भारतीय मानक

Indian Standard

IS 18794 : 2024

एयर हैंडलिंग यूनिट — विशिष्टि

Air Handling Units — Specification

ICS 23.120; 91.140.30

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Refrigeration and Air Conditioning Sectional Committee, MED 03

FOREWORD

This Indian Standard was adopted by the Bureau of Indian Standards, after the draft finalized by the Refrigeration and Air Conditioning Sectional Committee had been approved by the Mechanical Engineering Division Council.

This standard covers the general, mechanical, and thermal requirements, and test methods of air handling units.

In the formulation of this standard considerable assistance has been derived from the following International Standards:

Standards	*Title*
ISO 7235 : 2003	Acoustics — Laboratory measurement procedures for ducted silencers and air-terminal units — Insertion loss, flow noise and total pressure loss
ISO 9614	Acoustics — Determination of sound power levels of noise sources using sound intensity
(Part 1) : 1993	Measurement at discrete points
(Part 2) : 1996	Measurement by scanning
EN 308 : 2022	Heat exchangers — Test procedures for establishing performance of air to air heat recovery components
EN 1216 : 1998	Heat exchangers — Forced circulation air-cooling and air-heating coils — Test procedures for establishing the performance
EN 1886 : 2007	Ventilation for buildings — Air handling units — Mechanical performance
EN 13053 : 2019	Ventilation for buildings — Air handling units — Rating and performance for units, components and sections
AHRI 410 : 2023	Performance rating of forced-circulation air-cooling and air-heating coils
AHRI 431 : 2020	Performance rating of central station air-handling unit supply fans
AHRI 1061 : 2023	Performance rating of air-to-air exchangers for energy recovery ventilation equipment
AHRI 1351 : 2014	Mechanical performance rating of central station air-handling unit casings
UL 1995 : 2022	Standard for safety heating and cooling equipment

Air handling unit for health and hygiene applications is not covered in this Indian Standard but it is under consideration by the Committee.

Annex C gives the guidance for calculation for overall performance value (OPV) of air handling unit.

The composition of the Committee responsible for the formulation of this standard is given in Annex E.

For the purpose of deciding whether a particular requirement of this standard is complied with the final value, observed or calculated, expressing the result of a test or analysis shall be rounded off in accordance with IS 2 : 2022 'Rules for rounding off numerical values (*second revision*)'. The number of significant places retained in the rounded-off value should be the same as that of the specified value in this standard.

Indian Standard

AIR HANDLING UNITS — SPECIFICATION

1 SCOPE

1.1 This standard specifies general, performance, rating requirements, and method of tests for air handling units (AHU).

1.2 This standard covers units with rated voltage up to and including 240 V, 50 Hz a.c., single-phase and up to and including 415 V, 50 Hz a.c. for three-phase input power supply.

1.3 This standard is applicable to the following:

a) The standardized designs, which may be in a range of sizes having common construction;
b) The custom designs with and without heat recovery devices;
c) The units producing ventilation air, including a dedicated outdoor system (DOAS); and
d) Site assembled AHUs which are installed under factory personnel supervision while ensuring compliance to mechanical and thermal performance as specified in this standard.

1.4 This standard does not cover the following:

a) Fan coil units;
b) Control system;
c) Application in the explosive environment;
d) Health and hygiene applications; and
e) Site assembled AHUs except 1.3(d).

2 REFERENCES

The standards listed in Annex A contain provisions which, through reference in this text, constitute provisions of this standard. 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 edition of these standards.

3 TERMS AND DEFINITIONS

For the purpose of this standard, the terms given in IS 3615, and in addition following definitions listed below shall apply.

3.1 Air Handling Unit — It is an encased assembly of fan or fans with other necessary equipment to perform any one or more functions of circulating, filtering, cooling, heating, heat recovery, dehumidifying, humidifying and mixing of air.

3.1.1 *Air Handling Unit-Real Unit* — It is an enclosed unit serving as a prime mover of air conditioning installation where outdoor air, recirculated air or extracted air is treated or ventilation, consisting of a fan section with a filter section and heat exchanger. In addition but not limited to, the unit may consist of an inlet section (with one or more louvers and dampers), a mixing section, heat recovery section, one or more cooling and heating coils, humidifiers, sound attenuators and additional equipment such as controls and measuring sections, to establish complete performance for all the available functions of the air handing unit.

