Standard For Testing & Rating of Variable Refrigerant Flow Systems

ISHRAE - RAMA STANDARD 10002 : 2017

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STANDARD FOR VARIABLE REFRIGERANT FLOW (VRF) MULTIPLE SPLIT-SYSTEM AIR-CONDITIONERS AND HEAT PUMPS — GENERAL REQUIREMENTS, PERFORMANCE TESTING AND RATING

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Foreword

The publishing of the Guidelines for Testing & Rating of Variable Refrigerant Flow (VRF) Systems for India is yet another step towards creation of relevant Standards for HVAC&R Equipment after successful publishing of Guidelines for Rating & Testing of Liquid Chilling Packages. This is accomplished through combined efforts of two leading HVAC&R societies RAMA & ISHRAE. The Leadership of ISHRAE and RAMA set up a Ten Member Core Committee constituting of Two Chairs (one each from ISHRAE and RAMA) and the following members :

1. Dr.-Ing. Jyotirmay Mathur, Prof. & Dean Malviya Institute of Technology, Jaipur
2. Mr. V. Manjunath, Underwriters Laboratories, Bengaluru
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The Core Committee was formed through members with relevant expertise and representing all cross sections of the subject namely Academia, Standards & Testing Laboratory, Designers & HVAC Consultants, Users, Installers and Manufacturers.

The Core Committee reviewed all the available Standards in detail, and prepared the draft of the Guidelines which was reviewed by a Technical Committee of Manufacturers facilitated by RAMA.

The Technical Committee comprised experts nominated by VRF Manufacturers / Members of RAMA namely Blue Star, Carrier, Daikin, JCI-Hitachi, LG, Midea, Mitubishi Electric, Samsung and Voltas.

We are extremely thankful to the Technical Committee for their valuable inputs and guidance which will make this Guideline very useful to the Industry and other Stakeholders.

Standard was then put for review to a Panel comprising experts invited from many renowned Companies, Government Departments, Regulatory Authorities, International Certification Companies, SDOs. It was thereafter sent out for Public comments.

The guideline standardizes Design conditions, Testing criterion, ISEER and nameplates which will be very useful for the users.

We would also like to thank BEE (Bureau of Energy Efficiency) for its support and BIS (Bureau of Indian Standards) for referring these guidelines.

ISHRAE-RAMA Committee acknowledges contribution of research students from MNIT Jaipur for Weather Analysis and ISEER Coefficient calculations.

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1.0 Scope

a) This standard covers the performance criteria, general requirements, method of testing for the measurement of performance and Part load performance for calculating Indian Seasonal Energy Efficiency Ratio and Seasonal Performance Factor of factory-made,

b) electrically driven, Variable refrigerant flow multiple split air conditioners working on vapor compression principle,

c) with a single refrigeration circuit, utilizing one or more variable capacity compressors, one or more outdoor units and two or more indoor units of non-ducted and/or ducted type,

d) designed for individual operation and combined operation,

e) air cooled cooling only and / or cooling and heat pump,

f) to work with rated voltage up to and including 250 V, 50 Hz AC, single phase and up to and including 415 V, 50 Hz AC for three phase input power supply

1.1 This standard does not cover

a) Air conditioners working on Vapor Absorption principle

b) Individual assemblies not constituting complete refrigerant system

c) Evaporative cooled condensing units

d) Air conditioners with Water cooled condenser

e) Air conditioners with Heat recovery system

2.0 REFERENCES

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

The following Standards contain provisions which through reference in this text, constitute provisions of the standards. At the time of publication, the editions indicated were valid. All standards are subject to revision and parties to agreements based on this standard are encouraged to investigate the possibility of applying the most recent editions of the Standards indicated below:

IS Number	Title
101 (Part 6 : Sec 1)	Methods of sampling and test for paints, varnishes and related products – Part 6 : Durability tests – Section 1 : Resistance to humidity under conditions of condensation
IS 101 (Part 6 : Sec 5)	Method of sampling and test for paints, varnishes and related products Part 6 Durability test on Paint films section 5 Accelerated weathering test
IS 101 (Part 7 : Sec 1)	Methods of Sampling and Test for Paints, Varnishes and Related Products – Part 7 : Environmental Tests on Paint Films – Section 1 : Resistance to water
IS 101 (Part 7 : Sec 2)	Methods of sampling and test for paints, varnishes and related products part 7 Environmental tests on paint films Sec 2 Resistance to liquids
IS 101 (Part 7 : Sec 3)	Methods of sampling and test for paints, varnishes and related products Part 7 Environmental tests on paint films Sec 3 Resistance to heat
IS 196	Atmospheric conditions for testing
IS 325	Three phase induction motors
IS 1391 – Part 1	Room air conditioners – Unitary type
IS 1391 – Part 2	Room air conditioner – Split type
IS 8148	Packaged Air Conditioners
IS 2360	Voltage bands for electrical installations including preferred voltages and frequency
IS 3615	Glossary Of Terms Used In Refrigeration And Air Conditioning

ISO 5151	Non-ducted air conditioners and heat pumps – Testing and rating for performance
ISO 15042	Multiple split-system air-conditioners and air-to-air heat pumps – Testing and rating for performance
ISO 16358 – 1	Air-cooled air conditioners and air-to-air heat pumps – Testing and calculating methods for seasonal performance factors – Part 1: Cooling seasonal performance factor
ISO 16358 – 2	Air-cooled air conditioners and air-to-air heat pumps – Testing and calculating methods for seasonal performance factors – Part 2: Heating seasonal performance factor
ISO 16358 – 3	Air-cooled air conditioners and air-to-air heat pumps – Testing and calculating methods for seasonal performance factors – Part 3: Annual performance factor
ISO 5149 – 1	Refrigerating systems and heat pumps – Safety and environmental requirements – Part 1: Definitions, classification and selection criteria
ISO 5149 – 2	Refrigerating systems and heat pumps – Safety and environmental requirements – Part 2: Design, construction, testing, marking and documentation
ISO 5149 – 3	Refrigerating systems and heat pumps – Safety and environmental requirements – Part 3: Installation site.
ISO 5149 – 4	Refrigerating systems and heat pumps – Safety and environmental requirements – Part 4: Operation, maintrenance, repair and recovery
EN 14825	Air conditioners, liquid chilling packages and heat pumps with electrically driven compressors for space heating and cooling - Testing and rating at part load conditions
EN 145111 – 1	Air conditioners, liquid chilling packages and heat pumps with electrically driven compressors for space heating and cooling – Part 1: Terms, definitions and classification
EN 145111 – 2	Air conditioners, liquid chilling packages and heat pumps with electrically driven compressors for space heating and cooling – Part 2: Test conditions
EN 14511 – 3	Air conditioners, liquid chilling packages and heat pumps with electrically driven compressors for space heating and cooling – Part 3: Test methods
EN 14511 – 4	Air conditioners, liquid chilling packages and heat pumps with electrically driven compressors for space heating and cooling – Part 4: Operating requirements, marking and instructions
IS / ISO 817	Organic refrigerants – Number designation
ISO 3744	Acoustics – Determination of sound power levels and sound energy levels of noise sources using sound pressure – Engineering methods for an essentially free field over a reflecting plane
ISO 9614 – 1	Acoustics – Determination of Sound Power Levels of Noise Sources Using Sound Intensity – Part 1: Measurement at Discrete Points
ISO 9614 – 2	Acoustics – Determination of Sound Power Levels of Noise Sources Using Sound Intensity – Part 2: Measurement by Scanning
AHRI 1230	Performance Rating of Variable Refrigerant Flow (VRF) Multi-Split Air-Conditioning and Heat Pump Equipment

3.0 Terms and definitions

For the purposes of this standard, the terms given in IS 3615 – Glossary of terms used in Refrigeration and Air conditioning, and in addition following definitions listed below shall apply.

3.1 Standard air

Dry air at 20 °C and at a standard barometric pressure of 101.325 kPa, having a mass density of 1.204 kg/m3

3.2 Air-conditioner

An encased assembly or assemblies designed primarily to provide free or ducted delivery of conditioned air to an enclosed space room or zone (conditioned space)

NOTE: *It can be either single-package or split-system and comprises a primary source of refrigeration for cooling and dehumidification. It can also include means for heating other than a heat pump, as well as means for circulating, cleaning, humidifying, ventilating or exhausting air. Such equipment can be provided in more than one assembly, the separated assemblies (split-systems) of which are intended to be used together.*

3.3 Heat pump

An encased assembly or assemblies designed primarily to provide free or ducted delivery of conditioned air to an enclosed space, room or zone (conditioned space) and includes a prime source of refrigeration for heating.

NOTE: *It can 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 can also include means for circulating, cleaning, humidifying, ventilating or exhausting air. Such equipment can be provided in more than one assembly, the separated assemblies (split-systems) of which are intended to be used together.*

3.4 Variable Refrigerant Flow Multi-Split system

A split-system air-conditioner or heat pump incorporating a single refrigerant circuit, and one or more outdoor units at least one variable speed compressor or an alternative compressor combination for varying the capacity of the system by five or more steps, multiple indoor units, each of which can be individually controlled, each capable of individual zone temperature control, through zone temperature control devices and common communications network

3.5 Full capacity

Capacity of the system at rated condition when all indoor units and outdoor units are operated at full-load (100% load) operating conditions.

Note: *Rated capacity = Full capacity for purpose of this standard*

3.6 Total cooling capacity

Amount of sensible and latent heat that the equipment can remove from the conditioned space in a defined interval of time

3.7 Latent cooling capacity

Amount of latent heat that the equipment can remove from the conditioned space in a defined interval of time

3.8 Sensible cooling capacity

Amount of sensible heat that the equipment can remove from the conditioned space in a defined interval of time

3.9 Heating capacity

Amount of heat that the equipment can add to the conditioned space (but not including supplementary heat) in a defined interval of time

3.10 Part-load capacity

Capacity of the system when the indoor and outdoor units are operating at part load.

3.11 Capacity ratio

Ratio of the total stated cooling capacity of all operating indoor units to the stated cooling capacity of the outdoor unit at the rating conditions

3.12 Energy efficiency ratio (EER)

Ratio of the total cooling capacity to the effective power input to the device at any given set of rating conditions

3.13 Coefficient of performance (COP)

Ratio of the heating capacity to the effective power input to the device at any given set of rating conditions

3.14 Effective power input (P_E)

Average electrical power input to the equipment obtained from the

3.14.1 Power input for operation of the compressor(s),

3.14.2 The power input to electric heating devices used only for defrosting,

3.14.3 The power input to all control and safety devices of the equipment, and

3.14.4 The power input for operation of all fans, factory installed condensate pumps, if applicable.

3.15 Total power input (kW)

Average electrical power input to the equipment as measured during the standard rated condition test

3.16 Full-load operation

Operation with the equipment and controls configured for the maximum continuous duty refrigeration capacity specified by the manufacturer.

3.17 Indian Seasonal Energy Efficiency Ratio (ISEER)

A single value number that is a representation of the Cooling part load efficiency of a multi system air conditioner calculated based as described in Annexure F

3.18 Part load factor

Ratio of the performance when the equipment is cyclically operated to the performance when the equipment is continuously operated, at the same temperature and humidity conditions

3.19 Defined cooling load

Heat defined as cooling demand for a given outdoor temperature.

3.20 Cooling full-load operation

Operation with the equipment and controls configured for the maximum continuous refrigeration capacity specified by the manufacturer and allowed by the unit controls

Note: *Unless otherwise regulated by the automatic controls of the equipment, all indoor units and compressors shall be functioning during the full-load operation.*

3.21 Cooling half load operation

Operation with the equipment and controls configured for the 50% continuous refrigeration capacity specified by the manufacturer.

Note: *All indoor units shall be functioning during the half-load operation.*

3.22 Cooling minimum-load operation

Operation of the equipment and controls at minimum continuous refrigeration capacity

Note*: All indoor units shall be functioning during the minimum-load operation.*

3.23 Heating full-load operation

Operation with the equipment and controls configured for maximum continuous refrigeration capacity at rated heating capacity condition

Note: *Unless otherwise regulated by the automatic controls of the equipment, all indoor units and compressors shall be functioning.*

3.24 Minimum-load operation

Operation of the equipment and controls at minimum continuous refrigeration capacity

***Note**: All indoor units shall be functioning*

3.25 Standard heating full capacity

Heating capacity at rated condition at full-load operating condition

3.26 Ratings

3.26.1 Published rating

A statement of the assigned values of those performance characteristics, under stated rating conditions, by which a unit may be chosen to fit its application. These values apply to all systems of like nominal size and type produced. As used herein, the term Published Rating includes the rating of all performance characteristics shown on the unit or published in specifications, advertising or other literature controlled by the manufacturer, at stated Rating Conditions.

***Note:** The published ratings are the ratings declared by the manufacturer in any form as defined above.*

3.26.2 Standard Rating

Standard ratings shall be published for cooling capacities (sensible, latent and total), heating capacity, EER and COP, as appropriate, for all systems produced in conformance with this Standard. These ratings shall be based on data obtained at the established rating conditions in accordance with the provisions of this Standard.

3.26.3 Other rating

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

3.27 Sound Power Level:

Ten times the logarithm to the base 10 of the given sound power to the reference sound power which is 1 pW(10^{12} W), and expressed in decibels (dB)

***Note:** The Sound power should be measured as per ISO 13261 – 1; ISO 13261 – 2, for non-ducted indoor units and ducted indoor units.*

4.0 Construction

The construction of the variable refrigerant flow system should conform to the relevant requirements as defined in ISO 5149 – 1: Refrigerating systems and heat pumps – Safety and environmental requirements – Part 1: Definitions, classification and selection criteria and ISO 5149 – 2: Refrigerating systems and heat pumps – Safety and environmental requirements – Part 2: Design, construction, testing, marking and documentation.

5.0 Rating requirements

Standard rating shall be established by testing at standard rating conditions specified in clause 6 for cooling only equipment and clause 7 for heat pump.

5.1 Test requirements

5.1.1 Compressor and controller setting

The manufacturer shall specify the specific setting that is required to give full load capacity, half load capacity and minimum load capacity. Also, manufacturer must provide a schematic and sequence of operation for providing control of the system. If the manufacturer does not define the setting, the thermostat or controller shall be set to its allowable minimum temperature setting.

Manufacturer shall designate intermediate and minimum compressor speeds / controller setting for both cooling and heating.

If the equipment cannot be maintained at steady-state conditions by its normal controls, then the manufacturer shall modify or override such controls so that steady-state conditions are achieved.

5.1.1.1 Maximum compressor speed (or) controls setting for full capacity:

Shall be the compressor speed or controller setting as defined by manufacturer at which the compressor delivers full capacity. The maximum compressor speed or controller setting shall be a fixed value for cooling mode tests and heating mode tests. The value of maximum compressor speed or controller setting for heating mode tests may be same or different from the cooling mode value.

5.1.1.2 Half compressor speed (or) controls setting for half capacity:

Shall be the compressor speed or controller setting as defined by manufacturer at which the 50% of full capacity is delivered and falls within difference between minimum and maximum speeds (controller setting) for both cooling and heating mode.

5.1.1.3 Minimum compressor speed (or) controls setting for minimum capacity:

Shall be the compressor speed or controller setting as defined by manufacturer at which the compressor operates at a steady-state level below which the system would rarely operate. The minimum compressor speed or controller setting shall be a fixed value for cooling mode tests and heating mode tests. The value of minimum compressor speed or controller setting for heating mode tests may be the same or different from the cooling mode value.

5.2 Connecting tubing length

The connecting tubing for all standard ratings of equipment connecting tubing shall be as per manufacturer's specifications or not less than 7.5 m on each line. The lengths shall be actual lengths, not equivalent lengths, and no account shall be taken of the resistance provided by bends, branches, connecting boxes or other fittings used in the installation for the test equipment. The tubing length shall be measured from the enclosure of the indoor unit to the enclosure of the outdoor unit. Minimum of 40 % of the total length of the interconnecting tubing shall be exposed to the outdoor conditions with the rest of the tubing exposed to the indoor conditions. The tubing diameters, insulation, details of installation, evacuation and charging shall be in accordance with the manufacturer's published recommendations.

The Figure 1 The installation of indoor and outdoor unit

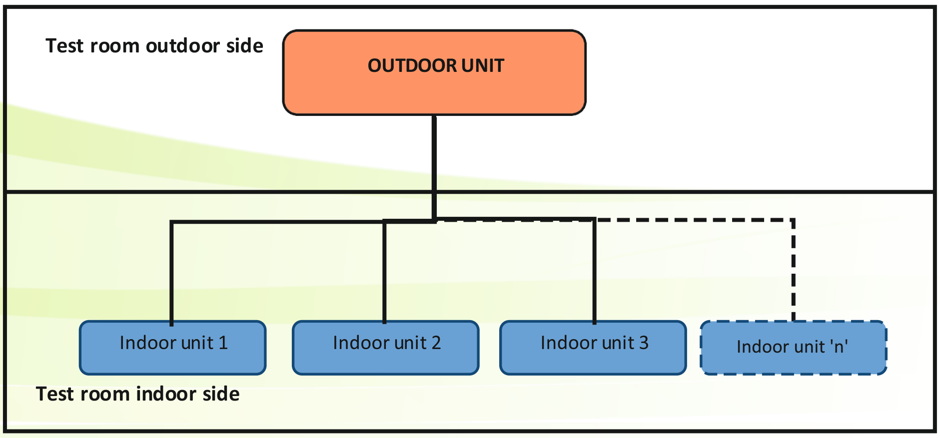


Figure – 1 Unit installation and tubing layout

5.3 Indoor unit selection:

For all tests other than part load test, the capacity ratio of indoor units to outdoor unit shall be equal to 1 (±5%). The number and capacity of individual indoor units shall be selected such that the capacity ratio requirement as per part load testing requirement shall be met.

Note: *The total indoor side airflow shall not exceed 0.053m^3/s per kW*

The face velocity on indoor unit heat exchanger shall not exceed 2.5 m/s

5.4 Airflow setting

5.4.1 General

The airflow settings for ducted and non-ducted units is specified as below.

Ducted indoor units rated less than 8 kW (cooling / heating capacity) and intended to operate at an external static pressure of less than 25 Pa shall be tested as non-ducted units.

5.4.2 Airflow setting for non-ducted indoor units measured by air-enthalpy method

The louvers and fan speed shall be set such that maximum steady state air flow is delivered by the indoor unit as specified by the manufacturer.

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

Tests shall be conducted with 0 Pa external static pressure maintained at the air discharge of the equipment. All air quantities shall be expressed as m^3/s of standard air.

The Cooling Minimum air volume rate is the air volume rate during minimum cooling test, unit operated at an external static pressure of 0 Pa and at the indoor fan setting used with compressor speed / controller setting at minimum capacity test.

The cooling half air volume rate is the air volume rate during half cooling test, unit operated at external static pressure of 0 Pa and at the indoor fan setting used with compressor speed / controller setting at half capacity test.

For heating test the air volume rate shall be selected similarly as defined above

5.4.3 Airflow setting for ducted indoor units

5.4.3.1 General

The airflow rate shall be specified by the manufacturer. This flow rate shall be for full-load cooling and be expressed in cubic meters per second (m^3/s) of standard air conditions, as defined in 3.1, and correspond to a non-operating compressor.

The airflow settings of the units shall be in accordance with Annexure A.

The rated airflow rate given by the manufacturer shall be set and the resulting external static pressure, P_e(ESP) measured. The measured ESP shall be larger than the ESP for rating, defined in Table 1. If the unit has an adjustable speed, it shall be adjusted to the lowest speed that provides at least the ESP for rating.

5.4.3.2 Cooling Minimum Air Volume Rate

For ducted units that regulate the speed (as opposed to the air volume) of the indoor fan,

$$Cooling\ minimum\ air\ volume = Cooling\ full\ load\ volume\ rate\ \times \frac{Cooling\ minimum\ fan\ speed}{Fan\ speed\ at\ rated\ condition}$$

Where cooling minimum fan speed corresponds to the fan speed used when operating at the minimum compressor speed. For such systems, obtain the Cooling Minimum Air Volume Rate regardless of the external static pressure

Manufacturer shall specify the cooling minimum air volume rate if the air volume is regulated by indoor fan.

5.4.3.3 Cooling half air volume rate

For ducted units that regulate the speed (as opposed to the air volume) of the indoor fan,

$$Cooling\ half\ air\ volume = Cooling\ full\ load\ volume\ rate \times \frac{Cooling\ half\ fan\ speed}{Fan\ speed\ at\ rated\ condition}$$

Where cooling half fan speed corresponds to the fan speed used when operating at the intermediate compressor speed. For such systems, obtain the Cooling intermediate Air Volume Rate regardless of the external static pressure

Manufacturer shall specify the cooling half air volume rate if the air volume is regulated by indoor fan.

5.4.4 External Static Pressure (ESP) for rating

5.4.4.1 If the rated External Static Pressure specified by the manufacturer is greater than or equal to the minimum value given in Table 1, the specified rated ESP is used as the ESP for rating.

5.4.4.2 If the rated ESP specified by the manufacturer is less than the minimum value given in Table 1, and larger than or equal to the 80 % of the maximum ESP, the specified rated ESP is used as the ESP for rating. The maximum ESP may either be specified by the manufacturer or identified from fan curves provided by the manufacturer.

5.4.4.3 If the rated ESP specified by the manufacturer is less than the minimum value given in Table 1 and less than 80 % of the maximum ESP, the value of Table 1 or 80 % of the maximum ESP, whichever is smaller, is used as the ESP for rating.

5.4.4.4 If the rated ESP is not specified by the manufacturer, the value of Table 1 or 80 % of the maximum ESP, whichever is smaller, is used as the ESP for rating.

5.4.4.5 The process of selecting the ESP for rating is shown in Figure 2.

If the determined ESP for rating is less than 25 Pa, the unit can be considered a non-ducted indoor unit.

Airflow measurements shall be made in accordance with the provisions specified in Annex A, as appropriate, as well as the provisions established in other appropriate annexes of this Standard.

Table 1 – External Static Pressure requirement for ducted split indoor units

Standard capacity ratings kW	Minimum external static pessure – Pa
0 < < 8	25
8 ≤ ≤ 12	37
12 ≤ ≤ 20	50
20 ≤ ≤ 30	62
30 ≤ ≤ 45	75
45 ≤ ≤ 82	100

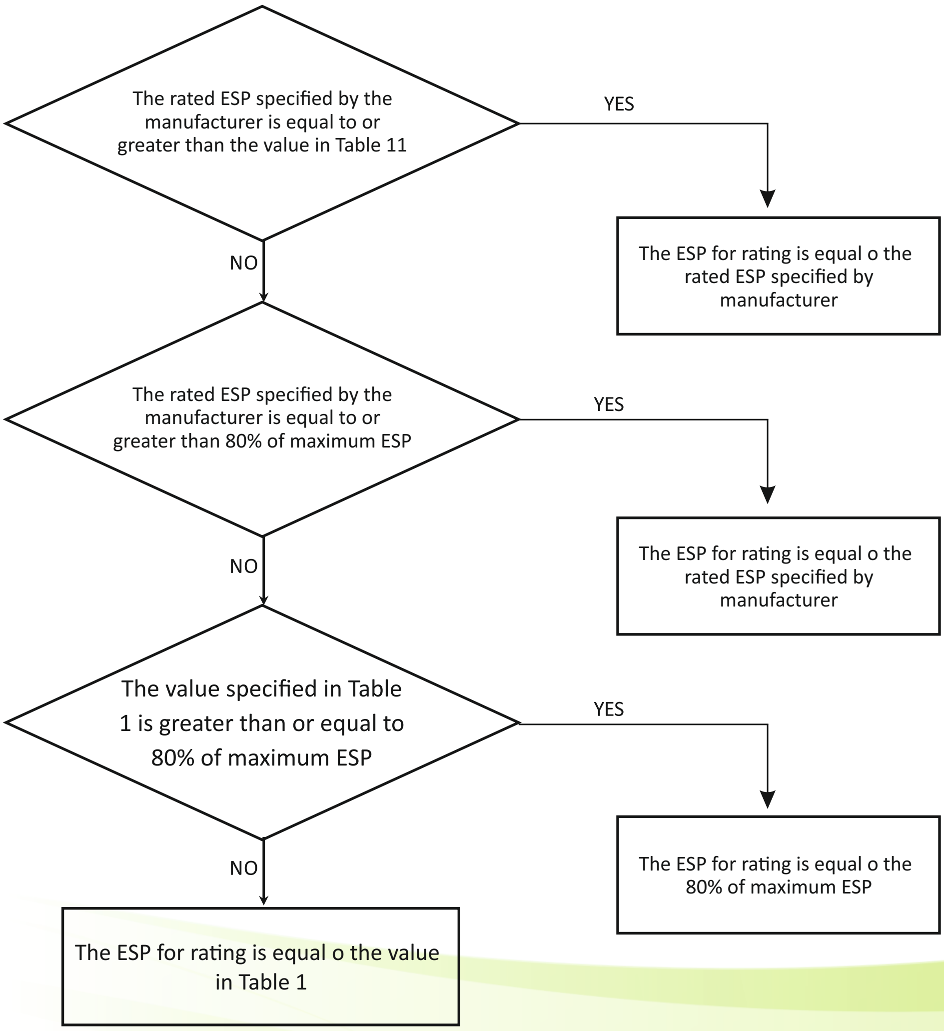


Figure – 2 – Flowchart for selecting External static pressure (ESP) for rating test

5.4.5 Outdoor air flow

If outdoor units with adjustable airflow, all tests shall be conducted at fan control setting as specified by the manufacturer.

