor-side dry-bulb temperature and the outdoor-side dry-bulb temperature should be continuously recorded with instrumentation having a total system accuracy of ± 0.15 °C. The outdoor-side dewpoint temperature should be determined with an error no greater than ± 0.25 °C using continuously recording instrumentation. All other data should be recorded at 5-min intervals during the heating cycle.

H.11.2 Defrost initiation, termination and complete test cycle time (from defrost termination to defrost termination) should be recorded. Defrost initiation is defined as the actuation (either automatically or manually) of the controls normally installed with the equipment which causes it to alter its normal heating operation in order to eliminate possible accumulations of frost on the outdoor coil. Defrost termination occurs when the controls normally within the equipment are actuated to change from defrosting operation to normal heating operation.

H.11.3 Provisions should be made so that the instrumentation is capable of recording the cooling occurring during defrosting as well as the total electrical energy usage during defrosting. These data and the continuously recorded data need be the only data obtained during defrosting.

H.12 Test instrumentation for the extra-low-temperature test

Instrumentation for the extra-low-temperature test should be identical to that of the high-temperature test as described in H.10.

Annex J
(informative)
Symbols used in annexes

Symbol	Description	Unit
A_n	Area of nozzle	m^2
C_d	Nozzle discharge coefficient	—
c_{pa}	Specific heat of dry air	J/(kg.K)
c_{pW}	Specific heat of water	J/(kg.K)
D_n	Diameter of nozzle throat	mm
D_t	Outside diameter of refrigerant tube	mm
f	Factor, dependent on temperature, for *Re*	—
h_{a1}	Enthalpy of air entering indoor-side compartment	J/kg of dry air
h_{a2}	Enthalpy of air leaving indoor-side compartment	J/kg of dry air
h_{a3}	Enthalpy of air entering outdoor-side compartment	J/kg of dry air
h_{a4}	Enthalpy of air leaving outdoor-side compartment	J/kg of dry air
h_{f1}	Enthalpy of refrigerant liquid at a saturation temperature corresponding to the pressure of refrigerant vapour leaving compressor	J/kg
h_{f2}	Enthalpy of refrigerant liquid leaving condenser	J/kg
h_{g1}	Enthalpy of refrigerant vapour entering compressor	J/kg
h_{g2}	Enthalpy of refrigerant vapour leaving condenser	J/kg
h_{k1}	Enthalpy of steam entering calorimeter evaporator	J/kg
h_{k2}	Enthalpy of fluid leaving calorimeter evaporator	J/kg
h_{r1}	Enthalpy of refrigerant entering indoor-side compartment	J/kg
h_{r2}	Enthalpy of refrigerant leaving indoor-side compartment	J/kg
L	Length of refrigerant tubing	m
m_1	Mass of cylinder and bleeder assembly, empty	g
m_3	Mass of cylinder and bleeder assembly with sample	g
m_5	Mass of cylinder and bleeder assembly with oil from sample	g

p_A	Barometric pressure	kPa
p_n	Pressure at nozzle throat	kPa
p_v	Velocity pressure at nozzle throat or static pressure difference across nozzle	Pa
P_i	Power input, indoor-side data	W
P_k	Power input to compressor	W
P_t	Total power input	W
ϕ_L	Line heat loss in interconnecting tubing	W
ϕ_e	Heat input to calorimeter evaporator	W
ϕ_{lci}	Latent cooling capacity (indoor-side data)	W
ϕ_{sc}	Sensible cooling capacity	W
ϕ_{sci}	Sensible cooling capacity (indoor-side data)	W
ϕ_{sri}	Sensible reheat capacity (indoor-side data)	W
ϕ_{tci}	Total cooling capacity (indoor-side data)	W
ϕ_{thi}	Total heating capacity (indoor-side data)	W
ϕ_{tho}	Total heating capacity (outdoor-side data)	W
q_c	Flow rate of indoor coil condensate	kg/s
q_i	Airflow rate, indoor, calculated	m^3/s
q_k	Fluid condensate (steam) flow rate	kg/s
q_{mi}	Airflow rate, indoor, measured	m^3/s
q_{mo}	Airflow rate, outdoor, measured	m^3/s
q_r	Refrigerant flow rate	kg/s
q_{ro}	Refrigerant/oil mixture flow rate	m^3/s
q_s	Airflow of standard air	m^3/s
q_{vi}	Volume airflow, indoors, measured	m^3/s
q_W	Condenser water flow rate	kg/s
Re	Reynolds number	—
t_a	Ambient temperature	°C
t_{a1}	Temperature of air entering indoor-side compartment, dry bulb	°C

t_{a2}	Temperature of air leaving indoor-side compartment, dry bulb	°C
t_{a3}	Temperature of air entering outdoor-side compartment, dry bulb	°C
t_{a4}	Temperature of air leaving outdoor-side compartment, dry bulb	°C
t_{a5}	Temperature of air leaving reheat coil, dry bulb	°C
t_c	Temperature of surface of calorimeter condenser	°C
t_{W1}	Temperature of water entering calorimeter	°C
t_{W2}	Temperature of water leaving calorimeter	°C
T	Insulation thickness, interconnecting tubing	mm
U	Heat leakage coefficient	J/(s.K)
v_{a1}	Specific volume of air leaving indoor-side compartment	m^3/kg of dry air
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 nozzle	m^3/kg of air-water vapour mixture
V_n	Velocity of air at nozzle	m/s
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 nozzle inlet	kg/kg of dry air
x_o	Concentration of oil based on mass of refrigerant and oil in sample	—
x_r	Mass ratio of refrigerant/oil mixture	—