3.1.2 *Air Handling Unit-Model Unit* — It is a unit specially built for general testing and measurement for general classification, comparison or categorization of series or individual casings (as defined in 6).

3.2 Section of Air Handling Unit — The functional element of an air handling unit consisting of one or more components in a single casing.

3.3 Casing of an Air Handling Unit — It is the enclosure of unit within which the components mounted to perform any of the functions of circulating, filtering, cooling, heating, heat recovery, dehumidifying, humidifying or mixing air.

3.4 Different Functions of Air Handling Unit

3.4.1 *Cooling* — Removal of sensible heat and/or latent heat from air.

3.4.2 *Heating* — Transfer of heat from one body or medium to air.

3.4.3 *Dehumidification* — Controlled removal of water vapour from air.

3.4.4 *Humidification* — Controlled addition of water vapour in to air.

3.4.5 *Filtration* — Removal of particulate matter from air.

3.4.6 *Heat Recovery* — Recovering heat from one airstream and transferring it to another, either directly or using an intermediary heat transfer medium.

3.4.7 *Mixing Air* — Controlled way of mixing outdoor air and the recirculation air.

3.5 Casing Surface Area — The total area of all the exterior surfaces of the AHU casing (calculated from the nominal external dimensions), excluding the area of the unit inlet and outlet airflow openings. Casing surface area is expressed in m^2.

NOTE — The area of components which are not the part of the unit casing shall be excluded. These exclusions can include, both are not limited to, casing attachments such as base rails and/or ceiling mount structures, externally mounted devices such as dampers, louvers, hoods, and the area of the block-off plates on openings of separately tested unit sections.

3.6 Air Flow Rate — Volume flow (movement of air within set boundaries) of air passing through a plane of unit area in unit time.

3.6.1 *Air Leakage Rate* — Leakage of the air from air handling unit, subject to air pressure. The air leaking through the casing of an air handling unit per square meters of casing surface area is expressed in ($l/s.m^2$). In other words, it is the ratio of the total air leaking through the casing measured at the maximum rated pressure to the casing surface area (per 1 m^2).

NOTE — Where a casing at design conditions has portions of the AHU operating in both positive and negative pressures, the air leakage rate shall be determined separately for casing sections applied under positive pressure from those applied under negative pressure.

3.6.2 *By-Pass Leakage* — Uncontrolled and non-desirable mixing of untreated air into the treated air between the components within the AHU casing. It is measured as ratio of the diverted air flow to the total air flow (sum of the main air flow and the diverted air flow).

3.7 Casing Deflection — The deformation of the external surface of the casing, measured perpendicular to reference plane to the maximum point of deflection of the casing surface, when the unit is subjected to a positive or negative internal air pressure. Casing deflection is expressed in mm.

3.8 Thermal Bridging Factor — The ratio of the lowest temperature difference between any point on the external surface and the mean internal air temperature to the mean air to air temperature difference. (*See* Table 10)

3.9 Thermal Transmittance — It is the heat flow per unit area per unit temperature difference expressed as ($W/m^2.K$), determined at steady state temperature. The classification of thermal transmittance is defined in Table 9.

NOTE — The casing surface area shall be used for the purposes of calculating the U-value.

4 SYMBOLS

The symbols used in this standard are given in the Table 1.

Table 1 Symbols

(*Clause* 4)

Sl No. (1)	Symbol (2)	Description (3)	Unit (4)
i)	qv_{nom}	Nominal air flow rate of the filter section	$l.s^{-1}$
ii)	Ql	Leakage rate	$l.m^{-2}.s^{-1}$
iii)	Ql_{m}	Measured leakage rate at the actual test pressure	$l.m^{-2}.s^{-1}$
iv)	qL	Sum of leakage through casing	l
v)	qL_{f}	Sum of leakages through joints between filter cell, frames and casing	l
vi)	qv_{a}	Filter bypass leakage rate	$l.m^{-2}.s^{-1}$
vii)	kb	Thermal bridging factor	—
viii)	k	Filter bypass leakage rate in percent of nominal volume flow rate	—
ix)	U	Thermal transmittance	$W.m^{-2}.K^{-1}$
x)	P_{el}	Electrical input to heaters and circulating fans	W
xi)	A	External surface area	m^2
xii)	ρ	Density of air	$kg.m^{-3}$