For outdoor units with fixed airflow, all tests shall be conducted at the air volume flow rate inherent in the equipment operated with all the standard accessories like louvers or ductwork and any such attachments supplied by the manufacturer for normal installation practice. Once established, the outdoor side air circuit of the equipment shall be unchanged throughout all the tests.

6.0 Cooling tests:

6.1 General conditions:

6.1.1 The standard rating test shall be conducted with all indoor units and compressors functioning, at test conditions as specified in Table 1. The test methods and uncertainty of measurement shall be as specified in Clause 8.0 and all tests shall be carried out in accordance with the test requirements of Annex B and the test methods of Annex D and Annex E. The electrical input values used for rating purposes shall be measured during the cooling capacity test.

6.1.2 Tests may be conducted to determine the cooling capacities of individual indoor units, operating with or without all other indoor units functioning. If tests for individual indoor unit capacity are conducted, the capacities shall be determined in accordance with the requirements of Annex G.

6.1.3 The specific setting of compressor and controller to deliver full load capacity or part load capacity for ISEER testing shall be provided by the manufacturer and the equipment shall be maintained at that setting. If the manufacturer does not define the setting, the thermostat or controller shall be set to its minimum allowable temperature setting.

6.1.4 If the equipment under test cannot be maintained at steady-state conditions by its normal controls, then the manufacturer shall modify or override such controls so that steady-state conditions are achieved

6.1.5 Temperature conditions:

The temperature conditions are as specified in Table 2.

6.1.6 Pre-conditions:

Equilibrium condition as specified in clause 8.3.1 has to be achieved for at least 60 minutes between the test room reconditioning apparatus and equipment under test.

6.1.7 Testing requirements:

Total, sensible and latent cooling capacity and rated power consumption shall be determined

6.1.8 Duration of test:

The output shall be measured in the steady state condition as specified in clause 8.3.1. The recording of the data shall continue for at least a 30 min period during which the tolerances specified in clause 8.2.1 shall be met and 6 sets of reading at every 10 minutes interval shall be recorded. Data shall be sampled at equal intervals that span 30 s or less

6.1.9 Calculation for cooling capacity:

The calculation for cooling capacity shall be done as defined in Annex D if testing done using Calorimeter method and as defined in Annex E if the testing is done using air enthalpy method.

6.1.10 Standard rating cooling capacity test

Table 2 – Cooling capacity rating conditions

Parameter	Standard rating condition
Temperature of air entering indoor side	
– Dry Bulb Temperature	27°C
– Wet Bulb Temperature	19°C
Temperature of air entering outdoor side	
– Dry Bulb Temperature	39.0°C
Test frequency	Rated frequency
Test voltage	Rated voltage
Compressor speed *	Rated speed for full capacity (or) Controller setting for full capacity #
Indoor side air flow **	Rated air flow
* Refer to clause 5.1.1 ** Refer to clause 5.4 to 5.8 # For compressors with variable refrigerant flow other than variable speed type	

6.2 Maximum operating test:

6.2.1 Pre-conditions:

The test shall be conducted with equipment run at full capacity condition. The temperature and electrical input shall be maintained at conditions as in Table 3.

6.2.2 Testing requirements:

The test voltage to the equipment shall be maintained as specified percentage of rated supply under running condition in the Table 3. During the restart of equipment after shutdown as required by the test, the test voltage shall be adjusted so that it is not less than 86 % of the rated voltage at the moment of restarting the equipment after the shut-down required after the test duration as specified in Table 3. The determination of cooling capacity and electrical power input is not required for this performance test.

Table 3 – Maximum operating Test conditions

Parameter	Standard rating condition
Temperature of air entering indoor side – Dry Bulb Temperature – Wet Bulb Temperature	 32 °C 23 °C
Temperature of air entering outdoor side – Dry Bulb Temperature	 46.0 °C
Test frequency	Rated frequency
Test voltage – Condition 1	110% Rated voltage
Test voltage – Condition 2	90% Rated voltage
Compressor speed *	Full load speed (or) Controller setting for full capacity delivery #
Indoor side air flow **	Full load air flow as specified by manufacturer
Test duration for test voltage condition 1 and test voltage condition 2 each	60 minutes continuous run after temperature conditions achieved. And then power cut off to equipment for 3 minutes. Restart unit and run for 60 minutes continuously
* Refer to clause 5.1.1 ** Refer to clause 5.4 to 5.8 # For compressors with variable refrigerant flow other than variable speed type	

6.2.3 Performance requirement:

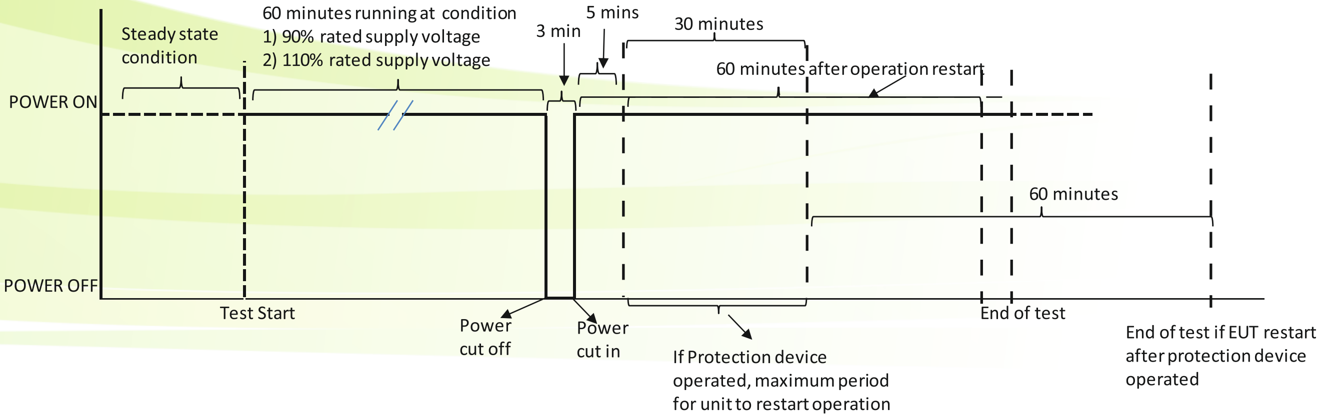
The equipment shall meet the following performance requirements.

a. During the entire test duration there shall be no indication of damage

b. The motors and compressors shall run continuously without any safety device operation or tripping of any safety protection device during the first 60 minutes of test

c. After the power cut-off 3 minutes and restart, the equipment shall resume operation within 30 minutes and then run continuously for 60 minutes.

d. The safety protection devices may trip only during first 5 minutes operation after power cut-off for 3 minutes and restart. Then equipment shall run continuously for 60 minutes without tripping of any safety protective device. For equipment designed not to start operation after initial trip within the first 5 minutes, the equipment shall resume operation within 30 minutes and then shall run continuously for 60 minutes.



6.3 Freeze-up air blockage test:

6.3.1 Pre-conditions:

The test conditions as specified in Table 4 shall be maintained. All indoor units shall be functioning during this test. The equipment shall be started and operated until operating test conditions as specified in table 4 have stabilized.

6.3.2 Air flow conditions:

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

6.3.3 Testing requirements:

Tests temperatures shall be as specified in Table 4. If lower minimum operating temperature conditions are specified in the manufacturer's specification sheets, they shall be used in lieu of those given in Table 4. The measurement of cooling capacity and electrical parameters is not required for this test.

6.3.4 Test duration:

After the operating test conditions have stabilized as specified in table 4, the equipment shall be operated for a period of 4 h. The equipment shall be permitted to stop and start under the control of an automatic limit device, if provided.

Table 4 – Freeze up air blockage test and Freeze up drip test

Parameter	Test operating condition
Temperature of air entering indoor side – Dry Bulb Temperature – Wet Bulb Temperature	 21.0 °C 15.0 °C
Temperature of air entering outdoor side – Dry Bulb Temperature	 21.0 °C
Test frequency	Rated frequency
Test voltage	Rated voltage

6.3.5 Performance requirement:

6.3.5.1 The equipment shall operate under the conditions specified without any indication of damage.

6.3.5.2 At the end of 4 h test, any accumulation of frost or ice on the indoor coil shall not cover more than 50 % of the indoor-side face area of the indoor coil or reduce the airflow rate by more than 25 % of the initial airflow rate. If the equipment and test apparatus do not allow visual observation of the indoor coil or if the indoor air volume rate is not measured, then the requirements of 6.3.5.3 shall be met.

6.3.5.3 During the 4 h test period, the midpoint temperature of every indoor coil circuit or the refrigerant suction pressure shall be measured at equal intervals that span 1 min or less. The measurement(s) made 10 min after beginning the 4 h test shall be defined as the initial value(s). If the suction pressure is measured, it shall be used to calculate the saturated suction temperature.

a) If the compressor(s) does(do) not cycle off on automatic controls during the test and

- If coil circuit temperatures are measured, the temperatures shall not remain more than 2 °C below the corresponding initial value for each circuit for more than 20 consecutive min, or

- If suction pressure is measured, the saturated suction temperature shall not remain more than 2 °C below the initial value for more than 20 consecutive min.

b) If the compressor(s) cycle(s) on and off on the automatic controls during the test and

- If coil circuit temperatures are measured, the individual circuit temperatures measured 10 min after the beginning of any on cycle during the test shall not be more than 2 °C below the corresponding initial circuit temperature(s), or

- If suction pressure is measured, the saturated suction temperature measured 10 min after the beginning of any "on" cycle during the test shall not be more than 2 °C below the initial saturated suction temperature.

6.4 Freeze-up drip test

6.4.1 General conditions

This test is applicable for non-ducted split units only. The freeze-up drip test shall be followed by completion of the freeze-up air blockage test. The test conditions shall be as specified in Table 4. The equipment shall be operating at functioning of full-load except for the airflow setting. The measurement of capacity and electrical power is not required for this performance test.

6.4.2 Temperature conditions

The temperature and test conditions shall be as specified in table 4.

6.4.3 Airflow conditions

The air entry to indoor heat exchanger shall be blocked completely, so as to attempt to achieve complete blockage of air by frosting or ice on indoor heat exchanger.

6.4.4 Test conditions:

6.4.4.1 Pre-conditions:

The equipment shall be started and operated till the test conditions as specified in table 4 are stabilized.

6.4.4.2 Test duration:

After the test conditions are stabilized, the equipment shall be operated for 4 hours continuously. The start and stop operation of the equipment is permitted by an automatic limit device, if provided. Stop the equipment at the end of the 4 hours of test, allow the frost or ice to be melted by removing the air inlet covering. Then, turn on the equipment with fans operating at high speed for 5 minutes.

6.4.4.3 Performance requirement:

During the test, the equipment shall not blow off any water or ice on the indoor side. Also there shall be no water or ice dripping in to indoor side from the coil.

6.5 Condensate disposal test and enclosure sweat test:

6.5.1 General conditions:

This test is applicable for non-ducted split units only. The test conditions shall be as specified in Table 5. The equipment shall be operating with all indoor units on and functioning at full-load except for the airflow setting. The measurement of capacity and electrical power is not required for this performance test.

6.5.2 Temperature conditions:

The temperature and test conditions shall be as specified in table 5.

6.5.3 Airflow condition:

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.

6.5.4 Test conditions:

6.5.4.1 Preconditions:

After establishing the specified temperatures, equipment shall be started with the condensate collection pan filled to the overflowing point and shall be run until the condensate flow has become uniform.

6.5.4.2 Test duration:

After the test conditions are stabilized, the equipment shall be operated for 4 hours continuously.

6.5.4.3 Performance requirement:

During the test, the equipment shall not blow off any condensate water on the indoor side. Also there shall be no water or ice dripping in to indoor side from the coil and equipment shall not shutdown.

Table 5 – Condensate disposal test

Parameter	Test operating condition
Temperature of air entering indoor side – Dry Bulb Temperature – Wet Bulb Temperature	 27.0°C 24.0°C
Temperature of air entering indoor side – Dry Bulb Temperature	 27.0 °C
Test frequency	Rated frequency
Test voltage	Rated voltage

7.0 Heating tests

7.1 Heating capacity tests

7.1.1 General conditions:

7.1.1.1 The standard rating test shall be conducted with all indoor units and compressors functioning, at test conditions as specified in Table 6. The test methods and uncertainty of measurement shall be as specified in Clause 8.0 and all tests shall be carried out in accordance with the test requirements of Annex B and the test methods of Annex D and Annex E. The electrical input values used for rating purposes shall be measured during the heating capacity test.

7.1.1.2 The test methods and uncertainty of measurement shall be as specified in Clause 8.3 and all tests shall be carried out in accordance with the test requirements of Annex B and the test methods of Annex D and Annex E. The electrical input values used for rating purposes shall be measured during the heating capacity test.

7.1.1.3 Resistive elements used for heating indoor air other than those used for defrosting shall be prevented from operating during the heating capacity tests.

7.1.1.4 Tests may be conducted to determine the heating capacities of individual indoor units, operating with or without all other indoor units functioning. If tests for individual indoor unit capacity are conducted, the capacities shall be determined in accordance with the requirements of Annex G.

7.1.1.5 If the manufacturer does not specify otherwise, the thermostat or controller shall be set at its maximum allowable temperature setting.

7.1.2 Temperature conditions

The temperature conditions are as specified in Table 6

7.1.2.1 Pre-conditions:

Equilibrium condition as specified in clause 8.3.1 has to be achieved for at least 60 minutes between the test room reconditioning apparatus and equipment under test.

7.1.2.2 Testing requirements:

Total heating capacity and rated power consumption shall be determined

7.1.2.3 Duration of test:

The output shall be measured in the steady state condition as specified in clause 8.3.1. The recording of the data shall continue for at least a 60 min period during which the tolerances specified in clause 8.2 shall be met and 6 sets of readings at every 10 minutes interval shall be recorded. Data shall be sampled at equal intervals that span 30 s or less

7.1.2.4 Calculation for heating capacity:

Annexure D defines the heating capacity calculation for testing done using Calorimetric method and Annexure E defines the calculation for testing done using air enthalpy method.

Table: 6: Heating capacity Rating condition

Parameter	Standard rating condition
Temperature of air entering indoor side – Dry Bulb Temperature – Wet Bulb Temperature	 20°C 15°C
Temperature of air entering outdoor side – Dry Bulb Temperature – Wet Bulb Temperature	 7°C 6°C
Test frequency	Rated frequency
Test voltage	Rated voltage
Compressor speed *	Rated speed for full capacity (or) Controller setting for full capacity #
Indoor side air flow **	Rated air flow
* Refer to clause 5.1.1 ** Refer to clause 5.4 to 5.8 # For compressors with variable refrigerant flow other than variable speed type	

7.1.3 Air flow conditions

7.1.3.1 For ducted indoor units, measurement of the indoor-side air volume rate is required in all cases, regardless of whether the calorimeter test method or the indoor air enthalpy test method is used to provide the primary measurement of heating capacity.

7.1.3.2 Airflow measurements shall be done as specified in specified in Annex A for ducted units and Annex C for other units, as appropriate, as well as the provisions established in the other annexes.

7.1.3.3 The air flow setting for both indoor and outdoor shall be same as that established during the cooling capacity tests. The heating capacity tests shall be conducted at the outdoor-side airflow rate that is inherent in the outdoor-side air circuit, with the exception of any adjustments allowed if using the outdoor air-enthalpy test method (see Annex K).

7.1.3.4 For ducted indoor units, heating capacity tests shall be conducted with the same setting of the damper or exhaust fan as set for the cooling capacity test

7.1.4 Defrost operation

7.1.4.1 Automatic defrost controls shall not be disabled or overridden. Only if manual defrosting has to be initiated during preconditioning, then the automatic controls can be overridden.

7.1.4.2 Any defrost cycle, whether automatically or manually initiated, that occurs while preparing for or conducting a heating capacity test, shall always be automatically terminated by the action of the heat pump's defrost controls.

7.1.4.3 If the heat pump turns the indoor fan off during the defrost cycle, airflow through the indoor coil shall stop.

7.1.5 Test procedure — General

7.1.5.1 The test procedure consists of three periods: a preconditioning period, an equilibrium period and a data collection period. The duration of the data collection period differs depending on whether the heat pump's operation is steady-state or transient. In addition, in the case of transient operation, the data collection period specified when using the indoor air enthalpy method (see 7.1.11.5) is different from the data collection period required if using the calorimeter method (see 7.1.11.6).

7.1.5.2 The pictorial representation of possible different sequences while conducting a heating capacity test sequences is described in Annex R.

7.1.6 Preconditioning period

7.1.6.1 The test room reconditioning apparatus and the heat pump under test shall be operated until the test tolerances specified in 8.3 are attained for at least 10 min.

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

7.1.7 Equilibrium period

7.1.7.1 The equilibrium period immediately follows the preconditioning period.

7.1.7.2 A complete equilibrium period is 60 minutes in duration.

7.1.7.3 The test tolerances as specified in table 13 of clause 8.3 shall be applicable except for transient test.

7.1.8 Data collection period

7.1.8.1 The data collection period immediately follows equilibrium period.

7.1.8.2 The data collection period shall be based on the test procedure selected.

7.1.8.3 An integrating electrical power (watt-hour) meter or measuring system shall be used for measuring the electrical energy supplied to the equipment. During defrost cycles and for the first 10 min following a defrost termination, the meter or measuring system shall have a sampling rate of at least every 10 s.

7.1.8.4 Except as specified in 7.1.8.3 and 7.1.8.5, data shall be sampled at equal intervals that span 30 s or less

7.1.8.5 During defrost cycles, plus the first 10 min following defrost termination, certain data used in evaluating the integrated heating capacity of the heat pump shall be sampled at equal intervals that span 10 s or less. When using the indoor air enthalpy method, these more frequently sampled data include the change in indoor-side dry-bulb temperature. When using the calorimeter method, these more frequently sampled data include all measurements required to determine the indoor-side capacity.

7.1.8.6 For heat pumps that automatically cycle off the indoor fan during a defrost, the contribution of the net heating delivered and/or the change in indoor-side dry-bulb temperature shall be assigned the value of zero when the indoor fan is off, if using the indoor air enthalpy method. If using the calorimeter test method, the integration of capacity shall continue while the indoor fan is off.

7.1.8.7 For both the indoor air-enthalpy and calorimeter test methods, the difference between the dry-bulb temperature of the air leaving and entering the indoor coil shall be measured. For each 5 min interval during the data collection period, an average temperature difference shall be calculated, $\Delta t_{i(\tau)}$). The average temperature difference for the first 5 min of the data collection period, $\Delta t_{i(\tau=0)}$, shall be saved for the purpose of calculating the change, Δt , expressed as a percentage, as given in Equation (1):

$$\%\Delta t = \left[\frac{\Delta t_{i(\tau=0)} - \Delta t_{i(\tau)}}{\Delta t_{i(\tau=0)}}\right] \times 100$$ Equation (1)

7.1.9 Test procedure when a defrost cycle (whether automatically or manually initiated) ends the preconditioning period (7.1.6)

7.1.9.1 If the quantity $\%\Delta t$ exceeds 2.5 % during the first 35 min of the data collection period, the heating capacity test shall be designated as a transient test (see 7.1.11). Likewise, if the heat pump initiates a defrost cycle during the equilibrium period or during the first 35 min of the data collection period, the heating capacity test shall be designated as a transient test.

7.1.9.2 If the conditions specified in 7.1.9.1 do not occur and the test tolerances given in 8.3 are satisfied during both the equilibrium period and the first 35 min of the data collection period, then the heat capacity test shall be designated a steady-state test. Steady-state tests shall be terminated after 35 min of data collection.

7.1.10 Test procedure when a defrost cycle does not end the preconditioning period (7.1.6)

7.1.10.1 If the heat pump initiates a defrost cycle during the equilibrium period or during the first 35 min of the data collection period, the heating capacity test shall be restarted as specified in 7.1.10.3.

7.1.10.2 If the quantity % Δt exceeds 2.5 % any time during the first 35 min of the data collection period, the heating capacity test shall be restarted as specified in 7.1.10.3. Prior to the restart, a defrost cycle shall occur. This defrost cycle may be manually initiated or delayed until the heat pump initiates an automatic defrost.

7.1.10.3 If either 7.1.10.1 or 7.1.10.2 apply, then the restart shall begin 10 min after the defrost cycle terminates with a new, 1-hour-long equilibrium period. This second attempt shall follow the requirements of 7.1.7 and 7.1.8, and the test procedure of 7.1.9.

7.1.10.4 If the conditions specified in 7.1.10.1 or 7.1.10.2 do not occur and the test tolerances given in 8.3 are satisfied during both the equilibrium period and the first 35 min of the data collection period, then the heat capacity test shall be designated as a steady-state test. Steady-state tests shall be terminated after 35 min of data collection.

7.1.11 Test procedure for transient tests

7.1.11.1 When, in accordance with 7.1.9.1, a heating capacity test is designated as a transient test, the adjustments specified in 7.1.11.2 to 7.1.11.5 shall apply.

7.1.11.2 The outdoor air-enthalpy test method shall not be used and its associated outdoor-side measurement apparatus shall be disconnected from the heat pump. In all cases, the normal outdoor-side airflow of the heat pump shall not be disturbed. The use of other confirming test methods is not required.

7.1.11.3 To constitute a valid transient heating capacity test, the test tolerances specified in Table 8 shall be achieved during both the equilibrium period and the data collection period. As noted in Table 8, the test tolerances are specified for two subintervals. Interval H consists of data collected during each heating interval, with the exception of the first 10 min after defrost termination. Interval D consists of data collected during each defrost cycle plus the first 10 min of the subsequent heating interval.

7.1.11.4 The test tolerance parameters in Table 7 shall be sampled throughout the equilibrium and data collection periods. All data collected during each interval, H or D, shall be used to evaluate compliance with the Table 8 test tolerances. Data from two or more H intervals or two or more D intervals shall not be combined and then used in evaluating Table 6 compliance. Compliance is based on evaluating data from each interval separately.

7.1.11.5 If using the indoor air enthalpy method, the data collection period shall be extended until 3 h have elapsed or until the heat pump completes three complete cycles during the period, whichever occurs first. If, at an elapsed time of 3 h, the heat pump is conducting a defrost cycle, the cycle shall be completed before terminating the collection of data. A complete cycle consists of a heating period and a defrost period, from defrost termination to defrost termination.

7.1.11.6 If using the calorimeter method, the data collection period shall be extended until 6 h have elapsed or until the heat pump completes six complete cycles during the period, whichever occurs first. If, at an elapsed time of 6 h, the heat pump is conducting a defrost cycle, the cycle shall be completed before terminating the collection of data. A complete cycle consists of a heating period and a defrost period, from defrost termination to defrost termination.

Note: Consecutive cycles are repetitive with similar frost and defrost intervals before selecting data used for calculating the integrated capacity and power.

7.1.11.7 Because of the confirming test method requirement of 8.1.3.1, the outdoor air enthalpy test apparatus may have to be disconnected from the heat pump, as specified in 7.1.11.2, during a heating capacity test. If removal during a test is required, the changeover interval shall not be counted as part of the elapsed time of the equilibrium or data collection periods. The changeover interval shall be defined as starting the instant the heating capacity test is designated a transient test and ending when the test tolerances from Table 7 are first re-established after the outdoor air-enthalpy apparatus is disconnected from the heat pump.

Table 7: Variations allowed in heating capacity tests when using the Transient test procedure

Reading	Variation of arithmetical mean values from specified test conditions		Variation of individual readings from specified test conditions	
	Interval H*	Interval D**	Interval H*	Interval D**
Temperature of air entering indoor-side: dry-bulb wet-bulb	±0.6 °C —	±1.5 °C —	±1.0 °C —	±2.5 °C —
Temperature of air entering outdoor-side: dry-bulb wet-bulb	±0.6 °C ±0.3 °C	±1.5 °C ±1.0 °C	±1.0 °C ±0.6 °C	±5.0 °C
Voltage	—	—	±2 %	±2 %
External resistance to airflow	—	—	±5 Pa	—

* Applies when the heat pump is in the heating mode, except for the first 10 min after termination of a defrost cycle.
** Applies during a defrost cycle and during the first 10 min after the termination of a defrost cycle when the heat pump is operating in the heating mode.

7.1.12 Heating capacity test results

7.1.12.1 The electrical energy supplied to the heat pump during the applicable test period specified in 7.1.8 shall be measured along with the corresponding elapsed time, in hours, of the test period.

7.1.12.2 Average heating capacity and average electrical power input shall be calculated in accordance with 9.1.4 and 9.1.5 using data from the total number of complete cycles that are achieved before data collection is terminated. In the event that the equipment does not undergo a defrost cycle during the data collection period, the entire 6 hours data set shall be used for the calculations.

7.2 Maximum heating performance test

7.2.1 General conditions

The conditions given in Table 8 shall be used during the maximum heating performance test. The determination of heating capacity is not required for this performance test. The test voltages in Table 9 shall be maintained at the specified percentages under running conditions. All indoor units and compressors shall be functioning during this test.

7.2.2 Temperature conditions

The temperature conditions given in Table 8 shall be used during these tests, unless the manufacturer specifies higher temperature conditions in the manufacturer's equipment specification sheets.

7.2.3 Airflow conditions

The maximum heating test shall be conducted using the indoor-side fan speed setting determined in 5.2.

7.2.4 Test conditions

7.2.4.1 Preconditions

The controls of the equipment shall be set for maximum heating.

7.2.4.2 Duration of test

The equipment shall be operated for 60 minutes after the specified air temperatures have been attained. The equipment shall be permitted to stop and start under the control of an automatic limit device, if provided.

Table 8: Maximum heating operating condition test

Parameter	Standard test conditions
Temperature of air entering indoor-side: dry-bulb	 27 °C
Temperature of air entering outdoor-side: dry-bulb wet-bulb	 24 °C 18 °C
Test frequency	Rated frequency
Test voltage – Condition 1	110% Rated voltage
Test voltage – Condition 2	90% Rated voltage
Compressor speed *	Full load speed (or) Controller setting for full capacity delivery
Indoor side air flow **	Full load air flow as specified by manufacturer
Test duration for test voltage condition 1 and test voltage condition 2 each	60 minutes continuous run after temperature conditions achieved. And then power cut - off to equipment for 3 minutes. Restart unit and run for 60 minutes continuously
* Refer to clause 5.1.1 ** Refer to clause 5.4 to 5.8	

7.2.4.3 The equipment shall operate under the conditions specified in Table 8 and 7.2.4.2, without indication of damage.

7.2.4.4 For equipment designed so that resumption of operation does not occur after initial trip within the first 5 min, the equipment may remain out of operation for not longer than 3 min. It shall then operate continuously for 60 minutes.

7.3 Minimum heating performance test

7.3.1 General conditions

The conditions given in Table 9 shall be used for this test. The test shall be conducted with the equipment functioning at full-load operation, as defined in 3.31. The voltage shall be maintained at the specified value under running conditions. All indoor units and compressors shall be functioning during this test. The determination of the heating capacity and electrical power input is not required for this performance test.

7.3.2 Temperature conditions

The temperature conditions shall be as given in Table 9, unless the manufacturer specifies lower conditions in the manufacturer's equipment specification sheets.

7.3.3 Airflow conditions

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

Table 9: Minimum heating operating condition

Parameter	Standard test conditions
Temperature of air entering indoor-side: dry-bulb	 20 °C
Temperature of air entering outdoor-side*: dry-bulb wet-bulb	 1 °C —
Test frequency	Rated frequency
Test voltage	Rated voltage

7.3.4 Test conditions

7.3.4.1 Preconditions

The equipment shall be operated for a sufficient period of time to reach stable operating conditions as specified in Table 10.

7.3.4.2 Duration of test

After the equipment has reached stable operating conditions (Tables 10 and 13), these conditions shall be maintained for 60 minutes.

7.3.4.3 Performance requirements

The equipment shall operate throughout the test without activation of any manual reset device. The equipment shall be permitted to stop and start under the control of an automatic limit device, if provided.

The equipment shall operate under the conditions specified in Table 10 and 7.3.4.2, without indication of damage.

7.4 Automatic defrost test

7.4.1 General conditions

This test is not required if provision is made to ensure that cool air (less than 18 °C) is not blown into the conditioned space during defrost. The test shall be conducted with the equipment functioning at full capacity, as defined in 3.31, except as required in 7.4.3. The determination of heating capacity and electrical power input is not required for this performance test.

7.4.2 Temperature conditions

The temperature conditions specified as below in table 10 shall be used during the automatic defrost test.

Table 10: Automatic defrost test condition

Parameter	Standard rating condition
Temperature of air entering indoor side – Dry Bulb Temperature – Wet Bulb Temperature	 20°C 15°C
Temperature of air entering outdoor side – Dry Bulb Temperature – Wet Bulb Temperature	 2°C 1°C
Test frequency	Rated frequency
Test voltage	Rated voltage
Compressor speed *	Rated speed for full capacity (or) Controller setting for full capacity #
Indoor side air flow **	Rated air flow
* Refer to clause 5.1.1 ** Refer to clause 5.4 to 5.8 # For compressors with variable refrigerant flow other than variable speed type	

7.4.3 Airflow conditions

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

7.4.4 Test conditions

7.4.4.1 Preconditions

The equipment shall be operated until the temperatures specified conditions in Table 10 have been stabilized.

7.4.4.2 Duration of test

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

7.4.5 Performance requirements

During the defrosting period, the temperature of the air from the indoor-side of the equipment shall not be lower than 18 °C for longer than 1 min.

8.0 Test methods and uncertainties of measurement

8.1 Test methods

8.1.1 General

The standard capacity rating tests shall be conducted as per the testing requirements specified in Annex B using either the calorimeter test method (see Annex D) or the indoor air-enthalpy test method (see Annex E) subject to the provision that the test results are within the limits of uncertainties of measurements established in Clause No.8.2

8.1.2 Calorimeter test method

8.1.2.1 In calorimeter test method, two simultaneous methods for determining capacities shall be used. While one method determines the capacity on the indoor side, the other measures the capacity on the outdoor side. For the test data to be valid, the capacity determined using the outdoor-side data shall agree within 5 % of the value obtained using the indoor-side data for the test.

8.1.2.2 Steady-state shall considered to be achieved and the measurements shall be considered valid only if the measured capacity at each 10 minutes time interval does not vary by more than 2 % from the average measured capacity of the entire test period.

8.1.2.3 The airflow measurement apparatus for setting the indoor-side airflow and static pressure measurements shall be located within the indoor-side compartment of the calorimeter for all tests, except where specifications in A.3 are used for setting the airflow. In this case, the airflow measuring apparatus may be removed after the damper has been set to obtain the required airflow and static pressure.

8.1.3 Indoor air enthalpy method

8.1.3.1 A confirming test may be conducted to verify the results obtained using the indoor air-enthalpy test method. The following test methods may be used for confirming purposes:

- Compressor calibration method (see Annex H);
- Refrigerant enthalpy method (see Annex J);
- Outdoor air-enthalpy test method (see Annex K);
- Indoor calorimeter confirmative test method (see Annex L);
- Outdoor calorimeter confirmative test method (see Annex M);
- Balanced-type calorimeter confirmative test method (see Annex N).

Note: Annex N is not used as a confirmative test by testing laboratories (see N.1.1).

8.1.3.2 The results of the primary test shall agree with the results of the confirmative test within 6 % to be valid.

8.2 Uncertainty of measurement

8.2.1 The uncertainty of measurement values shall be as specified in Table 11.

8.2.2 The steady-state cooling and heating capacities determined using the calorimeter method shall be determined with a maximum uncertainty of 5 %. This value is an expanded uncertainty of measurement expressed at the level of confidence of 95 %.

8.2.3 Heating capacity determined during transient operation (defrost cycles) using the calorimeter method shall be determined with a maximum uncertainty of 10 %. This value is an expanded uncertainty of measurement expressed at the level of confidence of 95 %.

8.2.4 The heating and cooling capacities measured on the air side using the air enthalpy method shall be determined with a maximum uncertainty of 10 %. This value is an expanded uncertainty of measurement expressed at the level of confidence of 95 %.

Table 11 — Uncertainties of measurement

Measured quantity	Uncertainty of measurement*
Air:	
Dry-bulb temperature	0.2 °C
Wet-bulb temperature **	0.3 °C
Volume flow	5 %
Static pressure difference	5 Pa 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 a series of measurements and can be characterized by experimental standard deviations. Estimates of other components can be based on experience or other information.	
* Uncertainty of measurement is an estimate characterizing the range of values within which the true value of the measurement lies, based on a 95 % confidence interval (see ISO/IEC Guide 98-3). ** Can be measured directly or indirectly.	

8.3 Test tolerances for the capacity tests

8.3.1 The maximum permissible variation of any individual observation from a specific test condition during a steady-state capacity test is listed in Table 12. If a test condition is not specified, the values in column 3 of Table 12 represent 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 average of the observations.

8.3.2 The maximum permissible variations of the average of the test observations from this Standard or specified test conditions are shown in Table 12.

8.3.3 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 12.

Table 12 — Variations allowed during steady-state cooling and heating capacity tests

Reading	Variations of arithmetical mean values from specified test conditions	Maximum variation of individual readings from specified test conditions*
Temperature of air entering indoor-side: dry-bulb wet-bulb *	 ± 0.3 °C ± 0.2 °C	 ± 0.5 °C ± 0.3 °C
Temperature of air entering outdoor-side: dry-bulb wet-bulb **	 ±0.3 °C ±0.2 °C	 ±0.5 °C ±0.3 °C
Voltage	± 1 %	± 2 %
Air volume flow rate ***	± 5 %	± 10 %
* Not applicable for heating tests. ** Applicable for Heating capacity test only *** Only applies to the indoor air enthalpy method. The test condition is defined as the measured arithmetical mean of airflow taken within the first 5 min of the data collection period.		

8.4 Test tolerances for performance tests

The maximum allowable variation of any individual observation made during a performance test from the specified test condition is established in Table 13.

Table 13 — Test tolerances for performance tests

Readings	Maximum variation of individual readings from specified test conditions*
Air temperatures:	
dry-bulb	± 1.0 °C
wet-bulb	± 0.5 °C
Voltage	± 2 %
* The test tolerances do not apply when the equipment is stopped, changing compressor speed or from defrost initi ationo 10 min a er defrost terminainationcept during these intervals, dry-bulb temperature tolerances of ± 2.5 °C on the indoor side and ± 5 °C on the outdoor side shall apply.	

9.0 Test results

9.1 Capacity calculations

9.1.1 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 the following quantities as are applicable to cooling or heating:

a. Total cooling capacity, in kW;

b. Sensible cooling capacity, in kW;

c. Latent cooling capacity, in kW;

d. Heating capacity, in kW;

e. Indoor-side airflow rate, in m^3/s of standard air;

f. External static pressure / External resistance to indoor airflow, in Pa;

g. Effective power input to the equipment or individual power inputs to each of the electrical equipment components, in kW.

Note: For determination of latent cooling capacity, see Annex D if using the calorimeter test method and Annex E if using the indoor air enthalpy test method

9.1.2 Adjustments

Test results shall be used to determine capacities without adjustment for permissible variations in test conditions. Air enthalpies, specific volumes and isobaric specific heat capacities shall be based on the measured barometric pressure.

9.1.3 Cooling capacity calculations

9.1.3.1 An average cooling capacity shall be determined from the set of cooling capacities recorded over a data collection period of at least 60 min.

9.1.3.2 An average electrical power input shall be determined from the set of electrical power inputs recorded over the data collection period or from the integrated electrical power for the same interval in cases where an electrical energy meter is used.

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

9.1.4 Heating capacity calculations

9.1.4.1 Steady-state capacity calculations

9.1.4.1.1 If the heating capacity test is conducted in accordance with the provisions of 7.1.9.2 or 7.1.10.4, the heating capacity shall be calculated using data from each data sampling in accordance with Annex D, if using the calorimeter test method, or in accordance with Annex E, if using the indoor air-enthalpy test method.

9.1.4.1.2 An average heating capacity shall be determined from the set of heating capacities recorded over the data collection period.

9.1.4.1.3 An average electrical power input shall be determined from the set of electrical power inputs recorded over the data collection or from the integrated electrical power for the same data collection period.

9.1.4.2 Transient capacity tests

9.1.4.2.1 If the heating capacity test is conducted in accordance with the provisions of 7.1.11, an average heating capacity shall be determined. This average heating capacity shall be calculated as specified in Annex D if using the calorimeter test method and as specified in Annex E if using the indoor air-enthalpy test method.

9.1.4.2.2 For equipment where one or more complete cycles occur during the data collection period, the following shall apply.

The average heating capacity shall be determined using the integrated capacity and the elapsed time corresponding to the total number of complete cycles that occurred over the data collection period. The average electrical power input shall be determined using the integrated power input and the elapsed time corresponding to the total number of complete cycles during the same data collection period as the one used for the heating capacity.

NOTE: A complete cycle consists of a heating period and a defrost period from defrost termination to defrost termination.

9.1.4.2.3 For equipment that does not conduct a complete cycle during the data collection period, the following shall apply.

The average heating capacity shall be determined using the integrated capacity and the elapsed time corresponding to the total data collection period (3 h if using the indoor air-enthalpy test method; 6 h if using the calorimeter test method).The average electrical power input shall be determined using the integrated power input and the elapsed time corresponding to the same data collection period as the one used for the heating capacity.

9.1.4.2.4 For equipment in which a single defrost occurs during the test period, the following shall apply.

The average heating capacity shall be determined using the integrated capacity and the elapsed time corresponding to the total test period (3 h if using the indoor air-enthalpy test method; 6 h if using the calorimeter test method). The average electrical power input shall be determined using the integrated power input and the elapsed time corresponding to the total test period.

9.1.5 Power input of fans

The fan power measured during the test shall be included in the declared power consumption and in the calculation of efficiencies. Standard ratings of capacities shall include the effects of circulating-fan heat, but shall not include supplementary heat.

9.2 Data to be recorded

The data to be recorded for the capacity tests are given in Table 14 for the indoor air enthalpy test method and Tables 16 and 17 for the room calorimeter test method. The tables identify the general information required but are not intended to limit the data to be obtained. Electrical input values used for rating purposes shall be those measured during the capacity tests.

Table 14 — Data to be recorded for the indoor air-enthalpy capacity tests

No.	Data
1	Date
2	Observers
3	Barometric pressure, in kPa
4	Fan speed setting indoor and outdoor
5	Applied voltage, in V
6	Frequency, in Hz
7	Total current input to equipment, in A
8	Total power input to equipment*, in kW
9	Setting of variable capacity compressor at full load, control dry-bulb and wet-bulb temperature of air (indoor-side calorimeter compartment), in˚C
10	Control dry-bulb and wet-bulb temperature of air (outdoor-side calorimeter compartment)**,in˚C
11	Average air temperature outside the calorimeter if calibrated (see Figure D.1), in˚C
12	Total power input to indoor-side and outdoor-side compartments, in Watts
13	Quantity of water evaporated in humidifier, in kilograms
14	Temperature of humidifier water entering indoor-side and outdoor-side (if used) compartments or in humidifier tank, in˚C
15	Cooling water flow rate through outdoor-side compartment heat-rejection coil, in liters per second
16	Temperature of cooling water entering outdoor-side compartment, for heat-rejection coil, in˚C
17	Temperature of cooling water leaving outdoor-side compartment, from heat-rejection coil, in˚C
18	Temperature of condensed water leaving outdoor-side compartment, in˚C
19	Mass of condensed water from equipment, in kilograms
20	Volume of airflow through measuring nozzle of the separating partition, in cubic meters per second
21	Air-static pressure difference across the separating partition of calorimeter compartments, in Pa.
22	Refrigerant charge added by the test house, in kilograms

* Total power input to the equipment, except if more than one external power connection is provided on the equipment; record input to each connection separately.

** See D.1.5.

Table 15 — Data to be recorded for calorimeter cooling capacity tests

No.	Data
1	Date
2	Observers
3	Barometric pressure, in kPa
4	Fan speed setting indoor and outdoor
5	Applied voltage, in V
6	Frequency, in Hz
7	Total current input to equipment, in A
8	Total power input to equipment*, in kW
9	Setting of variable capacity compressor at full load
10	Control dry-bulb and wet-bulb temperature of air (indoor-side calorimeter compartment), in ˚C
11	Control dry-bulb and wet-bulb temperature of air (outdoor-side calorimeter compartment)**, in ˚C
12	Average air temperature outside the calorimeter if calibrated (see Figure D.1), in ˚C

13	Total power input to indoor-side and outdoor-side compartments, in Watts
14	Quantity of water evaporated in humidifier, in kilograms
15	Temperature of humidifier water entering indoor-side and outdoor-side (if used) compartments or in humidifier tank, in ˚C
16	Cooling water flow rate through outdoor-side compartment heat-rejection coil, in liters per second
17	Temperature of cooling water entering outdoor-side compartment, for heat-rejection coil, in ˚C
18	Temperature of cooling water leaving outdoor-side compartment, from heat-rejection coil, in degrees Celsius
19	Mass of condensed water from equipment, in kilograms
20	Temperature of condensed water leaving outdoor-side compartment, in ˚C
21	Volume of airflow through measuring nozzle of the separating partition, in cubic metres per second
22	Air-static pressure difference across the separating partition of calorimeter compartments, in Pa
23	Refrigerant charge added by the test house, in kilograms
* Total power input to the equipment, except if more than one external power connection is provided on the equipment; record input to each connection separately. ** See D.1.5	

Table 16 – Data to be recorded for calorimetric heating capacity tests

No.	Data
1	Date
2	Observers
3	Barometric pressure, in kPa
4	Fan speed setting indoor and outdoor
5	Applied voltage, in V
6	Frequency, in Hz
7	Total current input to equipment, in A
8	Total power input to equipment*, in Watts
9	Setting of variable capacity compressor at full load
10	Control dry-bulb and wet-bulb temperature of air (indoor-side calorimeter compartment)**, in ˚C
11	Control dry-bulb and wet-bulb temperature of air (outdoor-side calorimeter compartment)**, in ˚C
12	Average air temperature outside the calorimeter if calibrated (see Figure D.1), in ˚C
13	Total power input to indoor-side and outdoor-side compartments, in watts
14	Quantity of water evaporated in humidifier, in kilograms
15	Temperature of humidifier water entering indoor-side and outdoor-side (if used) compartments or in humidifier tank, in ˚C
16	Cooling water flow rate through outdoor-side compartment heat-rejection coil, in liters per second
17	Temperature of cooling water entering outdoor-side compartment, for heat-rejection coil, in ˚C
18	Temperature of cooling water leaving outdoor-side compartment, from heat-rejection coil, in degrees Celsius
19	Mass of condensed water from equipment, in kg
20	Temperature of condensed water leaving outdoor-side compartment, in ˚C
21	Volume of airflow through measuring nozzle of the separating partition, in cubic meters per second
22	Air-static pressure difference across the separating partition of calorimeter compartments, in pascals
23	Refrigerant charge added by the test house, in kg.
* Total power input to the equipment, except if more than one external power connection is provided on the equipment; record input to each connection separately. ** See D.1.5	

9.3 Test report

9.3.1 General information

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

a) A reference to this Standard,

b) The date;

c) The test lab name;

d) The test location;

e) The test method(s) used (calorimeter or air-enthalpy);

f) The test supervisor;

g) A description of the test set-up, including equipment location;

h) The nameplate information (see 10.2).

9.3.2 Rating test results

The values reported shall be the mean of the values taken over the data collection period, and shall be stated with an uncertainty of measurement at a confidence level of 95 % and in accordance with ISO/IEC Guide 98-3.

9.3.3 Performance tests

All relevant information regarding testing shall be reported.

10.0 Marking provisions

10.1 Nameplate requirements

Each individual unit of the air-conditioner and heat pump system shall have a durable nameplate firmly attached to it and in a location accessible for reading.

10.2 Nameplate information

The nameplate shall provide the following minimum information in addition to the information required by applicable safety standards:

a) The manufacturer's name or trademark;

b) Manufacturing location Address

c) Any distinctive type or model designation and serial number;

d) The rated voltage;

e) The rated frequency;

f) Rated capacity (Cooling / Heating)

g) Maximum current

h) Refrigerant charge quantity (check with other standards)

i) The refrigerant designation in accordance with ISO 817.

j) Type of Indoor units tested

k) Number of indoor units tested

10.3 Additional information

In addition to the nameplate information in 10.2, the factory refrigerant mass charge shall be provided on the outdoor unit.

11.0 Publication of ratings

11.1 Standard ratings

11.1.1 Standard ratings shall be published for cooling capacities (sensible, latent and total), heating capacity, EER and COP, as appropriate, for all systems produced in conformance with this Standard. These ratings shall be based on data obtained at the established rating conditions in accordance with the provisions of this Standard.

11.1.2 The values of standard capacities shall be expressed in kilowatts, rounded to two decimals.

11.1.3 The values of EER and COP shall be expressed in multiples, rounded to two decimals.

Note: *The rating conditions and the operating limits other than those prescribed above shall be mutually agreed upon between the manufacturer and buyer.*

11.2 Other ratings

Additional ratings may be published based on conditions other than those specified as standard rating conditions, or based on the testing of various combinations of operating evaporators and/or compressors, if they are clearly specified and if the data are determined by the methods specified in this Standard, or by analytical methods which are verifiable by the test methods specified in this standard.