Table 1 (*Concluded*)

Sl No. (1)	Symbol (2)	Description (3)	Unit (4)
xiii)	pa	Atmospheric pressure	Pa
xiv)	pv	Partial pressure of water vapor in air	Pa
xv)	ta	Dry bulb temperature	ºC
xvi)	P_{tu}	External total pressure difference	Pa

5 CONSTRUCTION

5.1 The unit shall at least have a fan and filter enclosed in a thermal insulation casing with sufficient mechanical strength to meet the requirements as specified by this standard. The enclosure casing shall be constructed of corrosion-resistant material or coated with corrosion resistance paint conforming to IS 9844. In addition, the unit may consist of an inlet section with one or more louvers and dampers, a mixing section, a heat recovery section, one or more cooling and heating coils, humidifiers, sound attenuators, and additional equipment such as controls, measuring sections, etc.

5.2 The unit shall be provided with means for mounting in an intended manner. Any special fittings necessary for intended mounting shall be supplied with the unit. A free-standing, floor-supported unit need not be provided with mounting means. The unit shall be supplied with instructions for transportation, site preparation for installation, installation manual, and commissioning manual. The instructions shall provide specifications regarding the space required for maintenance, mounting, and supports, etc, with drawings and/or technical data. The drawing shall also include water connections, drain connections, electrical supply connections, and control settings. The unit shall be easy to connect to water, electrical and other connections and easy to disconnect for service or repair as needed.

5.3 Air handling unit shall be provided with suitable provision for lifting through devices such as crane eyes, pallets and for transportation by crane or forklift.

5.4 The safety devices for protection against damage to components, like fans, vibration isolator springs, during transportation, shall be identified clearly by a label stating that such devices shall be removed before installation.

5.5 An electrical part within the outer cabinet need not be individually enclosed if the assembly complies with all of the following:

a) The construction and location of the part are such that there is no possibility of emission of flame or molten metal through openings in the outer cabinet, or malfunction of the component does not result in a risk of fire;

b) The part is not in the vicinity of flammable material other than electrical insulation;

c) The sheet metal thickness of the enclosure casing is enough to prevent from spreading of fire;

d) The electrical supply part is not located in an air-handling section; and

e) The electrical current-carrying part is not accessible to unintended contact by personnel.

5.6 Electrical connection diagram shall be provided with clear instructions for field wiring of AHUs supplied with pre-wired electrical starter and controller panel.

5.7 All the labels shall be legible and durable. Compliance is checked by inspection and by rubbing the marking by hand for 15 s with a piece of cloth soaked with water and again for 15 s with a piece of cloth soaked with petroleum spirit. After all the tests of this standard, the marking shall be legible. It shall not be easily possible to remove marking plates nor shall they show curling.

NOTES

1 In considering the durability of the marking, the effect of normal use is taken into account.

2 The petroleum spirit to be used for the test is aliphatic solvent hexane having a maximum aromatics content of 0.1 percent by volume, a kauri-butanol value of 29, an initial boiling point of approximately 65 °C, a drypoint of approximately 69 °C and a specific mass of approximately 0.66 kg/l.

5.8 For parts (for example, controls, filters, oiling of bearings, adjustment of belts) required normal servicing or adjustment in the AHU in installed condition shall have sufficient and reasonable accessibility. Covers or access panels giving access to such parts that are required to be removed for routine maintenance shall not expose uninsulated hazardous voltage live parts.

5.9 The overcurrent protective device that can be replaced or reset by the user as required shall be accessible without removal of parts other than the service covers or panels.

5.10 The reset button or lever of manual resettable devices (for example, the operating handle of a circuit breaker, the reset button of a motor protector, the adjusting screw or knob of an adjustable temperature or pressure control) shall be accessible without the use of a tool, providing that the resetting of the device does not result in exposure to uninsulated live hazardous voltage parts or moving parts. Outdoor units shall be provided with suitable ingress protection.