11.2 Symbols

Symbol	Description	Unit
A_l	coefficient, heat leakage	J/s °C
A_n	nozzle area	m^2
a	pressure ratio	—
C_d	nozzle discharge coefficient	—
c_o	concentration of oil	—
c_{pa}	specific heat of moist air	J/kg °C
c_{pa1}	specific heat of moist air entering indoor side	J/kg °C
c_{pa2}	specific heat of moist air leaving indoor side	J/kg °C
c_{pw}	specific heat of water	J/kg °C
D_e	equivalent diameter	mm
D_n	nozzle throat diameter	mm
D_i	diameter of circular ducts, inlet	mm
D_o	diameter of circular ducts, outlet	mm
D_t	outside diameter of refrigerant tube	mm
h_{a1}	specific enthalpy of air entering indoor side	J/kg of dry air
h_{a2}	specific enthalpy of air leaving indoor side	J/kg of dry air
h_{a3}	specific enthalpy of air entering outdoor side	J/kg of dry air
h_{a4}	specific enthalpy of air leaving outdoor side	J/kg of dry air
h_{f1}	specific enthalpy of refrigerant liquid entering the expansion device	J/kg
h_{f2}	specific enthalpy of refrigerant liquid leaving condenser	J/kg
h_{g1}	specific enthalpy of refrigerant vapour entering compressor	J/kg
h_{g2}	specific enthalpy of refrigerant vapour leaving condenser	J/kq
h_{k2}	specific enthalpy of fluid leaving calorimeter evaporator	J/kg
h_{r1}	specific enthalpy of refrigerant entering indoor side	J/kg
h_{r2}	specific enthalpy of refrigerant leaving indoor side	J/kg

h_{w1}	specific enthalpy of water or steam supplied to indoor-side compartment	J/kg
h_{w2}	specific enthalpy of condensed moisture leaving indoor-side compartment	J/kg
h_{w3}	specific enthalpy of condensate removed by air-treating coil in the outdoor-side compartment of the reconditioning equipment	J/kg
h_{w4}	specific enthalpy of the water supplied to the outdoor-side compartment	J/kg
h_{w5}	specificenthalpy of, respectively, the condensed water (in the case of test condition, high) and the frost (in the case of test conditions low or extra-low) in the test unit	J/kg
K_1	latent heat of vaporization of water (2 500,4 J/g at 0 ^{0}C)	J/kg
L_d	length of duct	m
L_m	length to external static pressure measuring point	m
In	natural logarithm	—
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
$\eta_{fan,i}$	estimated indoor fan static efficiency	—
$\eta_{mot,i}$	estimated indoor motor efficiency	—
p_a	barometric pressure	kPa
p_c	compartment equalization pressure	kPa
p_e	external static pressure (ESP)	kPa
p_{isc}	internal static pressure drop of the indoor coil cabinet assembly measured from cooling capacity test	Pa
p_m	measured external static pressure	kPa
p_n	pressure at the nozzle throat	kPa abs
p_v	velocity pressure at nozzle throat or static pressure difference	Pa
R_e	Reynolds number	—
μ	kinematic viscosity of air	m^2/s
ϕ_{ci}	heat removed from indoor-side compartment	W
ϕ_c	heat removed by cooling coil in the outdoor-side compartment	W
ϕ_{lp}	heat leakage into indoor-side compartment through partition separating indoor side from outdoor side	W
ϕ_{li}	heat leakage into indoor-side compartment through walls, floor and	W
ϕ_{lo}	heat leakage out of outdoor-side compartment through walls, floor	W
ϕ_L	line heat loss in interconnecting tubing	W
ϕ_e	heat input to calorimeter evaporator	W
ϕ_d	latent cooling capacity (dehumidifying)	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_{hi}	heating capacity (indoor-side compartment)	W
ϕ_{ho}	heating capacity (outdoor-side compartment)	W
ϕ_{tci}	total cooling capacity (indoor-side data)	W
ϕ_{tco}	total cooling capacity (outdoor-side data)	W
ϕ_{thi}	total heating capacity (indoor-side data)	W
ϕ_{tho}	total heating capacity (outdoor-side data)	W
P_{fan}	estimated fan power to circulate indoor air	W
P_i	power input (indoor-side data)	W
ΣP_{ic}	other power input to the indoor-side compartment (e.g. illumination, electrical and thermal power input to the compensating device, heat balance of the humidification device)	W
ΣP_{oc}	sum of all total power input to the outdoor-side compartment, not including power to the equipment under test	W
P_E	effective power input to the equipment	W
P_K	power input to compressor	W
P_t	total power input to equipment	W
q_m	air mass flow rate	Kg/s
$qv_{,o}$	measured outdoor air volume flow	m^3/s
q_r	refrigerant flow rate	Kg/s
q_{ro}	refrigerant and oil mixture flow rate	kg/s
q_s	standard flow rate	m^3/s
qV	air-volume flow rate	m^3/s
$qV_{,1}$	indoor air-volume flow rate	m^3/s
q_w	condenser water flow rate	kg/s
q_{wc}	rate at which water vapour is condensed by the equipment	g/s
$q_{m,w}$	water mass flow supplied to the outside compartment for maintaining the test conditions	kg/s
t_a	temperature, ambient	°C
t_{a1}	temperature of air entering indoor side, dry bulb	°C
t_{a2}	temperature of air leaving indoor side, dry bulb	°C
t_{a3}	temperature of air entering outdoor side, dry bulb	°C
t_{a4}	temperature of air leaving indoor side, dry bulb	°C
t_c	temperature of surface of calorimeter condenser	°C
t_{w1}	temperature of water entering calorimeter	°C
t_{w1}	temperature of water leaving calorimeter	°C
v_n	velocity of air at nozzle	m/s
V_n	specific volume of dry air portion of mixture at nozzle	m^3/kg
V'_n	specific volume of air at nozzle	m^3/kg of air-water vapour mixture
W_{i1}	specific humidity of air entering indoor side	kg/kg of dry air
W_{i2}	specific humidity of air leaving indoor side	kg/kg of dry air
W_n	specific humidity at nozzle inlet	kg/kg of dry air
W_r	water vapour (rate) condensed by the equipment	g/s
X_r	mass ratio, refrigerant to refrigerant-oil mixture	—
Y	expansion factor	—

Annex A
Airflow settings for ducted units

A.1 General

Either of the following two methods of airflow settings are deployed for measurement:

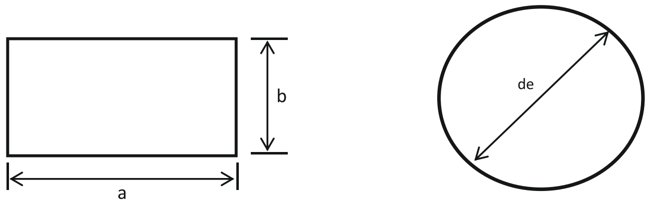
1. Fixed duct resistance method;

2. Adjusted exhaust fan setting method.

Both methods with their respective test apparatus are described in this annex.

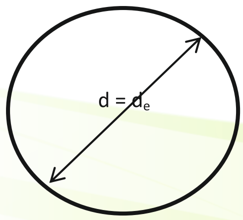
For measuring the static pressure of the air delivery of a ducted equipment, the measuring duct is connected to the duct flange of the equipment. This measuring duct is used in either methods. The equivalent diameter of the measurement duct shall be calculated as defined in equation A.1, where 'a' and 'b' are the dimensions of the outlet duct section:

$$d_e = \sqrt{\frac{(4a.b)}{\pi}} \qquad \text{(Equation: A.1)}$$



Air delivery outlet flange   Measurement duct

If the outlet of ducted equipment is circular in section with diameter d, then the equivalent diameter d_e is equal to d.



Air delivery outlet flange = measurement duct

The length of the measuring duct (L_d) shall be minimum 2.5 times d_e. The tapping for measurement of static pressure should be located at the distance $L_m = 2d_e$ from the outlet flange.

A.2 Test method

A.2.1 The Fixed duct resistance method air flow setting for the unit shall be as shown in Figure A.1 and for adjusted exhaust fan setting is as shown in Figure A.2.

A.2.2 The static pressure measurement taps shall be arranged as shown in Figure A.1 and Figure A.2. The equipment under test shall be operated without the compressor being ON.

A.2.3 Airflow measurements should be made as per the provisions specified in Annex C, as appropriate, as well as other provisions established in this Standard.

Note: Additional guidance concerning airflow measurements can be found in ISO 3966 and ISO 5167-1.

A.3 Fixed duct resistance method

A.3.1 General

A measuring duct shall be connected to the test equipment and a damper installed on the opposite end of the measuring duct, to which a discharge chamber is connected. The discharge chamber shall have sufficient cross-sectional dimensions so that airflow velocities along the wall surface at the static pressure tap (Figure A.1, item 4) is less than or equal to 1.25 m/s. The minimum length of the discharge chamber in the flow direction 'J' shall be 2 times of equivalent diameter d_e.

Note: The test set-up is as illustrated in Figure A.1.

A.3.2 Test procedure

A.3.2.1 Test conditions

The temperature and humidity conditions of the test room shall be within the range specified in 5.7. The equipment under test shall be operated in the fan only mode without the compressor being ON. The damper shall be adjusted so that the rated airflow rate in standard air conditions is obtained. At the same time, the airflow rate of the airflow measuring apparatus shall be adjusted such that static pressure in the discharge chamber is (0 ± 2) Pa. The above conditions shall be maintained for at least 60 minutes.

A.3.2.2 Blowing test

The dry-bulb and wet-bulb temperatures of the inlet air, airflow rate, ESP, p_e, dry-bulb and wet-bulb temperatures in front of the nozzle, and barometric pressure shall be measured. The measured airflow rate, q_m, shall be converted into the standard flow rate, q_s.

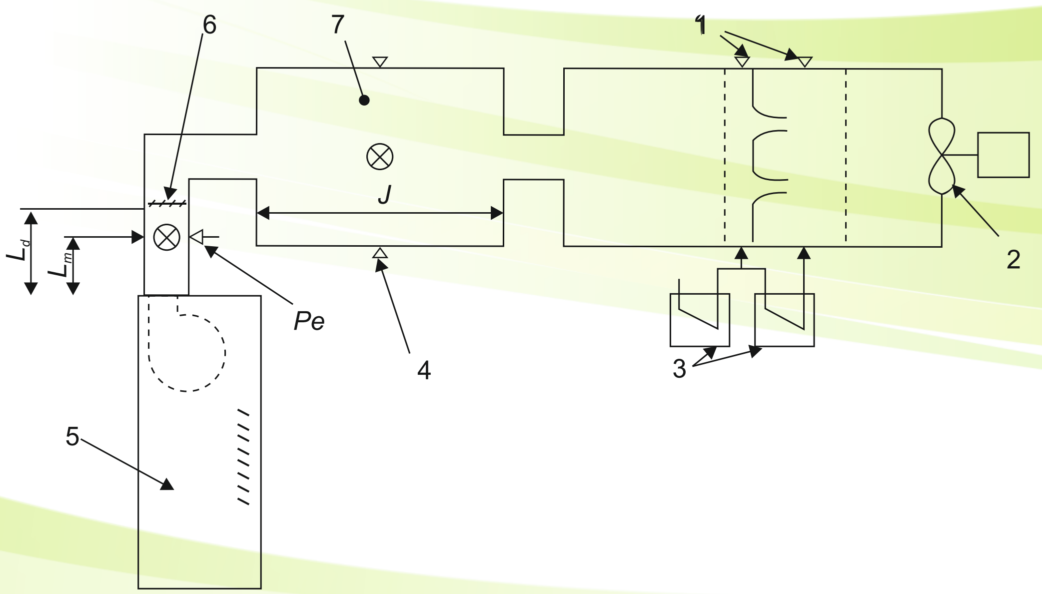
A.3.2.3 Evaluation

The ESP, p_e, shall be that specified in 5.7.

A.3.2.4 Cooling and heating tests

The damper's position shall remain fixed at the setting obtained in A.3.2.1 for all cooling and heating tests, which shall be conducted at the respective temperature and humidity conditions. During the cooling and heating tests, the static pressure of the discharge chamber shall be maintained at (0 ± 2) Pa.

The ESP, p_e, of the measuring duct at the cooling and heating tests is for reference only, and therefore does not need to be published. The airflow rate measured when the equipment is operating in the cooling or heating mode is used for calculation of cooling and heating capacities.



1 - Air flow measuring apparatus
2 - Exhaust fan
3 - Manometers
4 - Static pressure taps of Discharge chamber
5 - Equipment under test
6 - Damper
7 - Discharge chamber
J - Minimum length of discharge chamber
L_d - Minimum length of measuring duct
L_m - Distance of static pressure taps
p_e - External Static pressure of equipment

Figure A.1 – Fixed duct resistance method setup

A.4 Adjusted exhaust fan setting method

A measuring duct shall be connected to the equipment under test and an airflow measuring apparatus connected to the opposite end of the measuring duct.

Note: The set-up of the equipment under test unit, measuring duct and airflow measuring apparatus is illustrated in Figure A.2

A.4.1 Test procedure

The temperature and humidity conditions of the test room shall be within the range specified in 5.7. The equipment under test shall be operated in the fan only mode without the compressor being ON. The airflow measuring apparatus shall be adjusted so that the rated airflow rate in standard air is obtained. The above conditions shall be maintained for at least 60 minutes.

A.4.2 Blowing test

The dry-bulb and wet-bulb temperatures of the inlet air, airflow rate, External Static Pressure, p_e, dry-bulb and wet-bulb temperatures in front of the nozzle, and barometric pressure shall be measured. The measured airflow rate, q_m, shall be calculated according to Equation (C.6). The measured airflow rate, q_m, shall be converted into the standard flow rate, q_s.

A.4.3 Calculation of the value of C

The value of C shall be calculated from Equation (A.2).

$$C = \frac{p_m}{q_m^2} \qquad \text{Equation (A.2)}$$

Where

p_m - static pressure of the measuring duct, KPa, and p_m is considered to be equal to the external static pressure p_e.

A.4.4 Evaluation

The External Static Pressure, p_e, shall be as specified by 5.7.

A.4.5 Cooling and heating tests

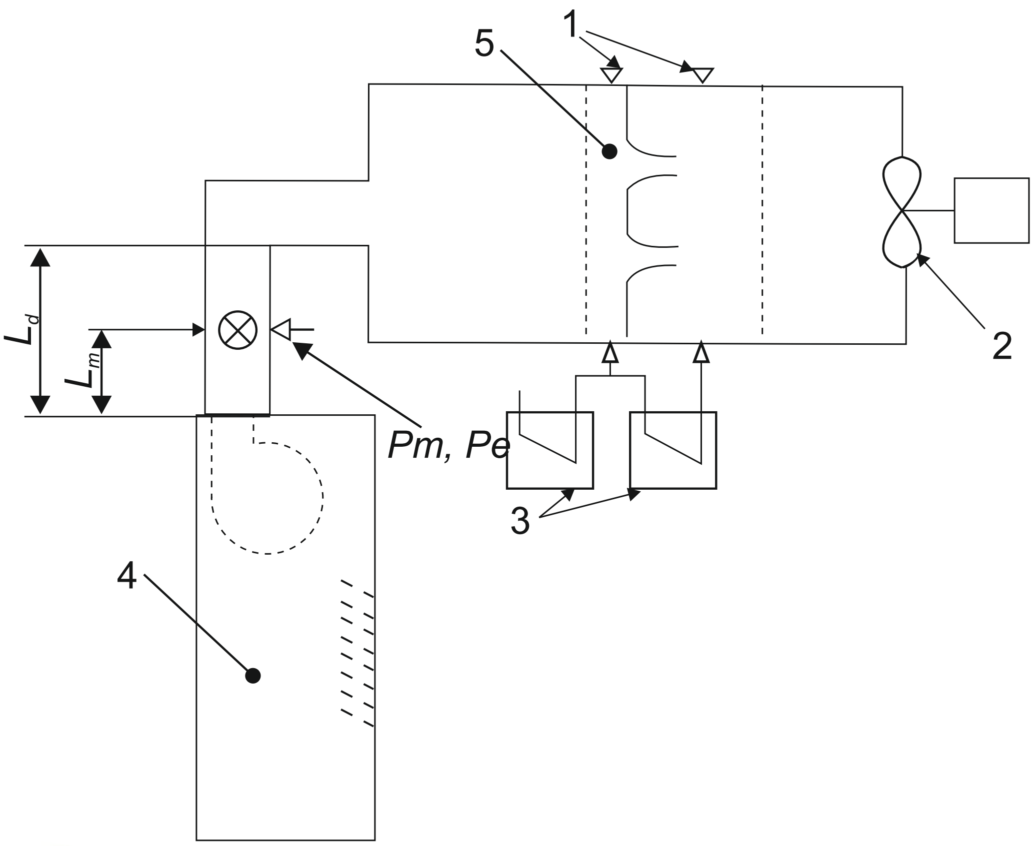
Cooling and heating tests shall be performed following the blowing test, at their respective temperature and humidity conditions. The speed of the exhaust fan of the airflow measuring apparatus shall be adjusted for the cooling and heating tests as below.

For the cooling test, operate the equipment with the compressor in the cooling mode and allow the temperature to stabilize. Once the temperature is stabilized adjust the airflow measuring apparatus to achieve the same value of *'C'* by changing its exhaust fan speed in small increments. The resulting value of *'C'* shall be in the range of ±1 % of that measured during the blowing test. Once stabilized, the cooling airflow rate and ESP shall be measured.

For the heating test, repeat the cooling test above, this time with the compressor operating in the heating mode. Measure the heating airflow rate and ESP.

The airflow rate measured when the equipment is operating in the cooling or heating mode shall be used to calculate the cooling and heating capacities.

The ESP of the measuring duct during the cooling and heating tests is for reference only, and therefore does not need to be published.



1 Air flow measuring apparatus
2 Exhaust fan
3 Manometers
4 Equipment under test
5 Nozzles

L_d Length of measuring duct
L_m Distance of static pressure taps
P_m External static pressure of equipment under test
P_e Static pressure of the measuring duct

Figure A.2 – Adjusted exhaust fan setting method setup

Annex B
Test Room Requirements

B.1 General Requirements of test room

B.1.1 The indoor condition test room shall be a room or space in which the desired test conditions can be maintained within the prescribed tolerances. It is recommended that air velocities in the vicinity of the equipment under test do not exceed 2.5 m/s.

B.1.2 The outdoor condition test room or space shall be of sufficient volume and shall circulate air in such a manner that it does not change the normal air circulating pattern of the equipment under test. It shall be of such dimensions 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 1.0 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 should preferably take this air from the direction of the equipment air discharge and return it at the desired conditions uniformly and at low velocities.

B.1.3 For the calorimeter room with a facility having more than two rooms, the additional rooms shall also comply with the requirements of Annex D.

B.1.4 For the air enthalpy method test facility having more than two rooms, the additional rooms shall also comply with the requirements of Annex E.

B.2 Equipment installation

B.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 multiple positions, then all tests shall be conducted in a position specified in the manufacturer's installation instructions. If the equipment can be installed in multiple positions as per installation manual of manufacturer, then all tests shall be conducted using the worst configuration. In all cases, the manufacturer's recommendations with respect to distances from adjacent walls, amount of extensions through walls, etc. shall be followed.

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

B.2.3 Ducted equipment rated at less than 8 kW and intended to operate at external static pressures of less than 25 Pa shall be tested at free delivery of air.

B.2.4 If necessary, the equipment shall be evacuated and charged with the type and amount of refrigerant specified in the manufacturer's instructions.

B.2.5 All standard ratings for equipment shall be determined by manufacturer's specifications within pipe lengths as per 5.1, of connecting tubing on each line. The lengths shall be actual lengths, not equivalent lengths, and no account shall be taken of the resistance provided by bends, branches, connecting boxes or other fittings used in the installation for the test piece. The length of the connecting tubing shall be measured from the enclosure of the indoor unit to the enclosure of the outdoor unit. Such equipment in which the interconnecting tubing is furnished as an integral part of the unit and not recommended for cutting to length shall be tested with the complete length of tubing furnished. Not less than 40 % of the total length of the interconnecting tubing shall be exposed to the outdoor conditions with the rest of the tubing exposed to the indoor conditions. The line diameters, insulation, details of installation, evacuation and charging shall be in accordance with the manufacturer's published recommendations.

B.3 Static pressure measurements across indoor coil

B.3.1 Equipment with a fan and a single outlet

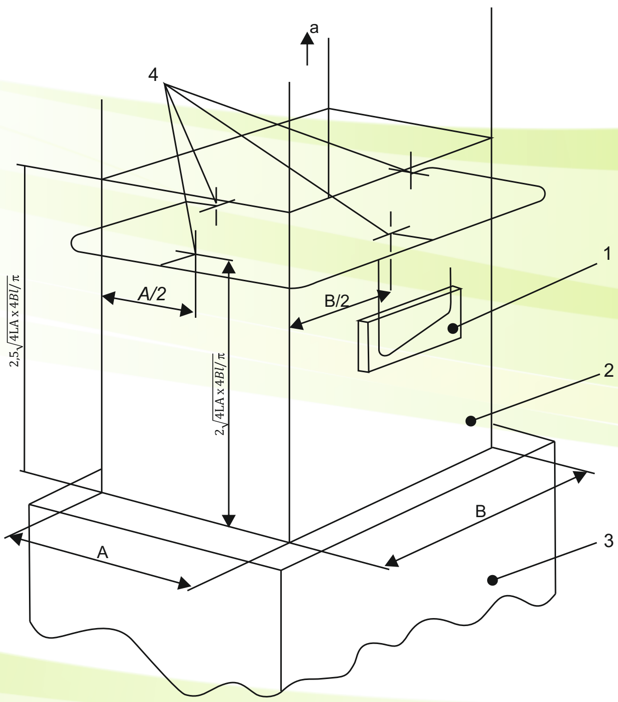
B.3.1.1 A short plenum shall be attached to the outlet of the equipment. This plenum shall have cross-sectional dimensions equal to the dimensions of the equipment outlets. A static pressure tap shall be added at the center of each side of the discharge plenum, if rectangular, or at four evenly distributed locations along the circumference of an oval or round plenum. These four static pressure taps shall be manifolded together. The minimum length of the discharge plenum and the location of the static pressure taps relative to the equipment outlets for testing a split-system shall be as shown in Figure B.1, and for a single-package unit as shown in Figure B.2.

B.3.1.2 A short plenum should be attached to the inlet of the equipment. The cross section of the plenum shall have the same cross-sectional dimensions as the equipment inlet. In addition, four static pressure taps shall be added and manifolded together. This plenum should otherwise be constructed as shown for the inlet plenum in Figure B.2, if testing a single-package unit, and as shown in Figure B.3, if testing a split-system.

B3.2. Equipment with multiple outlets or multiple indoor units

B.3.2.1 Equipment with multiple outlet duct connections or multiple indoor units shall have a short plenum attached to each outlet connection or indoor unit, respectively. Each of these short plenums shall be constructed as described in B.3.1.1, including static pressure taps. All outlet plenums shall discharge into a single common duct section. For the purpose of equalizing the static pressure in each plenum, an adjustable restrictor shall be located in the plane where each outlet plenum enters the common duct section. Multiple blower units employing a single discharge duct connection flange shall be tested with a single outlet plenum in accordance with B.3.1. Any other test plenum arrangements shall not be used except to simulate duct designs specifically recommended by the equipment manufacturer.

B.3.2.2 A short plenum should be attached to the inlet of each inlet duct connection or indoor unit. Each of these short plenums shall be constructed as described in B.3.1.2, including static pressure taps.



1	Manometer
2	Exhaust plenum
3	Equipment under test
4	Static Pressure Taps
a ®	To air flow measuring apparatus
A & B	Dimension of the EUT

Figure B.1 – External Static Pressure Measurement

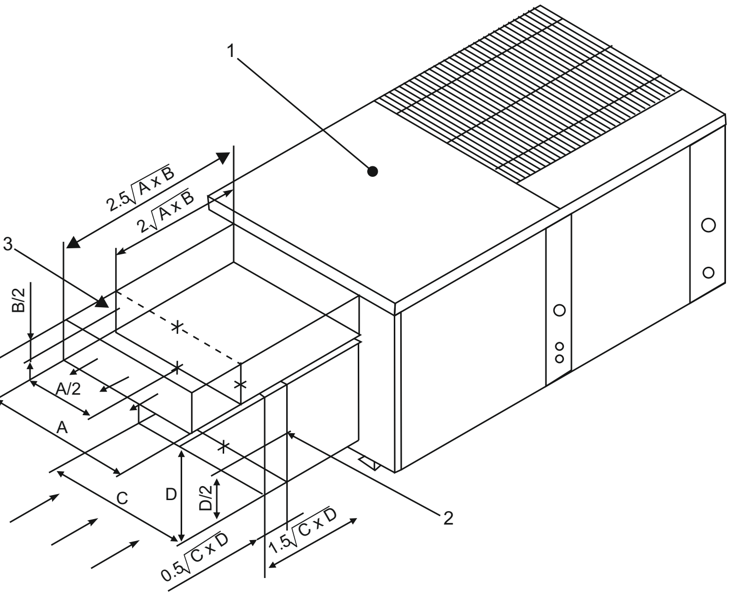
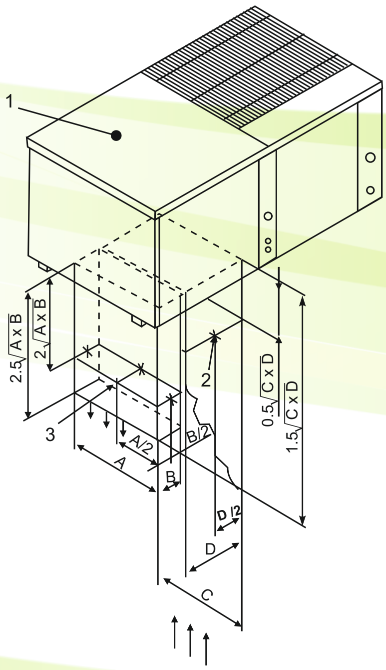


Figure B.2 – External Static Pressure measurements *(continued)*



1	Equipment under test – Single package unit
2	Static Pressure Taps – inlet (4 taps required)
3	Equipment under test – outlet (4 taps required)
4	Static Pressure Taps
For circular ducts with diameter ‘d’ substitute $\frac{\pi d^2}{4}$ for (A X B) or (C X D)	

Figure B.3 – External Static Pressure measurement

Annex C
Airflow Measurement

C.1 Airflow determination

C.1.1 Airflow should be measured using the apparatus and testing procedures given in this annex.

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

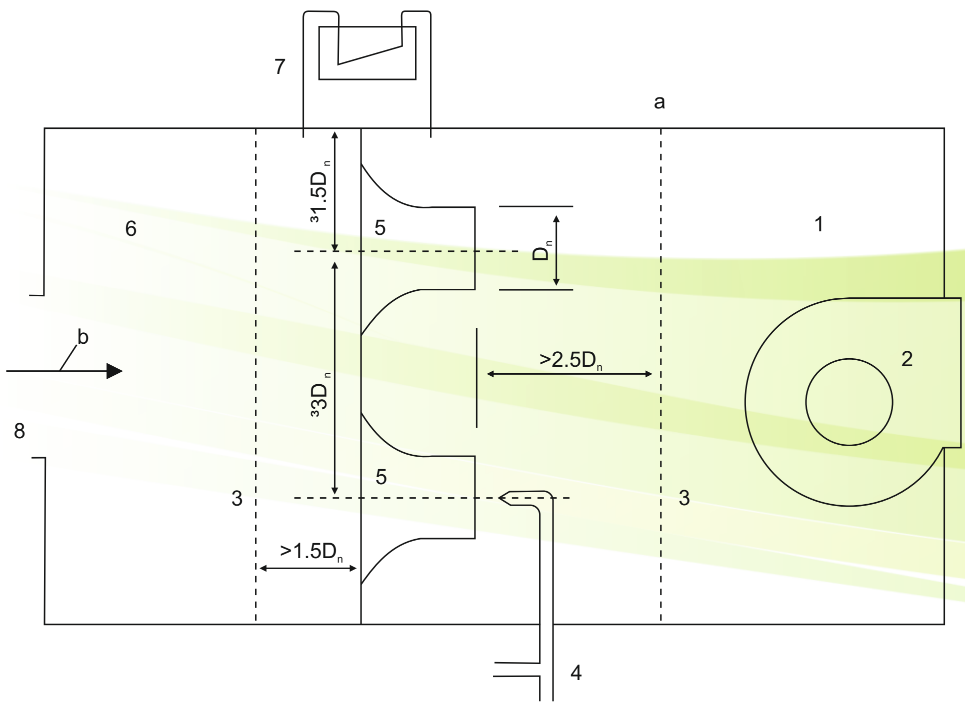
C.2 Airflow and static pressure

The area of a nozzle, An, should be determined by measuring its 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.

C.3 Nozzle apparatus

C.3.1 Nozzle apparatus, consisting of a receiving chamber and a discharge chamber separated by a partition in which one or more nozzles are located (see Figure C.1). Air from the equipment under test is conveyed via a duct to the receiving chamber, passes through the nozzle(s), and is then exhausted to the test room or channeled back to the equipment's inlet.

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



1	Discharge chamber	6	Receiving chamber
2	Exhaust fan	7	Apparatus for differeenal pressure measurement(manometer)
3	Diffusion baffle	8	Adapter duct (measurement duct)
4	Pitot tube (Optonal)	D_n	Nozzle throat diameter
5	Nozzles		
a	Diffusion baffles with uniform perforaoon with approximately 40% free area		
b	Air flow direccon		

Figure C.1 – Air flow measuring apparatus

The center-to-center distance between nozzles in use should be not less than 3 times the throat diameter of the larger nozzle, and the distance from the center of any nozzle to the nearest discharge or receiving chamber side wall should not be less than 1.5 times its throat diameter.

C.3.2 Diffusers, installed in the receiving chamber (at a distance of at least 1.5 times the largest nozzle throat diameter) upstream of the partition wall and in the discharge chamber (at a distance of at least 2.5 times the largest nozzle throat diameter) downstream of the exit plane of the largest nozzle.

C.3.3 Exhaust fan, capable of providing the desired static pressure at the equipment's outlet; it should be installed in one wall of the discharge chamber and means should be provided to vary the capacity of this fan.

C.3.4 Manometers, for measuring the static pressure drop across the nozzle(s): 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. Static pressure connections should be located so as not to be affected by airflow.

Alternatively, the velocity head of the air stream leaving the nozzle(s) may be measured by a Pitot tube as shown in Figure C.1, but when more than one nozzle is in use, the Pitot tube reading should be determined for each nozzle.

C.3.5 Means for determining the air density at the nozzle throat

C.3.5.1 The throat velocity of any nozzle in use should be not less than 15 m/s and not more than 35 m/s.

C.3.5.2 Nozzles should be constructed in accordance with Figure C.2, and applied in accordance with the provisions of C.3.5.3 and C.3.5.4.

C.3.5.3 Nozzle discharge coefficients, *Cd*, for the construction shown in Figure C.2, which have a throat-length-to-throat-diameter ratio of 0.6, may be determined using Equation (C.1):

$$C_d = 0.9886 - \frac{7.006}{\sqrt{R_e}} + \frac{1.346}{R_e}$$ Equation (C.1)

For Reynolds number R_e of 12000 and above.

The Reynolds number is defined as in equation C.2

$$R_e = \frac{V_n D_n}{\mu}$$ Equation (C.2)

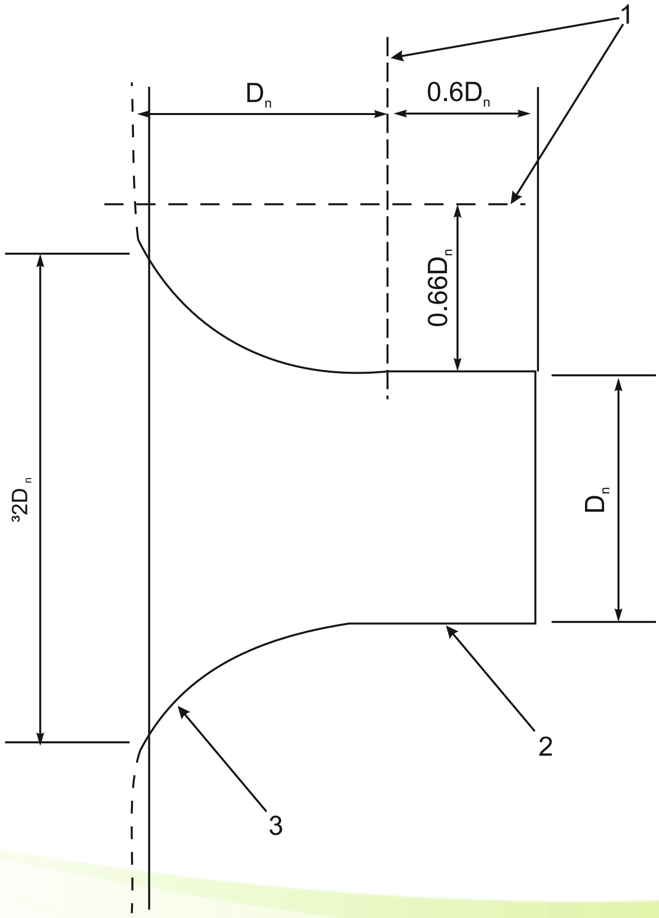
where

V_n is the mean airflow velocity at the throat of the nozzle;

D_n is the diameter of the throat of the nozzle;

μ is the kinematic viscosity of air.

The nozzle dimension and construction shall be as in figure C.2



1 Axes of ellipse
2 Throat section
3 Elliptical approach
D_n Diameter of nozzle throat, mm

Figure C.2 – Air flow measuring nozzle

C.4 Static pressure measurements

C.4.1 The pressure taps should consist of 6.25 mm (± 0.25 mm) diameter nipples soldered to the outer plenum surfaces and centered over 1 mm diameter holes through the plenum. The edges of these holes should be free of burrs and other surface irregularities.

C.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.

C.5 Discharge airflow measurements

C.5.1 The outlet or outlets of the equipment under test should be connected to the receiving chamber by adapter ducting of negligible air resistance, as shown in Figure C1.

C.5.2 To measure the static pressure of the receiving chamber, a manometer should have one side connected to one or more static pressure connections located flush with the inner wall of the receiving chamber.

C.6 Indoor-side airflow measurements

C.6.1 The following readings should be taken:

Barometric pressure;

Nozzle dry- bulb and wet-bulb temperatures or dew point temperatures;

Static pressure difference at the nozzle(s) or, optionally, nozzle velocity pressure.

C.6.2 Air mass flow rate, q_m, through a single nozzle is determined using Equation (C.3):

$$q_m = Y \times C_d \times A_n \sqrt{\frac{2\,P_v}{V_n'}}$$ Equation (C.3)

Where P_v is the velocity pressure at the nozzle throat or the static pressure difference across the nozzle.

The expansion factor, Y, is obtained using Equation (C.4):

$$Y = 0.452 + 0.548 \propto$$ Equation (C.4)

The pressure ratio, α, is obtained using Equation (C.5):

$$\propto = 1 - \frac{P_v}{P_n}$$ Equation (C.5)

Air volume flow rate through a single nozzle is determined using Equation (C.6):

$$q_v = C_d \times A_n \times \sqrt{2 P_v V_n'}$$ Equation (C.6)

Where V_n' is calculated using equation (C.7):

$$V_n' = \frac{v_n}{1+W_n}$$ Equation (C.7)

Where W_n is the specific humidity at nozzle inlet.

C.6.3 Airflow through multiple nozzles may be calculated in accordance with C.6.2, except that the total flow rate is then the sum of the q_m or q_v values for each nozzle used.

C.7 Ventilation, exhaust and leakage airflow measurements — Calorimeter test method

C.7.1 Ventilation, exhaust and leakage airflows should be measured using apparatus similar to that illustrated in Figure C.3 with the refrigeration system in operation and after condensate equilibrium has been achieved.

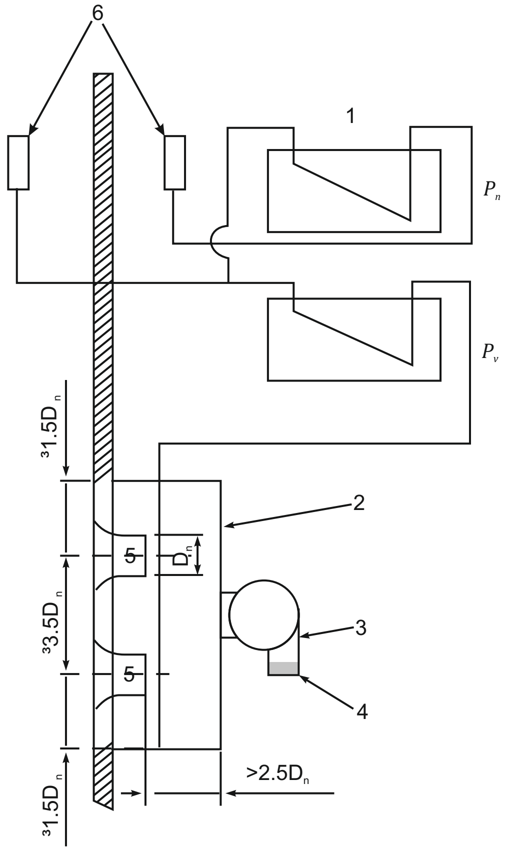
C.7.2 With the equalizing device adjusted for a maximum static pressure differential between the indoor-side and outdoor-side compartments to 1 Pa, the following readings should be taken:

Barometric pressure;

Nozzle wet- and dry-bulb temperatures;

Nozzle velocity pressure.

C.7.3 Airflow values should be calculated as defined in C.6.2.



1 Apparatus for differential pressure measurement (manometer)
2 Discharge chamber
3 Exhaust fan
4 Damper
5 Nozzle
6 Pick-up tube
D_n Nozzle throat diameter
P_c Compartment equalization pressure
P_v Nozzle velocity pressure

Figure C.3 – Pressure equalizing device

Annex D
Calorimeter test method

General

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

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

D.1.3 A pressure-equalizing device as illustrated in Figure C.3 should be provided in the partition wall between the indoor-side and the outdoor-side compartments to maintain a balanced pressure between these compartments and to permit measurement of leakage, exhaust and ventilation air. This device consists of one or more nozzles of the type shown in Figure C.2, a discharge chamber equipped with an exhaust fan, and manometers for measuring compartment and airflow pressures.

Since the airflow from one compartment to the other may be in either direction, two such devices mounted in opposite directions or a reversible device should be used. The manometer pressure pick-up tubes should be so located as to be unaffected by air discharged from the equipment or by the exhaust from the pressure-equalizing device. The fan or blower, which exhausts air from the discharge chamber, should permit variation of its airflow by any suitable means, such as a variable speed drive, or a damper as shown in Figure C.3. The exhaust from this fan or blower should be such that it does not affect the inlet air to the equipment.

The pressure equalizing device should be adjusted during calorimeter tests or airflow measurements so that the static pressure difference between the indoor-side and outdoor-side compartments is not greater than 1.25 Pa.

D.1.4 The size of the calorimeter should be sufficient to avoid any restriction to the intake or discharge openings of the equipment. Perforated plates or other suitable grilles should be provided at the discharge opening of the reconditioning equipment to avoid face velocities exceeding 0.5 m/s. Sufficient space should be allowed in front of any inlet or discharge grilles of the equipment to avoid interference with the airflow. Minimum distance from the equipment to the side walls or ceiling of the compartment(s) should be 1 m, except for the back of console-type equipment, which should be in normal relation to the wall. Ceiling-mounted equipment should be installed at a minimum distance of 1.8 m from the floor. Table D.1 gives the suggested dimensions for the calorimeter. To accommodate peculiar sizes of equipment, it may be necessary to alter the suggested dimensions to comply with the space requirements.

Table D.1 – Sizes of Calorimeter

Rated cooling capacity of equipment In Watts *	Suggested minimum inside dimensions of each room of calorimeter in meter		
	Width	Height	Length
3000	2.4	2.1	1.8
6000	2.4	2.1	2.4
9000	2.7	2.4	3.0
12000 **	3.0	2.4	3.7

* All figures are round numbers.
** Larger capacity equipment will require larger calorimeters.

D.1.5 Each compartment should be provided with reconditioning equipment to maintain specified airflow and prescribed conditions. Reconditioning apparatus for the indoor-side compartment should consist of heaters to supply sensible heat and a humidifier to supply moisture. Reconditioning apparatus for the outdoor-side compartment should provide cooling, dehumidification and humidification. The energy supply should be controlled and measured.

D.1.6 When calorimeters are used for heat pumps, they should have heating, humidifying and cooling capabilities for both rooms (see Figures D.1 and D.2). Other means, such as rotating the equipment, may be used as long as the rating conditions are maintained.

D.1.7 Reconditioning apparatus for both compartments should be provided with fans of sufficient capacity to ensure airflows of not less than twice the quantity of air discharged by the equipment under test in the calorimeter. The calorimeter should be equipped with means of measuring or determining specified wet- and dry-bulb temperatures in both calorimeter compartments.

D.1.8 It is recognized that in both the indoor-side and outdoor-side compartments, temperature gradients and airflow patterns result from the interaction of the reconditioning apparatus and test equipment. Therefore, the resultant conditions are peculiar to, and dependent upon, a given combination of compartment size, arrangement and size of reconditioning apparatus, and the air discharge characteristics of the equipment under test.

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

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

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

Air sampling tubes should be positioned on the intake side of the equipment under test.

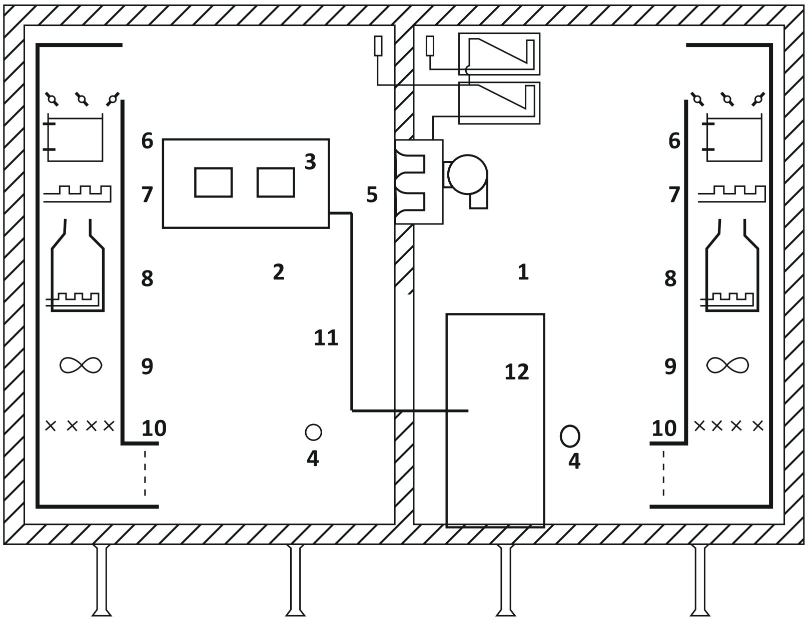
D.1.9 During the heating capacity test, the temperature of the air leaving the indoor-side of the heat pump shall be monitored to determine if its heating performance is being affected by a build-up of ice on the outdoor-side heat exchanger. A single temperature measuring device, placed at the center of the indoor-air outlet, will be sufficient to indicate any change in the indoor-air discharge temperature caused by a build-up of ice on the outdoor-side heat exchanger.

D.1.10 Interior surfaces of the calorimeter compartments should be of non-porous material with all joints sealed against air and moisture leakage. The access door should be tightly sealed against air and moisture leakage by use of gaskets or other suitable means.

D.1.11 If defrost controls on the heat pump provide for stopping the indoor airflow, provision shall be made to stop the test apparatus airflow to the equipment on both the indoor and outdoor sides during such a defrost period. If it is desirable to maintain operation of the reconditioning apparatus during the defrost period, provision may be made to bypass the conditioned air around the equipment as long as assurance is provided that the conditioned air does not aid in the defrosting. A watt-hour meter shall be used to obtain the integrated electrical input to the equipment under test.

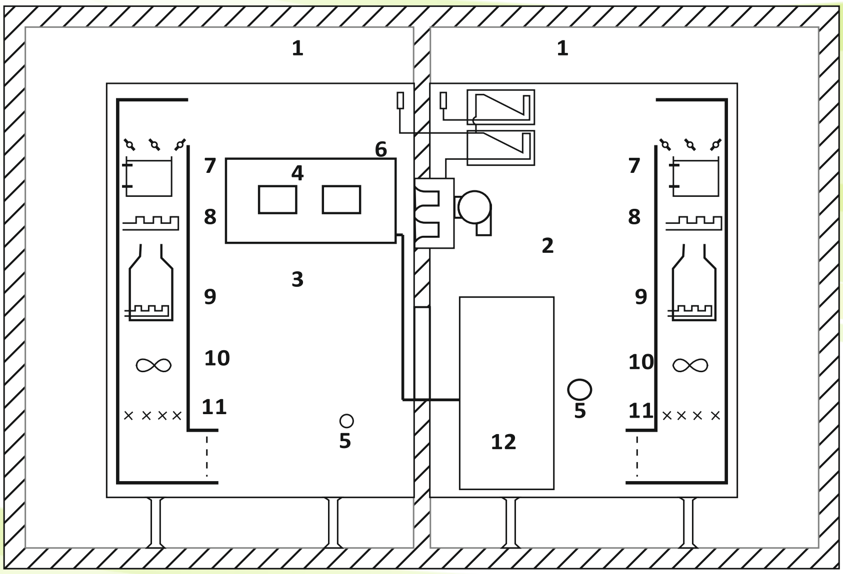
Calibrated room-type calorimeter

D.2.1 Heat leakage may be determined in either the indoor-side or outdoor-side compartment by the following method. All openings should be closed. Either compartment may be heated by electric heaters to a temperature of at least 11 °C above the surrounding ambient temperature. The ambient temperature should be maintained constant within ±1 °C outside all six enveloping surfaces of the compartment, including the separating partition. If the construction of the partition is identical to that of the other walls, the heat leakage through the partition may be determined on a proportional area basis.



1 Outdoor side compartment
2 Indoor side compartment
3 Equipment under test – Indoor unit
4 Air sampling tube
5 Pressure equalization device
6 Cooling coil
7 Heating coil
8 Humidifier
9 Fan
10 Mixer
11 Connecting refrigerant pipe
12 Equipment under test – Outdoor unit

Figure D.1 – Typical calibrated room-type calorimeter



1 Controlled temperature air space
2 Outdoor side compartment
3 Indoor side compartment
4 Equipment under test – Indoor unit
5 Air sampling tube
6 Pressure equalization device
7 Cooling coil
8 Heating coil
9 Humidifier
10 Fan
11 Mixer
12 Equipment under test – Outdoor unit

Figure D.2 – Typical balanced ambient room-type calorimeter

D.2.2 For calibrating the heat leakage through the separating partition alone, the following procedure may be used. A test is carried out as described above. Then the temperature of the adjoining area on the other side of the separating partition is raised to equal the temperature in the heated compartment, thus eliminating heat leakage through the partition, while the 11 °C differential is maintained between the heated compartment and the ambient surrounding the other five enveloping surfaces.

The difference in heat input between the first test and second test determines the leakage through the partition alone.

D.2.3 For the outdoor-side compartment equipped with means for cooling, an alternative means of calibration may be used to cool the compartment to a temperature at least 11 °C below the ambient temperature (on six sides) and carry out a similar analysis.

D.2.4 In addition to the two-room simultaneous method of determining capacities, the performance of the indoor room-side compartment shall be verified at least every six months using an industry standard cooling capacity calibrating device. A calibrating device may also be another equipment whose performance has been measured by the simultaneous indoor and outdoor measurement method at an accredited national test laboratory as part of an industry-wide cooling capacity verification program.

D.3 Balanced ambient room-type calorimeter

D.3.1 The balanced ambient room-type calorimeter is shown in Figure D.2 and is based on the principle of maintaining the dry-bulb temperatures surrounding the particular compartment equal to the dry-bulb temperatures maintained within that compartment. If the ambient wet-bulb temperature is also maintained equal to that within the compartment, the vapour-proofing provisions of D.1.10 are not required.

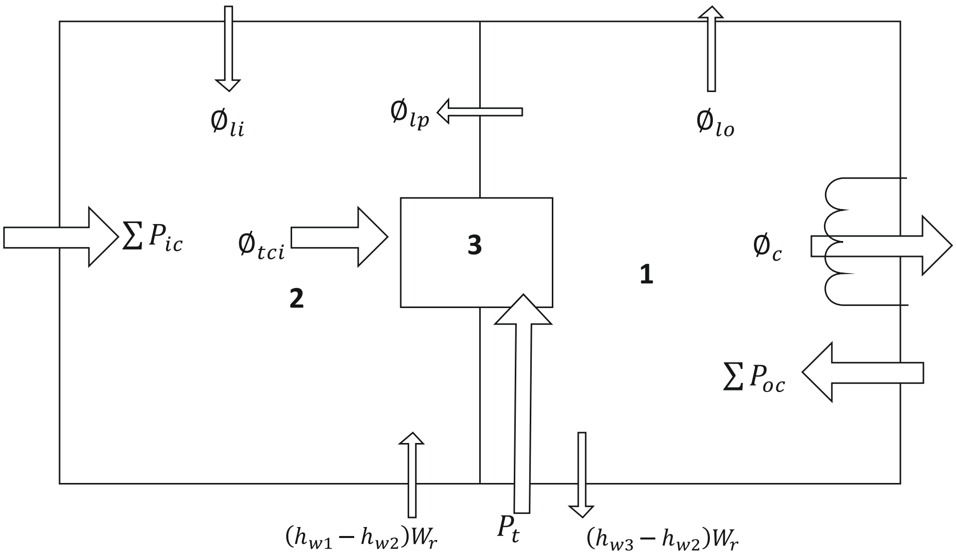
D.3.2 The floor, ceiling and walls of the calorimeter compartments shall be spaced at a sufficient distance away from the floor, ceiling and walls of the controlled areas in which the compartments are located in order to provide a uniform air temperature in the intervening space. It is recommended that this distance be at least 0.3 m. Means shall be provided to circulate the air within the surrounding space to prevent stratification.