5.11 A cover or door shall not depend solely upon screws or other similar means to hold it in a closed position, but shall be provided with an automatic latch or the equivalent. A spring latch, a magnetic latch, a dimple, or any other mechanical arrangement that will hold the door in place and would require some effort on the user's part to open is considered to be acceptable for holding the door closed. An access door with an interlocking mechanism, such that it:

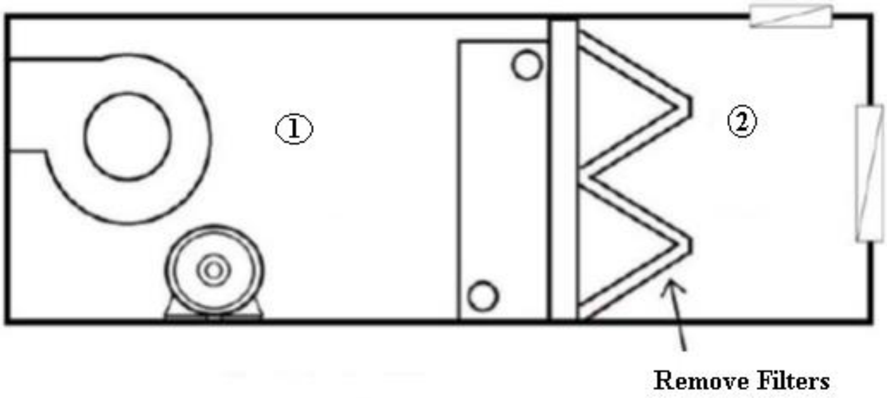
a) Secures the door in the closed position when engaged;

b) Shall be engaged before any moving parts and hazardous voltage circuit can be energized; and

c) Shall be located so that unintentional operation is unlikely during normal servicing.

The interlock that is required to reduce risk of electric shock or injury to persons shall withstand 1 000 cycles with a load not less than that controlled in the equipment, and 5 000 cycles without a load.

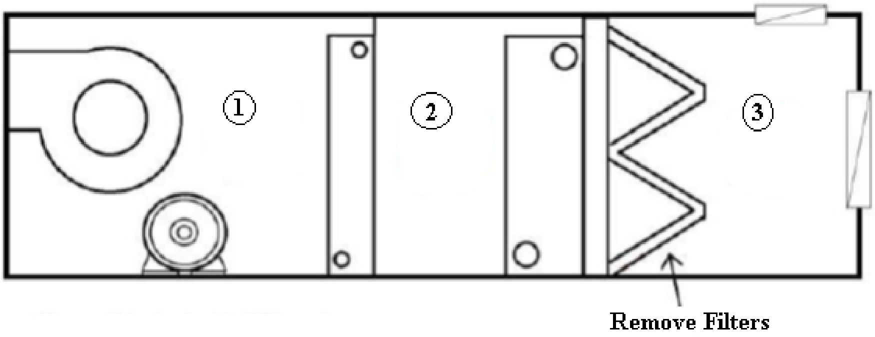
5.12 The typical construction of the AHU can be as shown in Fig. 1 to Fig. 4.



Heaters/Circulating fan(s) locations:

1 Between coil and fan.
2 Between end wall and coil.

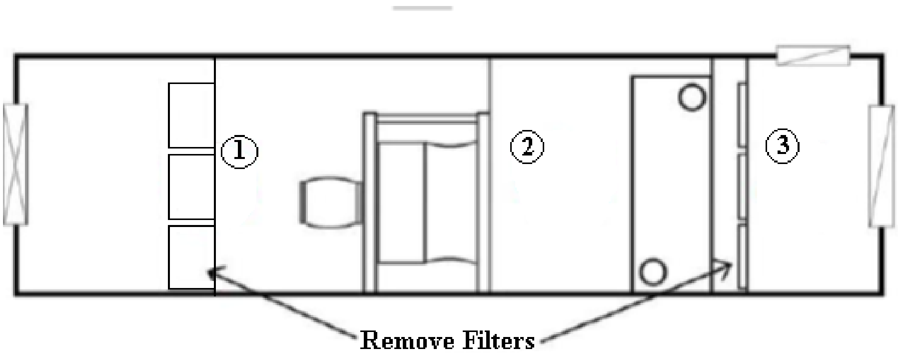
FIG. 1 AIR HANDLING UNIT WITH NO PRESSURE CHANGE WALL



Heaters/Circulating fan(s) locations:

1 Between coil and fan.
2 Between separated coils.
3 Between end wall and coil.

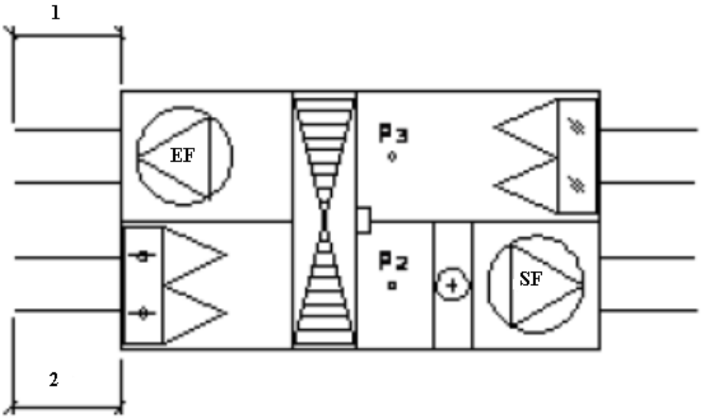
FIG. 2 AIR HANDLING UNIT WITH NO PRESSURE CHANGE WALL AND SEPARATE COILS



Heaters/Circulating fan(s) locations:

1 Between fan and discharge.
2 Between coil and fan wall.
3 Between end wall and coil.

FIG. 3 AIR HANDLING UNIT WITH PRESSURE CHANGE WALL



Key

1 Pressure drop on exhaust air side.
2 Pressure drop on supply air side.

EF-Exhaust air fan.
SF-Supply air fan.

FIG. 4 AIR HANDLING UNIT WITH HEAT RECOVERY WHEEL

6 CLASSIFICATION

Classification of air handling unit (AHU) shall be done based on the following parameters:

a) Mechanical performance of casing;
b) Casing air leakage;
c) Filter bypass leakage;
d) Thermal performance of casing; and
e) Mechanical safety.

The test for the classification parameters shall be done as per the test matrix given in Table 2.

7 MECHANICAL PERFORMANCE OF CASING

7.1 General

The mechanical strength tests shall be conducted on the model unit for general classification and the real unit for a particular classification of the casing and individual evaluation. The construction of the model unit for testing of mechanical strength of the casing shall be as per 7.1.1. The following table gives the test criteria of model box and real unit:

Sl No.	*Test Criteria*	*Kind of Casing*	
		Model Box (M)	Real Unit (R)
(1)	(2)	(3)	(4)
i)	Mechanical strength	General classification of casing construction	Particular classification of casing construction and individual evaluation
ii)	Air leakage	General classification of casing construction	Particular classification of casing construction and individual evaluation
iii)	Filter bypass leakage	General classification of casing construction	Particular classification of casing construction and individual evaluation
iv)	Thermal transmittance	General classification of casing construction	—
v)	Thermal bridging	General classification of casing construction	—

Table 2 Test Matrix for Model Unit and Real Unit

(*Clause* 6)

Sl No.	**Test Criteria**	**Unit Type**	
		Model Unit (M)	Real Unit (R)
(1)	(2)	(3)	(4)
i)	Mechanical strength	General classification of casing construction	Particular classification of casing construction and individual evaluation
ii)	Casing air leakage		
iii)	Filter bypass leakage		
iv)	Thermal transmittance		—
v)	Thermal bridging		—

7.1.1 *Construction of Model Unit* (*M*)

7.1.1.1 The model unit shall be manufactured from the type of design and method of assembly as used by the manufacturer in normal production and with the same fastener as that of the production unit. Every/each design shall be manufactured separately. If more than one type of construction or assembly method is available, the construction adopted for each test shall be clearly stated by the manufacturer. The manufacturing process and process controls (example: the torque applied to fixings), shall be in accordance with normal manufacturing procedures and standards for the product range. The enclosure shall be designed taking account of the following specifications:

a) Height and width shall have external dimensions of between 0.9 m and 1.4 m; and

b) The total external surface area shall be between 10 m² and 30 m².

7.1.1.2 For the model unit under test, the enclosure shall reproduce an assembly of at least two sections of a unit joined in accordance with the normal methods of manufacturing. The operating side of each section shall have at least one access door (with hinges and standard closures, but with no window), and shall include at least one fixed panel. Every/each construction detail of the real unit shall be included in the model unit (for example, doors, mullions, panels). Screws shall be tightened as in normal production.