D.3.3 Heat leakage through the separating partition shall be introduced into the heat balance calculation and may be calibrated in accordance with D.2.2 or may be calculated.

D.3.4 It is recommended that the floor, ceiling and walls of the calorimeter compartments be insulated so as to limit heat leakage (including radiation) to no more than 10 % of the test equipment's capacity, for an 11 °C temperature difference, or 300 W for the same temperature difference, whichever is greater, as tested using the procedure given in D.3.2.

Calculations for cooling capacities

D.4.1 The energy flow quantities used to calculate the total cooling capacity based on indoor-side and outdoor-side measurements are shown below in Figure D.3.



1 Outdoor side compartment
2 Indoor side compartment
3 Equipment under test

Note: Values for the variables identified in the figure are calculated using the equations in D.4.2 to D.4.10.

Figure D.3 — Calorimeter energy flows during cooling capacity tests

D.4.2 The total cooling capacity on the indoor side, as tested in either the calibrated- or balanced-ambient room-type calorimeter (see Figures D.1 and D.2), is calculated using Equation (D.1):

$$\emptyset_{tci} = \sum P_{ic} + (h_{w1} - h_{w2})W_r + \emptyset_{lp} + \emptyset_{li}$$ Equation (D.1)

Note: *If no water is introduced during the test, h_{w1} is taken at the temperature of the water in the humidifier tank of the conditioning apparatus.*

D.4.3 When it is not practical to measure the temperature of the air leaving the indoor-side compartment to the outdoor-side compartment, the temperature of the condensate may be assumed to be at the measured or estimated wet-bulb temperature of the air leaving the test equipment.

D.4.4 The water vapour condensed by the equipment under test, W_r, may be determined by the amount of water evaporated into the indoor-side compartment by the reconditioning equipment to maintain the required humidity.

D.4.5 Heat leakage, $\varnothing_{lp}$, into the indoor-side compartment through the separating partition between the indoor-side and outdoor-side compartments may be determined from the calibrating test or, in the case of the balanced-ambient room-type compartment, may be based on calculations.

D.4.6 The total cooling capacity on the outdoor side, $\varnothing_{tco}$, as tested in either the calibrated- or balanced-ambient room-type calorimeter (see Figures D.1 and D.2), is calculated using Equation (D.2):

$$\emptyset_{tci} = \emptyset_c - \sum P_{oc} - P_t + (h_{w3} - h_{w2})W_r + \emptyset_{lp} + \emptyset_{lo}$$ Equation (D.2)

Note: The *hw3* enthalpy is taken at the temperature at which the condensate leaves the outdoor-side compartment of the reconditioning apparatus.

D.4.7 The heat leakage rate into the indoor-side compartment through the separating partition, $\varnothing_{lp}$, between the indoor-side and outdoor-side compartments may be determined from the calibrating test or, in the case of the balanced-ambient room-type compartment, may be based on calculations.

Note: This quantity will be numerically equal to that used in Equation (D.1) if, and only if, the area of the separating partition exposed to the outdoor-side is equal to the area exposed to the indoor-side compartment.

D.4.8 The latent cooling capacity (room dehumidifying capacity), d, is calculated using Equation (D.3):

$$\varnothing_d = K_1 W_r \qquad \text{Equation (D.3)}$$

D.4.9 The sensible cooling capacity, $\varnothing_{sci}$, is calculated using Equation (D.4):

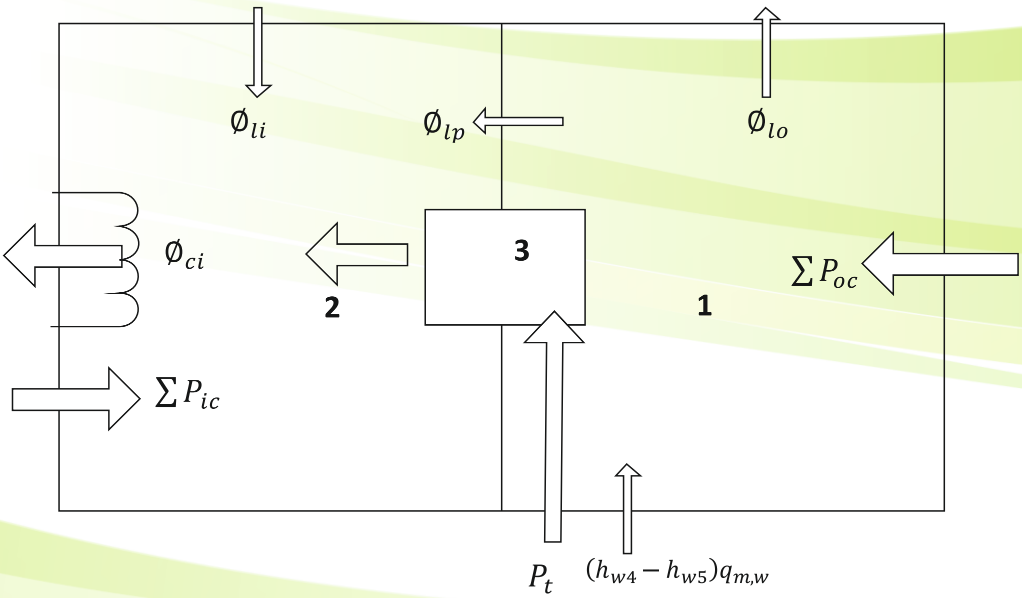
$$\varnothing_{sci} = \varnothing_{tci} - \varnothing_d \qquad \text{Equation (D.4)}$$

D.4.10 Sensible heat ratio (SHR) is calculated using the following:

$$\varnothing_{sci} / \varnothing_{tci}$$

D.5 Calculation of heating capacity

D.5.1 The energy flow quantities used to calculate the total heating capacity based on indoor- and outdoor-side measurements are shown below in Figure D.4.



1 Outdoor side compartment
2 Indoor side compartment
3 Equipment under test

Note: Values for the variables identified in the figure are calculated using the equations in D.4.2 to D.4.10.

Figure D.4 — Calorimeter energy flows during heating capacity tests

D.5.2 Determination of the indoor-side heating capacity by measurement in the indoor-side compartment of the calorimeter is calculated using Equation (D.5):

$$\varnothing_{hi} = \varnothing_{ci} - \sum P_{ic} - \varnothing_{lp} - \varnothing_{li} \qquad \text{Equation (D.5)}$$

Note: $\sum P_{ic}$ 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.5.3 Determination of the heating capacity by measurement of the heat-absorbing side, $\varnothing_{ho}$, is calculated for equipment where the evaporator takes the heat from an airflow using Equation (D.6):

$$\varnothing_{ho} = \sum P_{oc} + P_t + (h_{w4} - h_{w5})q_{m,w} - \varnothing_{lp} - \varnothing_{lo}$$

Where

$\sum P_{oc}$ is the total power input to the outdoor-side compartment with the exception of the power input to the equipment, in watts;

$q_{m,w}$ is the water mass flow supplied to the outside compartment to maintain the test conditions, in kilograms per second;

h_{w5} is the specific enthalpy of, respectively, the condensed water (in the case of test condition, high) and frost (in the case of test condition, H2 or H3) in the equipment, in joules per kilogram

$\varnothing_{lo}$ is the heat flow through the remaining enveloping surfaces into the outdoor-side compartment, in watts.

Annex E

Indoor Air Enthalpy Test Method

E.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.

E.2 Application

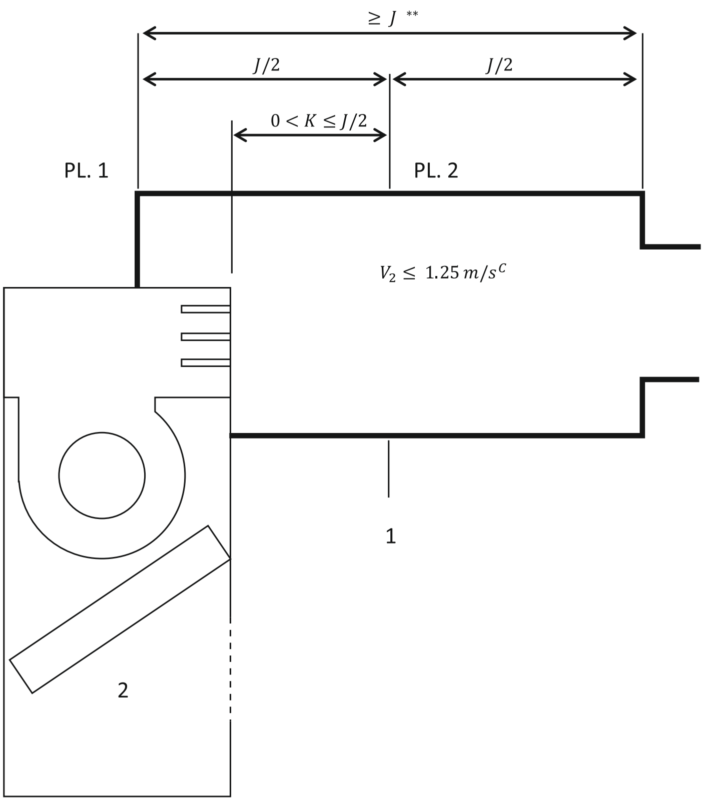
E.2.1 Air leaving the equipment under test shall lead directly to the discharge chamber. If a direct connection cannot be made between the equipment and the discharge chamber, a short plenum shall be attached to the equipment. In this case, the short plenum shall have the same size as the discharge opening of the equipment or shall be constructed so as not to prevent the leaving air from expanding. The cross-section area of the airflow channel through the discharge chamber shall be such that the average air velocity is less than 1.25 m/s against the airflow rate of the equipment under test. The static pressure difference between the discharge chamber and intake opening of the equipment under test shall be zero. An example of the discharge chamber test setup is shown in Figure E.1.

Airflow measurements shall be made in accordance with the provisions specified in Annex C.

E.2.2 When conducting cooling or steady-state heating capacity tests using the indoor air enthalpy test method, the additional test tolerances given in Table E.1 shall apply.

Table E.1 — Variations allowed during steady-state cooling and heating capacity tests that only apply when using the indoor air enthalpy method

Reading	Variations of arithmetical mean values from specified test conditions	Maximum variation of individual readings from specified test conditions
Temperature of air leaving indoor-side: dry-bulb	—	±2.0 °C *
External resistance to indoor airflow	± 5 Pa	± 5 Pa
* The tolerance represents the greatest permissible difference between the maximum and minimum observations during the test.		



1 Static pressure tapings
2 Equipment under test
3 To air sampler and airflow measuring apparatus
a $J = 2D_e$ where $D_e = \sqrt{4AB/\pi}$ and A and B are the dimensions of the equipment's air outlet
c V_2 is the average air velocity at PL.2

Figure E.1 — Discharge chamber requirements when using the indoor air enthalpy test method

E.2.3 When conducting transient heating capacity tests using the indoor air enthalpy test method, the additional test tolerances given in Table E.2 shall apply.

Table E.2 — Variations allowed during the transient heating tests that only apply when using the indoor air enthalpy test method

Reading	Variations of arithmetical mean values from specified test conditions		Variation of individual readings from specified test conditions	
	Interval H *	Interval D **	Interval H *	Interval D **
External resistance to airflow	±5 Pa	—	±5 Pa	—
NOTE For transient heating tests, see 7.1.11.				
* Applies when the heat pump is in the heating mode, except for the first 10 min after termination of a defrost cycle. ** Applies during a defrost cycle and during the first 10 min after the termination of a defrost cycle when the heat pump is operating in the heating mode.				

Calculations for cooling capacities

The total capacity based on the indoor-side test data, $_{ci}$∅, shall be calculated using Equation (E.1):

$$\emptyset_{tci} = \frac{q_{V,i}(h_{a1} - h_{a2})}{V_n} = \frac{q_{V,i}\,(h_{a1} - h_{a2})}{V_n'(1+W_n)} \qquad \text{Equation (E.1)}$$

The sensible cooling capacity based on the indoor-side test data, ∅$_{sci}$, shall be calculated using Equation (E.2):

$$\emptyset_{sci} = \frac{q_{V,i}\,(c_{pa1}\,t_{a1} - c_{pa2}\,t_{a2})}{V_n} = \frac{q_{V,i}\,(c_{pa1}t_{a1} - c_{pa2}t_{a2})}{V_n'\,(1+W_n)} \qquad \text{Equation (E.2)}$$

The latent cooling capacity based on the indoor-side test data, ∅$_{d}$, shall be calculated using Equation (E.3) or (E.4):

$$\emptyset_{d} = \frac{K_1 q_{V,i}\,(W_{i1} - W_{i2})}{V_n} = \frac{K_1 q_{V,i}\,(W_{i1} - W_{i2})}{V_n'\,(1+W_n)} \qquad \text{Equation (E.3)}$$

$$\emptyset_{d} = \emptyset_{tci} - \emptyset_{sci} \qquad \text{Equation (E.4)}$$

E.4 Calculations for heating capacities

Total heating capacity based on indoor-side data, ∅$_{thi}$, shall be calculated using Equation (E.5):

$$q_{thi} = \frac{q_{V,i}\,(c_{pa2}t_{a2} - c_{pa1}t_{a1})}{V_n} = \frac{q_{V,i}\,(c_{pa2}t_{a2} - c_{pa1}t_{a1})}{V_n'\,(1+W_n)} \qquad \text{Equation (E.5)}$$

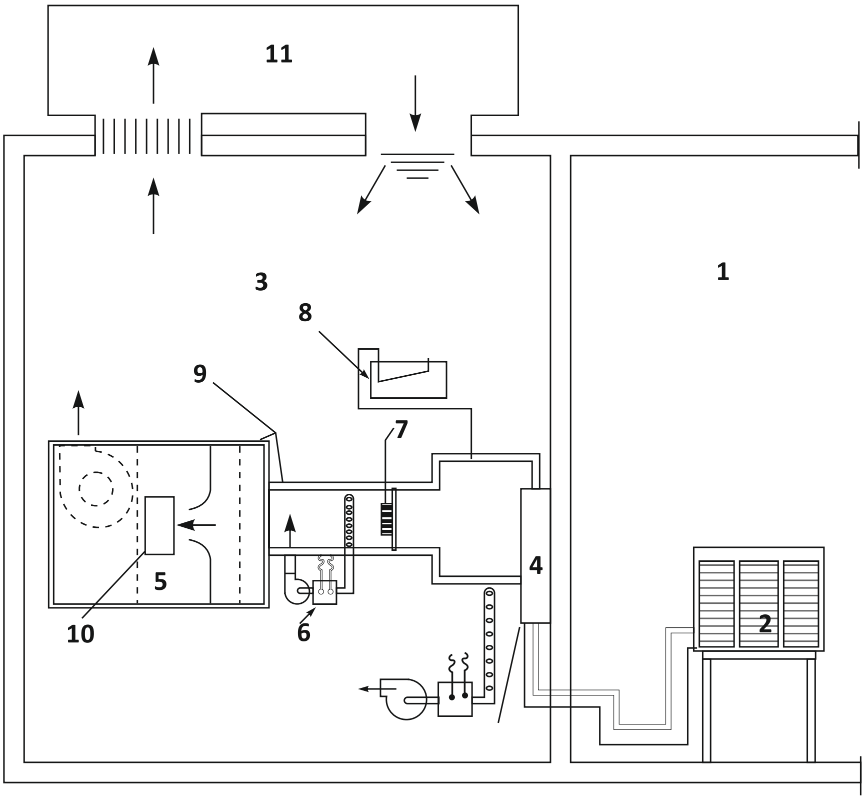
Note: Equations (E.1), (E.2), (E.3) and (E.5) do not take into consideration heat leakage in the test duct and the discharge chamber.

E.5 Airflow enthalpy measurements

The following test apparatus arrangements are recommended.

E.5.1 Tunnel air enthalpy method

The equipment to be tested is typically located in one as more test rooms. An air measuring device is attached to the equipment air discharge (indoor, 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 (see Figure E.2). Suitable means for measuring the wet- and dry-bulb temperatures of the air entering and leaving the equipment and the external resistance shall be provided.



1 Outdoor side test room
2 Outdoor of equipment under test
3 Indoor side test room
4 Indoor of equipment under test
5 Air flow measuring apparatus
6 Air temperature & humidity measuring instrument
7 Mixer
8 Apparatus for differential pressure measurement
9 Insulation
10 Door / window
11 Room conditioning equipment

Figure E.2 — Tunnel air enthalpy test method arrangement

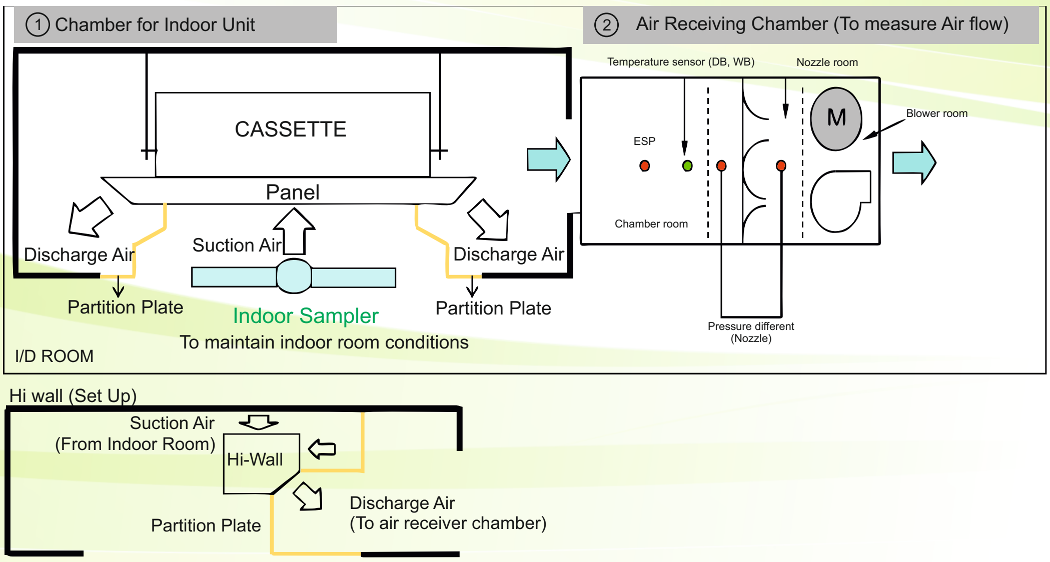


Figure E 2.1: Arrangement for Cassette type and hi-wall type indoor units

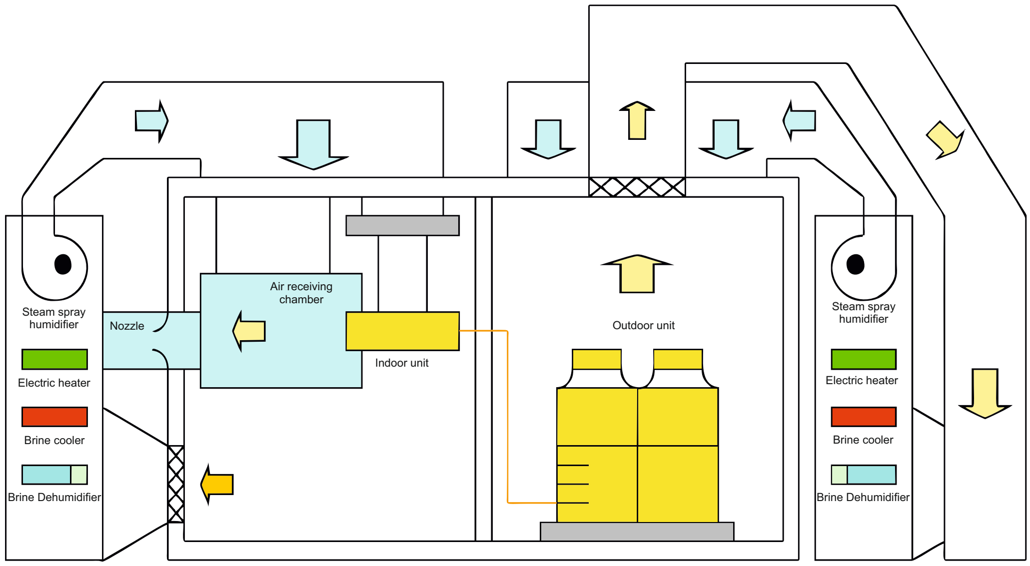
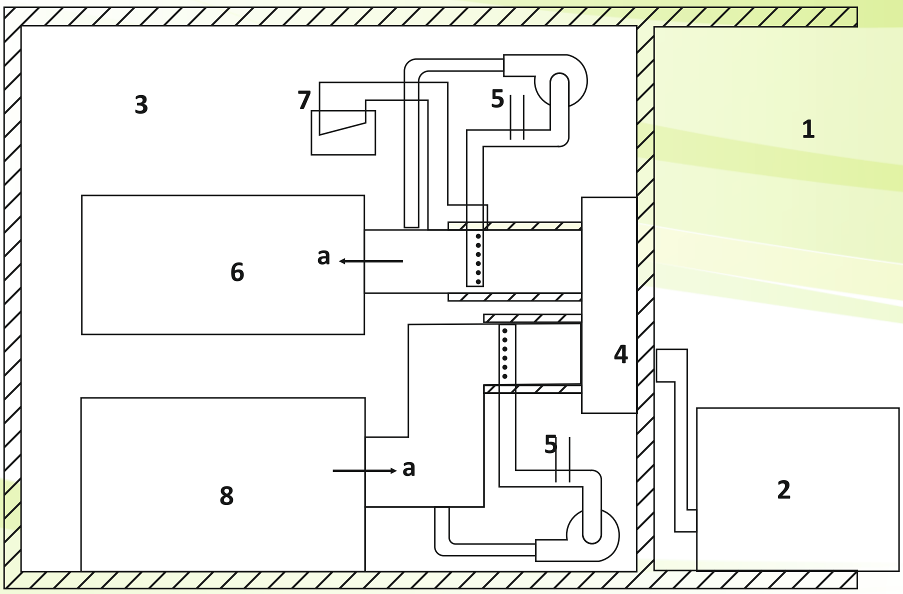


Figure E 2.2: Arrangement for Ducted type indoor units

E.5.2 Loop air enthalpy method

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 (see Figure E.3). The resulting test "loop" shall 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 shall be maintained within ±3.0 °C of the desired test inlet dry-bulb temperature. Wet- and dry-bulb temperatures and external resistance are to be measured by suitable means.