7.1.1.3 A filter frame (without the filter medium) shall be installed while all measurements are taken, allowing filter bypass leakage to be measured. The filter frame shall be placed away from the section joints so that negative pressure impinges on the joint during the casing leakage test. This enables the effect of the joint on casing air leakage to be taken into account. If the test is executed/conducted without a filter frame, it shall be noted separately in the test report. Weatherproof units shall not be covered (for example, with a roof or roofing membrane) when the thermodynamic values are determined.

7.1.1.4 If a model unit enclosure is used, any internal fittings, such as filters or coils~~,~~ shall be removed, except for the filter holder. The assembly shall be supported by insulating blocks, at the bottom or the base frame of the enclosure 0.3 m to 0.4 m above the floor of a draught-free room (airflow velocity less than 0.1 m/s). The total area of the insulating blocks shall not be greater than 5 percent of the air handling unit base area. No radiant heat shall enter the test environment. The following shall be mounted inside the enclosure:

a) One or more externally controllable electric heating elements; and

b) One or more circulating fans with a total free air volume performance equivalent to 100 air changes per hour to 110 air changes per hour, allowing the internal air temperature difference across the measurement points not to be greater than 2.0 K. The test equipment assembly inside the unit shall not influence the heat transmission of the casing. Annex B gives examples of these arrangements.

7.1.1.5 The enclosure shall be divided into three equal measurement sections along the longest side. Sixteen numbers of temperature measuring devices shall be installed inside the enclosure; one in each corner and at the corners of each section division, every 0.1 m from the side panels as shown in Fig. 5.

7.1.1.6 All air temperature measuring devices used inside and outside of the enclosure shall be protected against thermal radiation. The accuracy and resolution of the measuring devices to be used, shall comply with the Table 3, if not specified otherwise.

7.1.2 *Test Conditions for Mechanical Strength of Casing*

The test pressure as per Table 4 shall be applied on the model unit or real unit. Parts of the real unit, which are running under positive pressure, shall be tested under positive pressure. Parts of the real unit, which are running under negative pressure, shall be tested under negative pressure.

7.1.3 *Measurement*

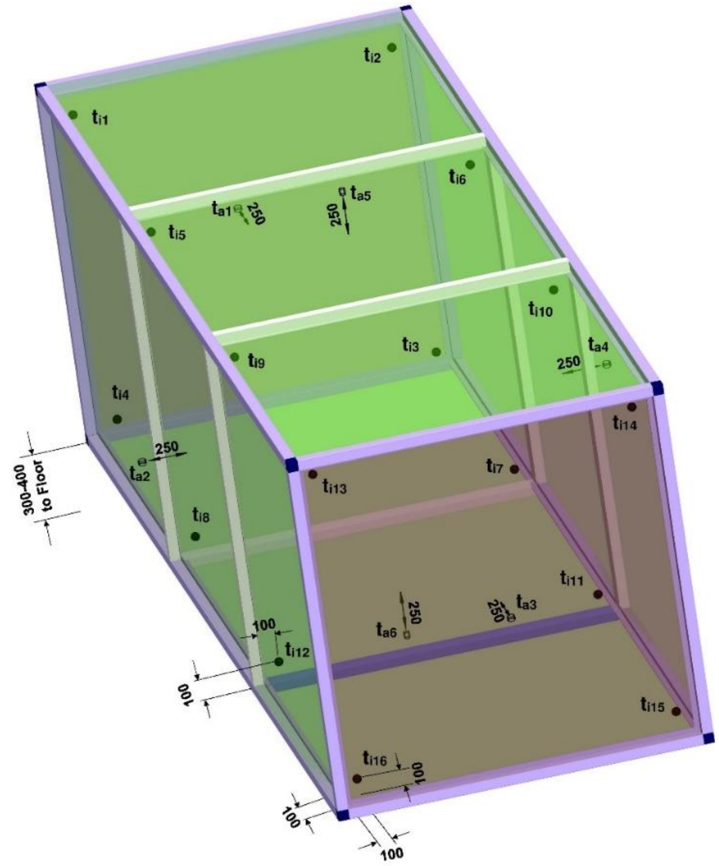
The panel deflection shall be measured on span A shown in Fig. 6 and frame deflection shall be measured on span B as shown in Fig. 6.