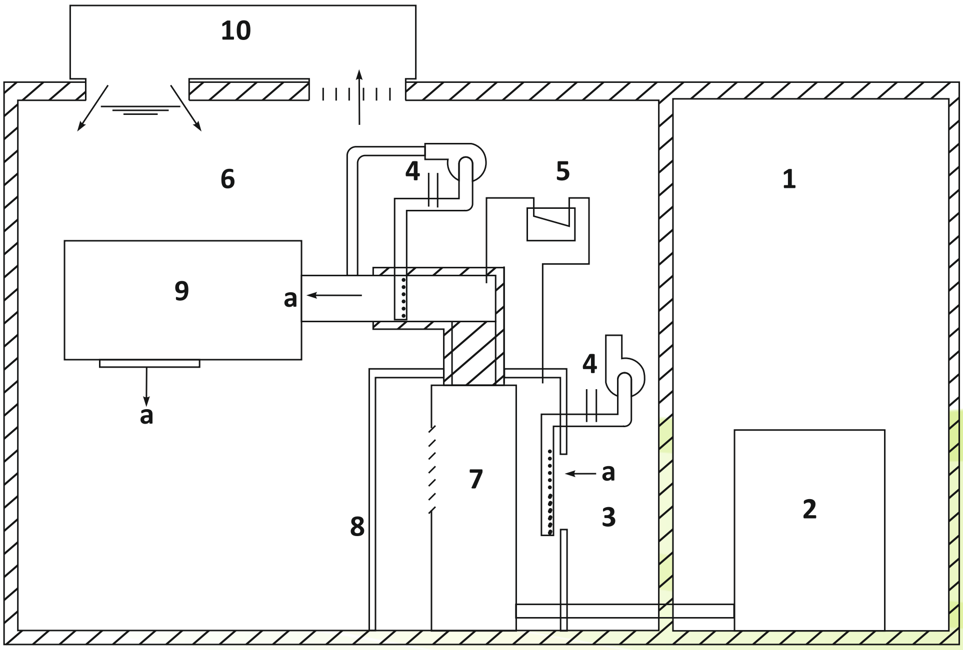


1 Outdoor side test room
2 Outdoor of equipment under test
3 Indoor side of test room
4 Indoor of equipment under test
5 Temperature and humidity measuring instrument
6 Air flow measuring apparatus
7 Apparatus for differential pressure measurement
8 Reconditioning apparatus
a Air flow direction

Figure E.3 — Loop air enthalpy test method arrangement

E.6 Calorimeter air enthalpy method

For equipment in which the compressor is ventilated independently of the indoor air stream, the calorimeter air enthalpy method arrangement shall be employed to take into account compressor heat radiation (see Figure E.4). In this arrangement, an enclosure is placed over the equipment, or applicable part of the equipment, under test. This enclosure may be constructed of any suitable material, but shall be non-hydroscopic, airtight and preferably insulated. It shall be large enough to permit inlet air to circulate freely between the equipment and the enclosures and in no case shall the enclosure be closer than 150 mm to any part of the equipment. The inlet to the enclosure shall be remotely located from the equipment's inlet so as to cause circulation throughout the entire enclosed space. An air measuring device is to be connected to the equipment's discharge. This device shall be well insulated where it passes through the enclosed space. Wet- and dry-bulb temperatures of the air entering the equipment are to be measured at the enclosure inlet. Temperature and external resistance measurements shall be carried out by suitable means.



1	Outdoor side test room	7	Indoor of equipment under test
2	Outdoor of equipment under test	8	Enclosure
3	Air inlet	9	Air flow measuring apparatus
4	Air temperature & humidity measuring instrument	10	Room conditioning apparatus
5	Apparatus for differential pressure measurement	A	Air flow direction
6	Indoor side test		

Figure E.4 — Calorimeter air enthalpy test method arrangement

Annex F

Determination of India Seasonal Energy Efficiency Ratio (ISEER)

F 1 Purpose

The purpose of this annex is to define a uniform procedure for the calculation of a single value number that is a representation of the part load efficiency of the variable refrigeration flow system. The single value number will be called as India Seasonal Energy Efficiency Ratio or ISEER.

F 2 Scope

This annex procedure is only for equipment covered by this standard. The ISEER equation and procedure are intended to be an average representation of a Variable refrigerant flow system in a typical application with conventional operating parameters. A fixed set of operating load points and conditions are defined to allow comparison of products.

The equation has been derived to provide a representation of the average part load efficiency. However, for operating cost and energy analysis it is best to use a comprehensive analysis tool that reflects the actual weather data, building load characteristics, operational hours, when calculating the applied variable refrigerant flow system efficiency.

F 3 Equation

F 3.1 The single value part load rating shall be determined by using the following equation;

$$ISEER = A \times EER_{100\%} + B \times EER_{75\%} + C \times EER_{50\%} + D \times EER_{25\%}$$

where:

$EER_{100\%}$ = EER at full load rating point and operating conditions

$EER_{75\%}$ = EER at 75% load rating point and operating conditions

$EER_{50\%}$ = EER at 50% load rating point and operating conditions

$EER_{25\%}$ = EER at 25% load rating point and operating conditions

A= weighting factor for 100% load

B= weighting factor for 75% load

C= weighting factor for 50% load

D= weighting factor for 100% load

The values of A, B, C, and D are based on the average of the most common building types across climatic zones of India. Values that have been developed are shown in Table F1.

Table F 1: Weighting coefficients A to D for calculation of ISEER

Load rate (%)	100	75	50	25
Weighting oefficients	A= 6	B= 48	C= 36	D= 10

The ISEER rating requires that the unit efficiency be determined at 100%, 75%, 50% and 25% at the conditions specified in Table F2.

Table F2: India Seasonal Energy Efficiency Testing Conditions

Parameter	Testing condition
Temperature of air entering indoor side – Dry Bulb Temperature – Wet Bulb Temperature	 27°C 19°C
Temperature of air entering outdoor side – Dry Bulb Temperature 100% load – Dry Bulb Temperature 75% load – Dry Bulb Temperature 50% load – Dry Bulb Temperature 25% load	 39° C 32° C 26° C 20° C
Test frequency	Rated frequency
Test voltage	Rated voltage
Compressor speed *	Speed set as per the % load capacity condition (or) Controller setting or full capacity #
Indoor side air flow **	Rated air flow
* Refer to clause 5.1.1 ** Refer to clause 5.4 to 5.8 # For compressors with variable refrigerant flow other than variable speed type	

F 3.3 Part load test method:

F 3.3.1 General conditions:

The standard rating test shall be conducted with all indoor units and compressors functioning, at test conditions as specified in Table F2. The test methods and uncertainty of measurement shall be as specified in Clause 8.0 and all tests shall be carried out in accordance with the test requirements of Annex B and the test methods of Annex D and Annex E. The electrical input values used for rating purposes shall be measured during the cooling capacity test.

Tests may be conducted to determine the cooling capacities of individual indoor units, operating with or without all other indoor units functioning. If tests for individual indoor unit capacity are conducted, the capacities shall be determined in accordance with the requirements of Annex G.

The specific setting of compressor and controller to deliver full load capacity shall be provided by the manufacturer and the equipment shall be maintained at that setting. If the manufacturer does not define the setting, the thermostat or controller shall be set to its minimum allowable temperature setting.

If the equipment under test cannot be maintained at steady-state conditions by its normal controls, then the manufacturer shall modify or override such controls so that steady-state conditions are achieved

F 3.3.2 Temperature conditions:

The temperature conditions are as specified in Table F2.

F 3.3.3. Pre-conditions:

Equilibrium condition as specified in clause 8.3 has to be achieved for at least 60 minutes between the test room reconditioning apparatus and equipment under test.

F3.3.4. Testing requirements:

Total, sensible and latent cooling capacity and rated power consumption shall be determined

F3.3.5. Duration of test:

The output shall be measured in the steady state condition as specified in clause 8.3 . The recording of the data shall continue for at least a 30 min period during which the tolerances specified in clause 8.2.1 shall be met and 6 sets of reading at every 10 minutes interval shall be recorded. Data shall be sampled at equal intervals that span 30 s or less

F3.3.6. Calculation for cooling capacity:

The calculation for cooling capacity shall be done as defined in Annex D if testing done using Calorimeter method and as defined in Annex E if the testing is done using air enthalpy method.

The EER at different load conditions shall be calculated as below from the capacity and power consumption determined by testing unit at conditions specified in Table F2.

$$EER_{X\%} = \frac{\emptyset_{X\%}}{P_{X\%}}$$

F4 Approach adopted for ISEER coefficient calculations:

(I) Weather data is taken from ISHRAE weather file used for energy simulation of buildings.

(II) Following building types have been analysed through simulation for studying the variable refrigerant flow system load variation:

- **a.** Office (Small): 24*7, 12*5
- **b.** Office (Medium): 24*7, 12*5
- **c.** Office (Large): 24*7, 12*5
- **d.** Hotel
- **e.** Retail
- **f.** Hospital
- **g.** Educational: School, University
- **h.** Residential: Group housing, villa

(III) Building envelopes, occupancy, LPD, EPD etc. are the taken from recently built buildings

(IV) Models of all buildings have been simulated for representative cities of various climatic zones: hot & dry, composite, warm & humid, and moderate.

(V) Grouping of data as per bin method for computation of ISEER coefficients is done on the basis of load on variable refrigerant flow system.

(VI) Bin group is selected in such a way that average of peak bin group should be 75% load and similarly average of low bin group and min bin group should be 50% and 25% load respectively.

(VII) ISEER coefficients for 25%, 50%, 75% and 100% load are first computed separately for each building type in each representative city. Average of all the cases has led to the final set of ISEER coefficients.

Annex G
Individual Indoor Unit Capacity Tests

G.1 General

The test methods described provide means to determine the capacity of an individual indoor unit, either operating on its own with the other indoor units switched off, or with all indoor units operating.

All tests shall be made in accordance with the requirements of Annex B.

G.2 The calorimeter method

If measurements are made by the calorimeter method, then the testing of an individual unit, with all others operating, will require at least a three-room calorimeter test facility. If only one unit is operating, a two-room calorimeter will suffice. Each calorimeter shall satisfy requirements described in Annex D.

G.3 The air enthalpy method

G.3.1 If measurements are made by the air enthalpy method, then the testing shall be done with one or more indoor rooms and one or more air measuring devices connected to the indoor units. The outdoor unit shall be situated at least in an environmental test room.

G.3.2 The test facility shall satisfy the requirements described in Annex E, except that the individual indoor unit to be tested shall have its own plenum and airflow measuring device.

G.4 Temperature conditions

Temperature conditions shall be as specified in 6.1.2 and 7.1.2.

G.5 Airflow conditions

All air quantities shall be as specified in Clause 5.

G.6 Test conditions

Test conditions shall be as specified in 6.1.3 and from 7.1.4 to 7.1.11.

G.7 Test methods and uncertainty of measurement

Test methods and uncertainty of measurement shall be as specified in Clause 8.

G.8 Test results

Test results shall be recorded and expressed as specified in Clause 9.

G.9 Published ratings

The publication of individual capacities of indoor units shall be as specified in Clause 11. The published results shall specify if all indoor units are operating or only one indoor unit is operating during the test

Annex H

Compressor Calibration Test Method

H.1 General Description

H.1.1 In the compressor calibration test method, total cooling or heating capacity is determined as follows.

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 3.0 °C.

By measuring capacity directly with a calorimeter when the compressor is operating at the identical conditions encountered during the equipment test.

H.1.2 When the compressor calibration method is employed, the requirements in H.2 and H.3 apply to both the equipment test and the compressor calibration test.

H.1.3 Cooling and heating capacities obtained by the compressor calibration method should include thermal effects of the fan.

H.2 Measurement of refrigerant properties

H.2.1 The equipment should be operated at the desired test conditions, and measurements of the temperature and pressure of the refrigerant entering and leaving the compressor should be recorded at equal intervals that span 5 min or less. These readings should be obtained during the data collection period of the cooling or heating capacity test.

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

H.2.3 On equipment sensitive to refrigerant charge, refrigerant pressures should be determined after this test because the connection of pressure gauges might result in a loss of charge. To accomplish this, temperatures are measured 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 sub-cooling. Following the test, gauges are connected to the lines and the equipment is evacuated and charged with the type and quantity of refrigerant specified on the nameplate. The equipment is then operated again at test conditions and, if necessary, refrigerant charge is added or removed 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 ±2.0 °C of their original values, and the temperature of the liquid entering the expansion device is reproduced within ±0.6 °C. The opeating pressures should then be observed.

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

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

H.2.6 Temperatures and pressures of the refrigerant vapour entering and leaving the compressor should be measured in the refrigerant lines approximately 250 mm 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 250 mm from the valve.

H.3 Compressor calibration

H.3.1 The refrigerant flow rate should then be determined from the calibration of the compressor at the predetermined compressor, entering and leaving refrigerant pressures and temperatures, by one of the primary test methods described in the IS 5111 or ISO 917.

H.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.

H.3.3 The refrigerant flow, *qr*, is calculated using Equation (H.1):

$$q_r = {}^{\emptyset_{tci}}\!/_{h_{g1} - h_{f1}}$$ Equation (H.1)

For the:

a) Secondary refrigerant calorimeter method;

b) Flooded system primary refrigerant calorimeter method;

c) Dry system primary refrigerant calorimeter method;

d) Concentric tube calorimeter method.

H.3.4 The gaseous refrigerant flow meter method gives refrigerant flow directly.

H.3.5 Total cooling capacity is calculated as prescribed in H.5.1 and H.5.2. Total heating capacity is calculated as prescribed in H.6.

H.4 Direct heating capacity measurements

H.4.1 For compressor calibration tests, when the evaporator superheat on the heating cycle is less than 3.0 °C, the refrigerant flow rate should be determined 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 in H.3.3.

H.4.2 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.

H.4.3 The compressor calibration test should be run as specified in H.3. 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 ambient.

H.4.4 The refrigerant flow rate, qr, is calculated using Equation (H.2):

$$q_r = \left[q_e c_{pw}(t_{w1} - t_{w2}) + A_1(t_c - t_a) \Big/ (h_{g2} - h_{f2}) \right]$$ Equation (H.2)

H.4.5 The total heating capacity, $\emptyset_{thi}$, is calculated as given in H.6.

H.5 Calculations for cooling capacities

H.5.1 For tests in which the evaporator superheat is 3.0 °C or more, total cooling capacity based on compressor calibration data is calculated from the refrigerant flow rate using Equation (H.3):

$$\emptyset_{tci} = q_r(h_{r2} - h_{r1}) - P_t$$ Equation (H.3)

H.5.2 For tests in which the evaporator superheat is less than 3.0 °C, total cooling capacity is calculated using Equation (H.4):

$$\emptyset_{tci} = \emptyset_e + A_1(t_a - t_c) - P_I$$ Equation (H.4)

H.6 Calculations for heating capacities

The total heating capacity, $\emptyset_{thi}$, based on compressor calibration data is calculated from the refrigerant flow rate using Equation (H.5):

$$\emptyset_{thi} = q_r(h_{r1} - h_{r2}) - P_I$$ Equation (H.5)

Annex J
Refrigerant Enthalpy Test Method

J.1 General

J.1.1 In this method, capacity is determined from the refrigerant enthalpy change and flow rate. 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 flow meter in the liquid line.

J.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.

J.1.3 This method should neither be used for tests in which the refrigerant liquid leaving the flow meter is sub-cooled less than 2.0 °C nor for tests in which the superheat of the vapour leaving the indoor side is less than 3.0 °C.

J.2 Refrigerant flow method

J.2.1 The refrigerant flow rate should be measured with an integrating-type flow meter connected in the liquid line upstream of the refrigerant control device. This meter should be sized such that its pressure drop does not exceed the vapour pressure change that a 2.0 °C temperature change would produce.

J.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 sub-cooled. Sub-cooling of 2.0 °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.

J.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, co, calculated using Equation (J.1):

$$c_0 = \frac{m_5 - m_1}{m_3 - m_1} \qquad \text{Equation (J.1)}$$

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

J.3 Refrigerant temperature and pressure measurements

The temperature of the refrigerant entering and leaving the indoor side of the equipment should be measured with instruments having an accuracy of ±0.1 °C. The pressure of the refrigerant entering and leaving the indoor side of the equipment should be measured with instruments having an accuracy of ±2.0 % of the indicated value.

J.4 Calculation of cooling capacity

The total cooling capacity, $\varnothing_{thi}$, based on volatile refrigerant flow data is calculated using Equation (I.2):

$$\varnothing_{tci} = X_r q_{r0}(h_{r2} - h_{r1}) - P_i \qquad \text{Equation (J.2)}$$

J.5 Calculation of heating capacity

The total heating capacity, $\varnothing_{thi}$, based on volatile refrigerant flow data is calculated using Equation (I.3):

$$\varnothing_{thi} = X_r q_{r0}(h_{r1} - h_{r2}) - P_i \qquad \text{Equation (J.3)}$$

Annex K
Outdoor Air Enthalpy Test Method

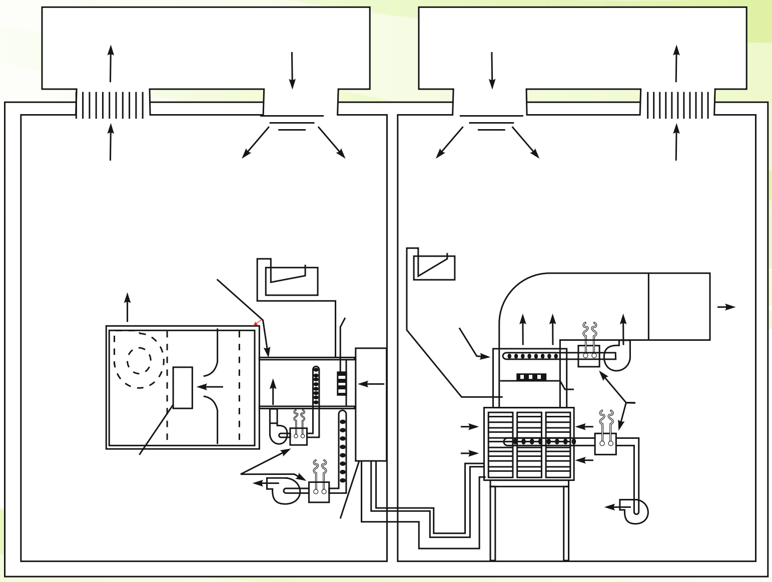
K.1 General

K.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.

K.1.2 Outdoor air enthalpy tests are subject to the apparatus arrangement limitations specified in J.2.1. Additional provisions apply if the compressor is independently ventilated (see J.2.2). Line loss adjustment permitted by J.4.3 may be made if the equipment employs remote outdoor coils.

K.2 Test room requirements

K.2.1 When the air enthalpy method is employed for outdoor-side tests, it should be ascertained whether the attachment of the airflow measuring device changes the performance of the equipment being tested and, if so, corrections should be made for this change (see Figure J.1). To accomplish this, the equipment should have thermocouples soldered to return bends at approximately the midpoints of each indoor 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 at 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 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 equilibrium has been attained at the proper conditions, with the outdoor 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 to both the cooling and the heating cycle, but needs to be done at any one condition for each.



1	Room conditioning apparatus	7	Insulation
2	Outdoor–side test room	8	Apparatus for differential pressure measurement
3	Airflow measuring apparatus	9	Indoor–side coil section of equipment under test
4	Air temperature and humidity measuring instruments	10	Door / window
5	Mixer	11	Indoor–side test room
6	Outdoor unit of equipment under test		

Figure K.1 – Outdoor calorimeter test method arrangement

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

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

K.3 Testing conditions

When the outdoor air enthalpy method is used, the requirements in 6.1.3.1 apply to both the preliminary test (see K.2.1) and the regular equipment test.

K.4 Calculations

K.4.1 The total indoor cooling capacity based on outdoor-side data, $\varnothing_{tci}$, is calculated using Equation (J.1):

$$\phi_{tci} = \frac{q_{V,o}\left(c_{pa4}t_{a4} - c_{pa3}t_{a3}\right)}{V'_n\left(1+W_n\right) - P_t}$$

K.4.2 The total heat capacity based on outdoor-side data, $\varnothing_{tho}$ is calculated using Equation (K.2):

$$\phi_{tho} = \frac{q_{V,o}\left(h_{a3} - h_{a4}\right)}{V'_n\left(1+W_n\right) + P_K}$$

K.4.3 If line loss corrections are to be made, they should be included in the capacity calculations. Allowance should be made using Equation (K.3):

$$\phi_L = \left(\frac{1}{R_1 + R_2}\right)L(\Delta t)$$

Where

$$R_1 = \frac{\ln\left(\frac{0,5D_t + t}{0,5D_t}\right)}{2\pi\lambda} = \frac{1}{2\pi\lambda}\ln\left(1+\frac{2t}{D_t}\right)$$

$$R_2 = \frac{1}{\pi(D_t + 2t)\alpha_a}$$

D_t is the temperature difference between the inside and outside of the tube

Annex L
Indoor Calorimeter Confirmative Test Method

L.1 General

L.1.1 This annex provides a test method for confirming the test results when the cooling and heating capacities are determined by the indoor air enthalpy test method.

L.1.2 In this test method, confirmation should be carried out in the test room specified in L.2 using the measuring method specified in L.3.

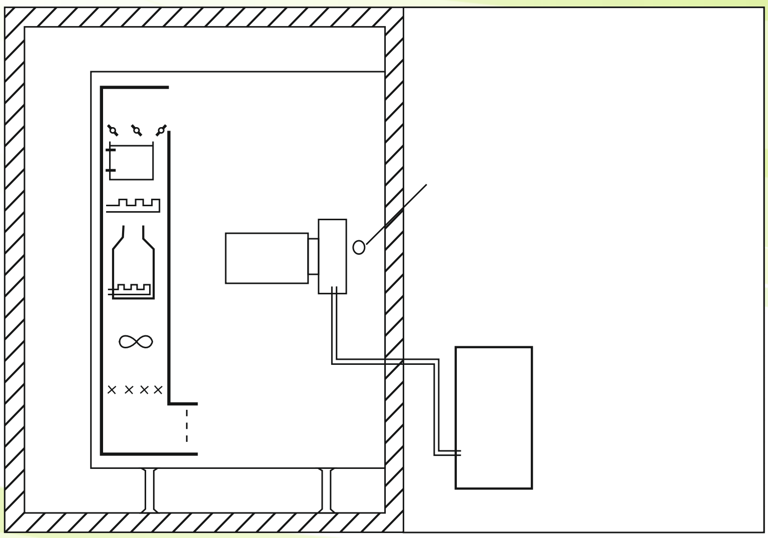
L.2 Test room requirements

A recommended test room is shown in Figure L.1. This test room should be constructed such that the air enthalpy test apparatus is installed in the indoor-side compartment of the calorimeter described in Annex D. The calorimeter should be of either the calibrated-room type or the balanced-ambient room type. The air enthalpy test apparatus should be equipped with means of not only measuring airflow rate and enthalpies at the inlet and outlet of the equipment under test but also means for measuring the total power input to the air-enthalpy test apparatus. It is recommended that air leaving the air-enthalpy test apparatus lead to the vicinity of the intake opening of the reconditioning apparatus of the calorimeter.

L.3 Measurement

L.3.1 Measurements should be made 1 h after attaining equilibrium conditions.

L.3.2 Simultaneous measurements made by the calorimeter and the air enthalpy test apparatus should be made in accordance with the methods specified. The cooling capacity determined by measurements using the calorimeter should be calculated in accordance with Equation (D.1), and the heating capacity should be calculated in accordance with Equation (D.5). Likewise, the cooling capacity determined by measurements with the air enthalpy test apparatus is calculated in accordance with Equation (E.3), and the heating capacity in accordance with Equation (E.5).



1	Outdoor-side compartment	7	Fan
2	Equipment under test–outdoor unit	8	Humidifier
3	Air-sampling tube	9	Heating coil
4	Equipment under test-indoor unit	10	Colling coil
5	Airflow measuring apparatus	11	Controlled-temperature air space
6	Mixer	12	Indoor-side compartment

Figure L.1 - Indoor calorimeter test method arrangement

Annex M

Outdoor Calorimeter Confirmative Test Method

M.1 General

M.1.1 This annex provides a test method for confirming the test results when the cooling and heating capacities are determined by the indoor air enthalpy test method.

M.1.2 In this test method, confirmation should be made in the test room specified in L.2 using the measuring method specified in L.3.

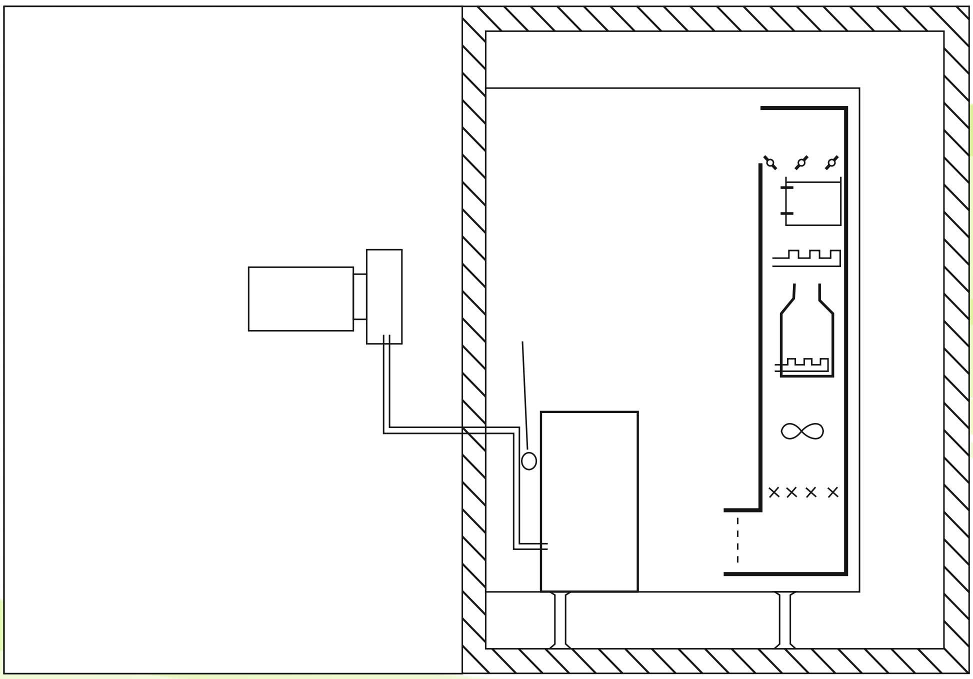
M.2 Test room requirements

The air enthalpy test apparatus in the indoor-side compartment should be constructed in accordance with this International Standard. The outdoor-side apparatus is the calorimeter, which should be constructed and equipped with the measuring means described in Annex D. A recommended test room is shown in Figure L.1.

M.3 Measurement

M.3.1 Measurements should be made 1 h after attaining equilibrium conditions.

M.3.2 Simultaneous measurements should be made using the air enthalpy apparatus on the indoor side and the calorimeter on the outdoor side in accordance with the methods specified. The cooling capacity determined by measurements using the calorimeter should be calculated in accordance with Equation (D.2), and the heating capacity should be calculated in accordance with Equation (D.6).



1	Controlled-temperature air space	7	Mixer
2	Outdoor-side compartment	8	Equipment under test-outdoor unit
3	Cooling coil	9	Air-sampling tube
4	Heating coil	10	Equipment under test-indoor unit
5	Humidifier	11	Airflow measuring apparatus
6	Fan	12	Indoor-side compartment

Figure M.1 - Outdoor calorimeter test method arrangement

Annex N

Balanced-type Calorimeter Confirmative Test Method

N.1 General

N.1.1 This annex provides a test method for manufacturers to confirm the test results when the cooling and heating capacities are determined by the indoor air enthalpy test method.

This test method should not be used as a confirmative method by testing laboratories because it does not provide for simultaneous confirmative test results.

N.1.2 This method should be carried out by installing the equipment, which has been measured by the balanced-type calorimeter, in the indoor air enthalpy test apparatus for measurement under the same conditions as in the balanced-type calorimeter.

N.1.3 The performance of the indoor air enthalpy apparatus should be verified at least every 12 months using an industry standard cooling/heating calibrating device. A calibrating device may also be another piece of equipment for which the performance has been measured at an accredited test laboratory as part of an industry-wide cooling/heating capacity verification programme.

N.2 Measurement

N.2.1 When this test method is employed, it is desirable to confirm that there is no difference between the capacities measured by the calorimeter and the indoor air enthalpy test apparatus. To accomplish this, the equipment should have thermocouples soldered to the return bends at approximately the midpoints of each of indoor and outdoor coil circuits. Equipment not sensitive to refrigerant charge may, alternatively, be provided with the pressure gauges connected to access valves or tapped into the suction and discharge lines.

N.2.2 Firstly, the equipment to be tested should be installed in the balanced-type calorimeter described in Annex D to carry out the measurement of the capacity. Then, the equipment should be moved to the indoor air enthalpy test apparatus and measured by the specified method. It is desirable to measure both cooling and heating capacities, though only one may be measured. However, if the cooling capacity is measured by the calorimeter, the same measurement should also be made in the indoor air-enthalpy test apparatus.

N.2.3 If no alteration is made to the installation of the equipment under test, a series of tests which are conducted subsequently should be deemed valid.

Annex O

Cooling Condensate Measurements

O.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.

O.2 Calculations

O.2.1 The latent cooling capacity, $\emptyset_d$, is calculated using Equation (N.1):

$$\emptyset_d = 1000\ K_1 q_{wc}$$ Equation (O.1)

O.2.2 The sensible cooling capacity, $\emptyset_{sci}$, is then calculated using Equation (N.2):

$$\emptyset_{sci} = \emptyset_{tci} - \emptyset_{lci}$$ Equation (O.2)

Annex R

Pictorial Examples Of The Heating Capacity Test Procedures Given In 7.1

R.1 General

The six schematic diagrams given in the examples in O.2 show several of the cases which could occur while conducting a heating capacity test as specified in 7.1. All examples show cases where a defrost cycle ends the preconditioning period. Examples 2 to 6 in O.2 represent cases where the indoor air enthalpy method is used and, as a result, the data collection period for the transient test lasts 3 h or three complete cycles (as opposed to 6 h or six complete cycles if using the calorimeter test method).

R.2 Procedure flowchart for heating capacity test

The following flowchart gives the procedures to adopt and the clauses in the main text to use when conducting the heating capacity test.

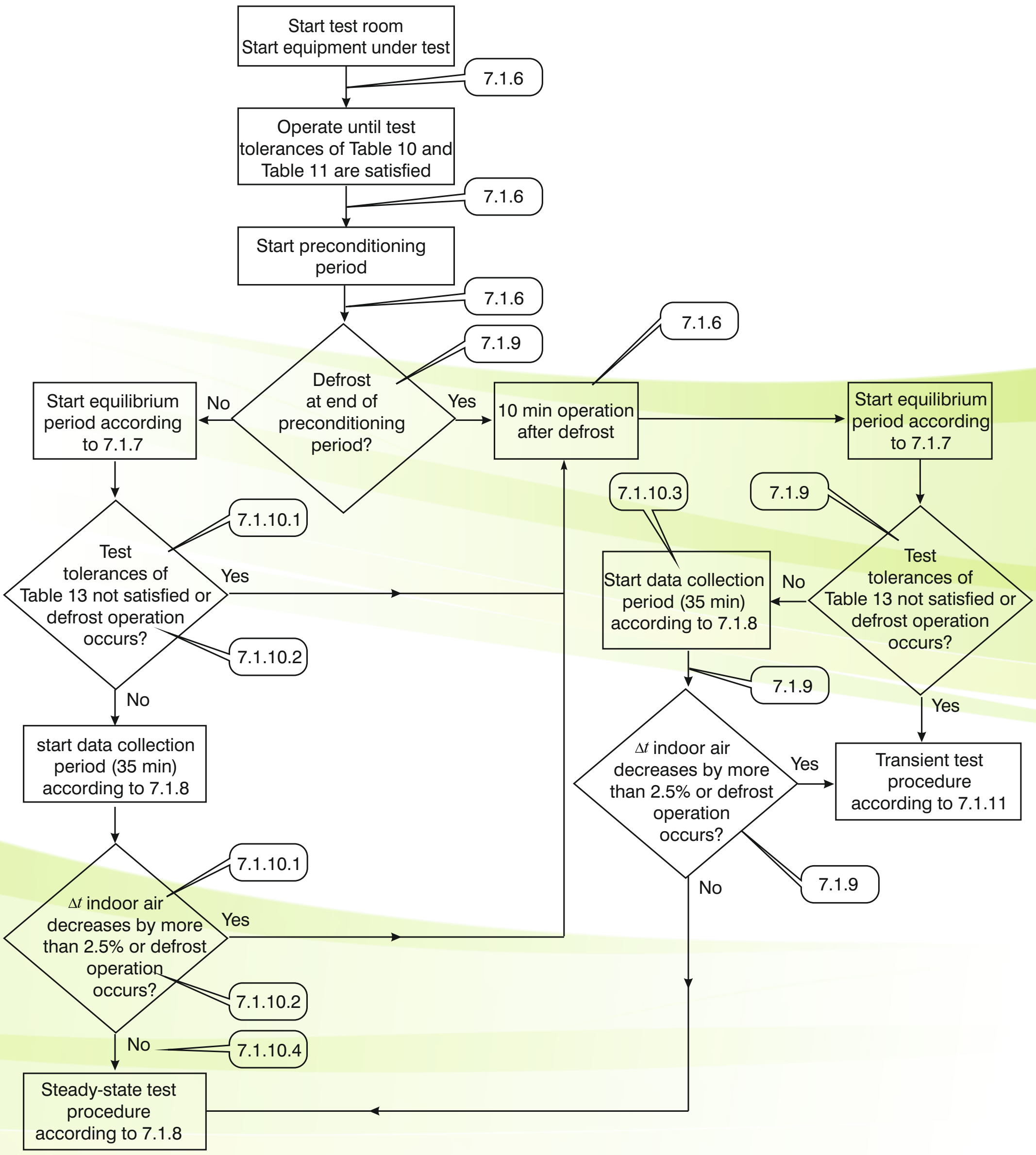
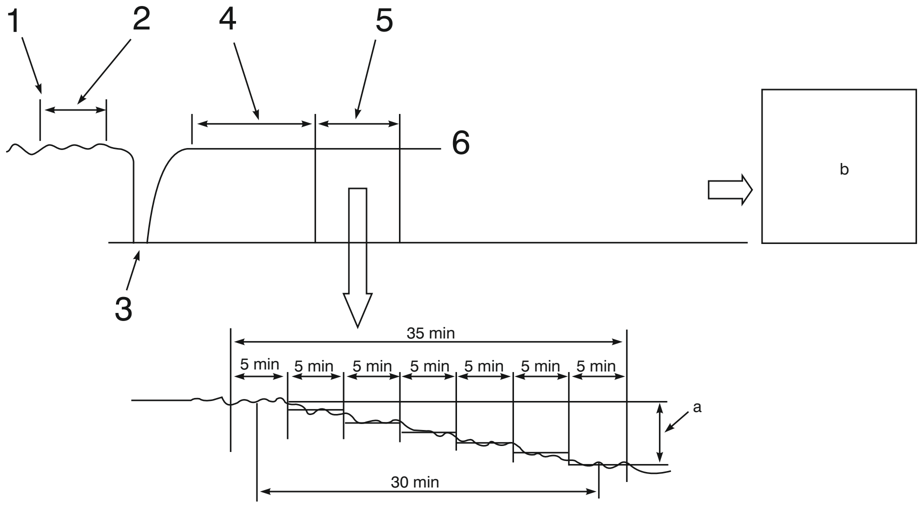


Figure Q.1-Procedure flowchart

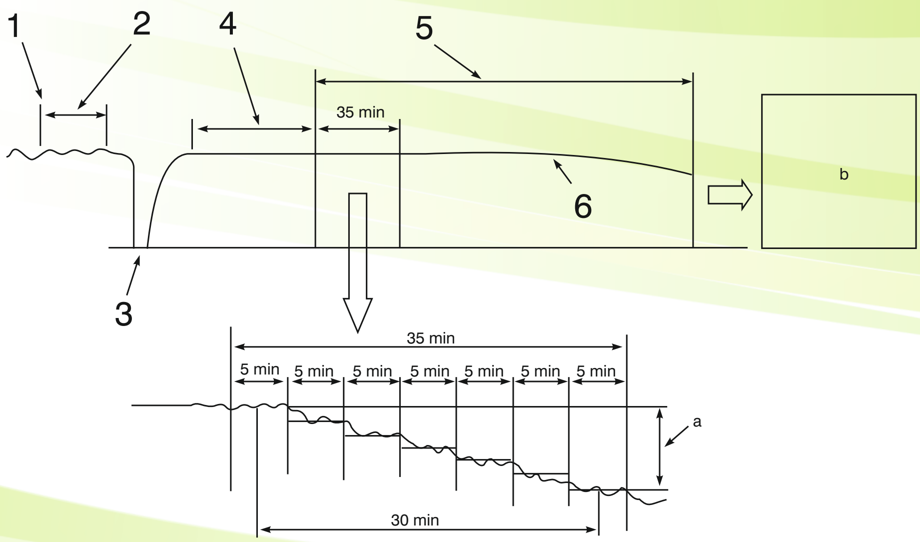
Example1 Steady-state heating capacity test.



Key

1 Compliance with test tolerances first achieved
2 Preconditioning period (10 min minimum)
3 Defrost at end of preconditioning period
4 Equilibrium period (60 min)
5 Data collection period (35 Min)
6 Inside air temperature difference, Dt indoor air
a Dt indoor air decreases by 2.5% or less during the first 35 min of the data collection period.
b Steady-state test terminate test when data collection period equals 35 min.

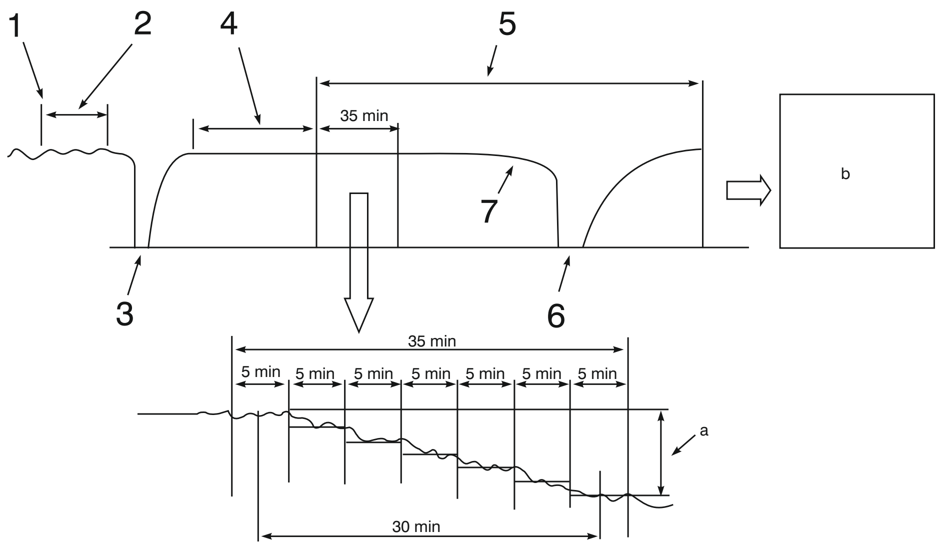
Example2 Transient heating capacity test with no defrost cycles.



Key

1 Compliance with test tolerances first achieved
2 Preconditioning period (10 min minimum)
3 Defrost at end of preconditioning period
4 Equilibrium period (60 min)
5 Data collection period (3 h)
6 Inside air temperature difference, D$t_{\text{indoor air}}$
a D$t_{\text{indoor air}}$ decreases by 2.5% or less during the first 35 min of the data collection period.
b Transient test terminate test when data collection period equals 3 h.

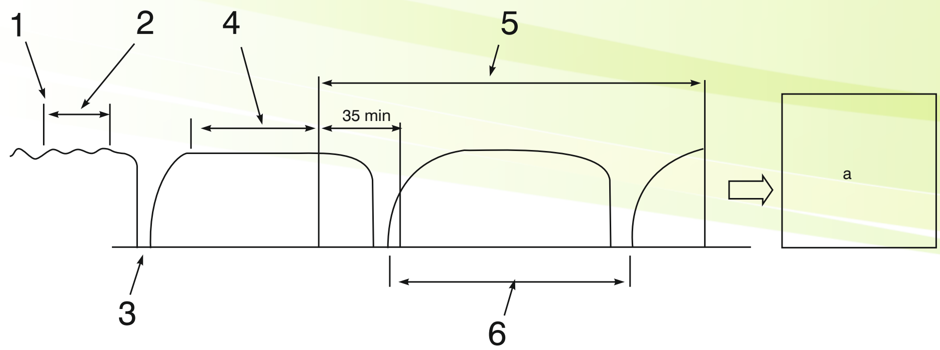
Example3 Transient heating capacity test with one defrost cycles during the data collection period.



Key

1 Compliance with test tolerances first achieved
2 Preconditioning period (10 min minimum)
3 Defrost at end of preconditioning period
4 Equilibrium period (60 min)
5 Data collection period (3 h)
6 Inside air temperature difference, $Dt_{\text{indoor air}}$
a $Dt_{\text{indoor air}}$ decreases by 2.5% or less during the first 35 min of the data collection period.
b Transient test terminate test when data collection period equals 3 h.

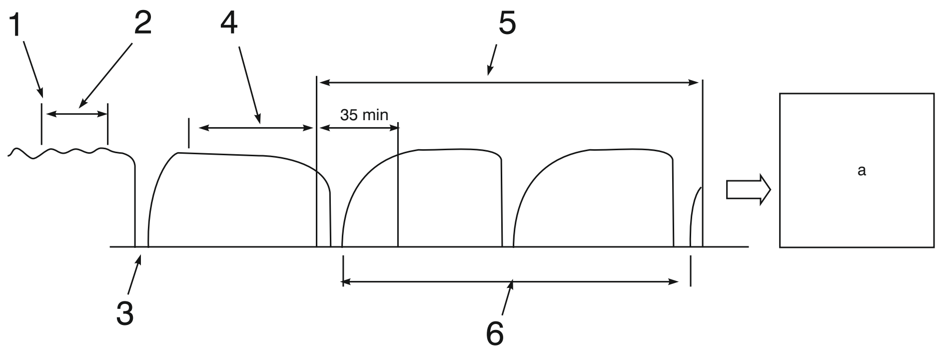
Example4 Transient heating capacity test with one defrost cycles during the data collection period.



Key

1 Compliance with test tolerances first achieved
2 Preconditioning period (10 min minimum)
3 Defrost at end of preconditioning period
4 Equilibrium period (60 min)
5 Data collection period (3 h)
6 Inside air temperature difference cycle
a Transient test terminate test when data collection period equals 3 h.

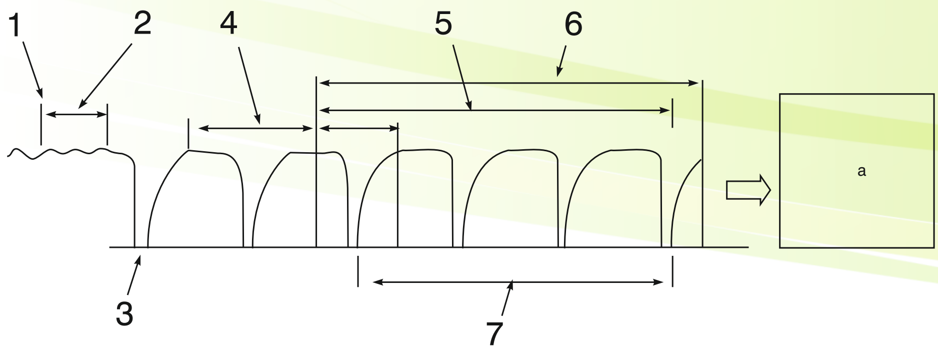
Example5 Transient heating capacity test with two complete cycles during the data collection period.



Key

1 Compliance with test tolerances first achieved
2 Preconditioning period (10 min minimum)
3 Defrost at end of preconditioning period
4 Equilibrium period (60 min)
5 Data collection period (3 h)
6 Two complete defrost cycle
a Transient test terminate test when data collection period equals 3 h.

Example 6 Transient heating capacity test with three complete cycles during the data collection period.



Key

1 Compliance with test tolerances first achieved
2 Preconditioning period (10 min minimum)
3 Defrost at end of preconditioning period
4 Equilibrium period (60 min)
5 Data collection period
6 Three hours
6 Three complete defrost cycle
a Transient test terminate test at the end of three complete cycles within the data collection period.

About ISHRAE

The Indian Society of Heating, Refrigerating and Air Conditioning Engineers (ISHRAE), was founded in 1981 at New Delhi by a group of eminent HVAC&R professionals. ISHRAE today has over 10,000 HVAC&R professionals as members and additionally there are 8,500 Student-members. ISHRAE operates from over 40 Chapters and sub Chapters spread all over India, with HQ in Delhi.

It is led by a team of elected officers, who are members of the Society, working on a voluntary basis, and collectively called the Board of Governors.

ISHRAE Objectives:

- Advancement of the Arts and Sciences of Heating, Ventilation, Air Conditioning and Refrigeration Engineering and Related Services.
- Continuing education of Members and other interested persons in the said sciences through Lectures, Workshops, Product Presentations, Publications and Expositions.
- Rendition of career guidance and financial assistance to students of the said sciences.
- Encouragement of scientific research.

ISHRAE Mission

To promote the goals of the Society for the benefit of the general public. Towards this objective, the Chapters of the Society participate in, and organize, activities to protect the Environment, improve Indoor Air Quality, help Energy Conservation, provide continuing education to the Members and others in the HVAC & related user Industries and offer certification programs, career guidance to students at the local colleges and tertiary institutions.

Activities

As part of its objectives to promote the interests of the HVAC&R Industry, ISHRAE is involved in various activities. ISHRAE reaches out to all its members and seeks their active participation & involvement in all the Events/Programs organized by the society.

Programs

ISHRAE conducts Conferences, Seminars, Exhibitions, Workshops, Panel Discussions and Product Presentations throughout the country with both national and international participants to discuss, promote and display the state of the art technologies, systems, products and services.

Publications

ISHRAE publications strive to help its members & the industry keep up-to date with the technical developments, latest trends, and sunrise technologies. ISHRAE Standards, Fundamental books on various topics, safety guidelines, HVAC&R Handbooks and the extremely popular & informative ISHRAE Journal, are a few such publications.

ACREX INDIA

ISHRAE organizes ACREX INDIA, the largest international exposition in South Asia on the Air-Conditioning, Refrigeration, Ventilation and Building services industry. Held annually, ACREX with nearly 500 exhibitors is considered to be a major opportunity to showcase the latest technologies/innovations, and provide a platform for buyer-seller meet, for technical & commercial personnel in the HVAC&R field.

Education & Training

ISHRAE Institute of Excellence (IIE), the educational arm of the Society, is working towards human resource development in the HVAC&R industry in the country by conducting various courses. One of the most important objectives of ISHRAE is Technical Training, and this is done at various levels.

At the apex of the pyramid we have the ICP (ISHRAE Certified Professional) Certification Courses on Clean rooms AC-Design, AC Service and others. At the next level ISHRAE offer a full time Diploma Course for graduate engineers. In addition at the Chapter level ISHRAE holds several successful training programs, workshops, short term courses and offers e-learning opportunities. ISHRAE is also working with associates in Skill Development activities.

Student Activities

ISHRAE student chapters in more than 150 engineering colleges encourage students to opt for careers in the HVAC&R industry. Knowledge dissemination is done through seminars, quiz contests like aQuest, plant and site visits.

ISHRAE has launched “ISHRAE Job Junction” nationally, providing a platform for leading employers to recruit candidates who are members from ISHRAE student chapters.

K-12 initiative of ISHRAE is focused on school students’ contests, in making them aware of subjects like, energy conservation and environmental concerns through drawing competitions, poster design, quiz and planting of trees. Emphasis on STEM education is stressed to inculcate a scientific fervor & help develop these young children into responsible citizens.

Research

ISHRAE promotes research in the field of HVAC&R technology. It offers financial support to Graduate/Post Graduate students, to carry out innovative work on R & D in Technology, Systems, and Processes. ISHRAE partners with Industry & academia to carry out scientific research associated with the HVAC&R Industry.

SearchO

Provides a unique platform for B2B and B2C users to share their expertise & requirements in an industry specific search engine. We wish to provide unparalleled user experience HVAC & R and Building Services Industry to increase their reach to all concerned in services & trade. This search engine will help promote the Make in India drive, by providing easy referencing to all stakeholders.

Interaction with Govt. Departments and Associate Societies

ISHRAE works in the National interest with various Govt. Ministries/Departments, e.g. in the development of Standards & drafting of NBC for BIS, working on ECBC with BEE, with Ozone Cell of MoEFCC, on refrigerant gases. ISHRAE is a member & active supporter of National Centre for Cold Chain development (NCCD) Ministry of Agriculture & works closely with NCCD on refrigeration.

ISHRAE is also working in close co-operation with other similar Societies & Organizations, both at national and international level, for the promotion and development of issues like Sustainability, Green Buildings, Energy Efficiency, Environmental Responsibility, Indoor Air Quality, Fire & Safety. Interaction with Think-tanks & NGOs like NRDC, CEEW, TERI, CSE & UN bodies like UNDP/UNEP is a regular feature. ISHRAE is looked upon as a repository of technical knowledge in the HVAC&R & Building Industry field by peer Organizations & the Govt. of India.