Table 3 Accuracy of Measurement Instrument

(*Clause* 7.1.1.6)

Sl No. (1)	Parameter (2)	Accuracy (3)	Resolution (4)
i)	Air temperature, °C	± 0.5	0.1
ii)	Ambient RH, percent	± 2 percent	0.1
iii)	Air temperature, DBT, °C	± 0.5	± 0.01
iv)	Surface temperature, °C	± 0.5	± 0.01
v)	Test pressure, Pa	5	0.1
vi)	Atmospheric pressure, Pa	± 0.5 percent	0.1
vii)	Pressure drop, Pa (air and water)	± 1 percent	0.1
viii)	Power, W	1 percent of reading	0.01
ix)	Voltage, V	± 1 percent of reading	0.01
x)	Frequency, Hz	± 1 percent of reading	0.01
xi)	Leakage airflow measurement device	± 3 percent	0.01
xii)	Deflection in length, mm	± 0.05	0.01
xiii)	Length, width and height, mm	± 2	0.1

The external air temperature shall be measured at points 0.25 m from the center of the top, bottom, and all four vertical sides of the enclosure.



Key

t_{ix} – Internal air temperature

t_{ax}– External air temperature

All dimensions in millimetres.

FIG. 5 TEST MODEL PREPARATION-ZONING AND TEMPERATURE SENSING DEVICE INSTALLATION

Table 4 Test Pressure

(*Clause* 7.1.2)

Sl No.	Test Criteria	Casing Type	
		Model Unit (R)	Real Unit (A)
(1)	(2)	(3)	(4)
i)	Deflection — Normal operating pressure at selected designed fan speed and maximum fan pressure — maximum fan pressure at selected design fan speed	± 1 000 Pa	Normal pressure at design fan speed
ii)	Maximum withstand fan pressure	± 2 500 Pa	Maximum pressure at design fan speed

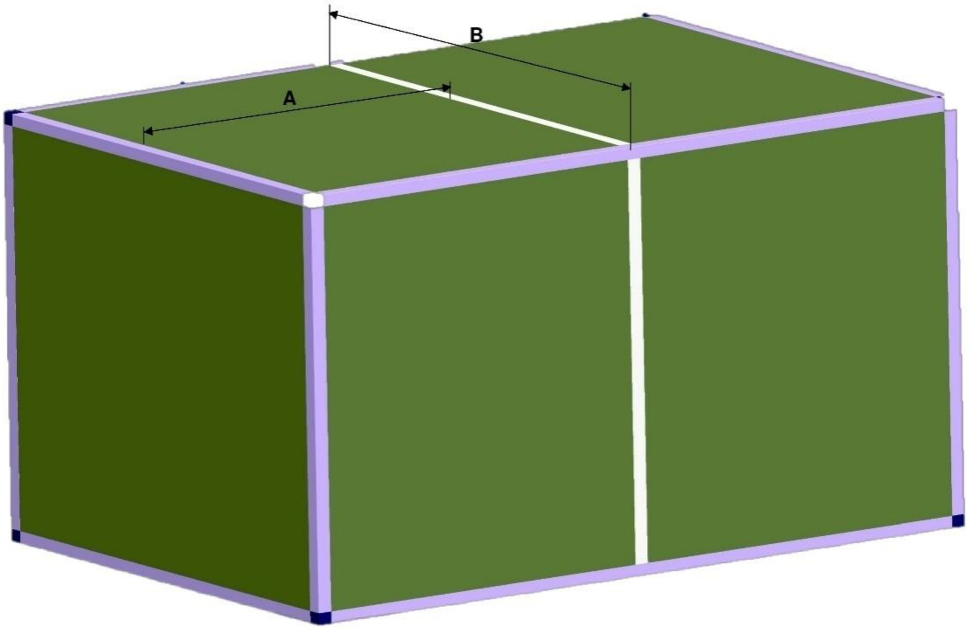


FIG. 6 ILLUSTRATION OF PANEL AND FRAME SPANS OF AIR HANDLING UNITS

Deflection shall be measured within an accuracy of ± 0.5 mm whilst the air handling unit is operating under test conditions. For example, referring to Fig. 7, deflection X'X" is measured for span R'S', deflection XX" is measured for span PQ.

Deflection X'X" is a function of panel stiffness. Deflection XX" is a function of both frame and panel stiffness. Frame deflection is RR' and SS'.

Example:

PQ = 2 m

R'S' = RS = 1 m

Measured deflection XX" = 8 mm

Measured deflection X'X" = 5 mm

Hence, the deflection of span R'S' is 5 mm/m and that of span PQ is 4 mm/m. The class is determined by the highest value of the measured relative deflections. In this example the deflection of R'S' (the shortest span) determines that class M2 is met.

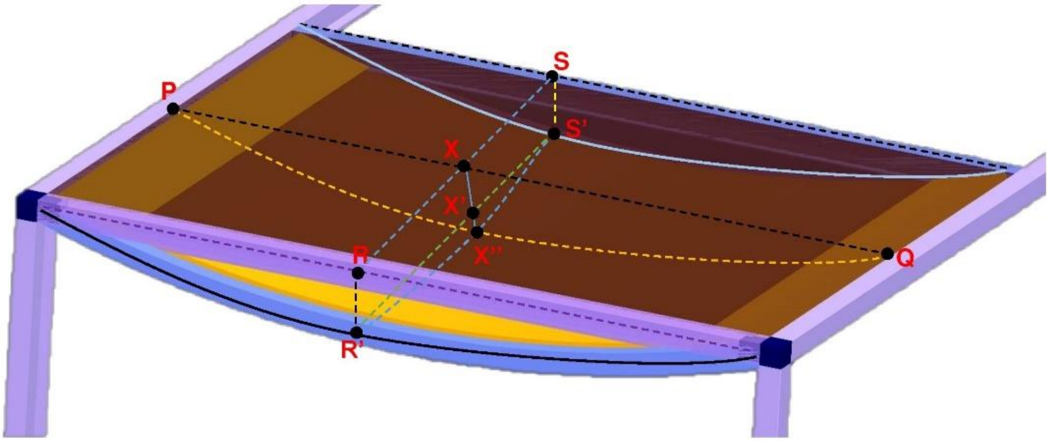


FIG. 7 DEFLECTION OF PANELS AND FRAMES OF AIR HANDLING UNITS

7.1.4 *Performance Requirement*

The casings shall withstand the maximum fan pressure (not shock pressure) at the selected design fan speed. No permanent deformation (hysteresis maximum ± 2.0 mm per meter of frame/panel span is allowed) of the structural parts (structures and supports) or damage to the casing may occur.

NOTES

1 In addition to the requirements of this standard, the ability of the real unit to withstand the maximum designed fan pressure may be demonstrated by prior agreement between the manufacturer and purchaser, by blanking off the inlets to the unit and running the fan up to its design operating speed. Downstream sections of blow-through units shall be proved by blanking off the air handling unit's outlets.

2 Any special requirements, for example, the ability to survive shock loading caused by the sudden closure of fire dampers, shall be specified.

3 The measurement made on the real unit shall be presented with a suffix 'A' – example MD1 (A) and for the measurement made on the model unit by using letter 'R' – example MD1 (R).

4 Class MD1 and Class MD2 casings shall be designed and selected so that the maximum deflection of any span of the panels and/or frames does not exceed the limits given in Table 5 as demonstrated in Fig. 7.

5 In addition to the requirements of this standard, Deviating test pressures shall be as mutually agreed between the manufacturer and purchaser.

The casing mechanical strength class designation of air handling unit shall be defined by the casing deflection at the corresponding test pressure specified in Table 5.

8 CASING AIR LEAKAGE

8.1 General

The leakage test shall be done after the strength test as specified in 7. The casing air leakage tests shall be conducted on the model test unit for general classification and the real unit for a particular classification of the casing and individual evaluation. The construction of the model unit for testing shall be as per 7.1.1.

8.2 Testing

8.2.1 *Test Apparatus*

The test apparatus shall be as shown in Fig. 8, using a fan with duty at least capable of meeting the anticipated leakage rate at the respective test pressure(s).

If the air handling unit is too large for the capacity of the leakage test apparatus (accuracy ± 3.0 percent), or a restriction of access for delivery requires that the unit should be tested in sections or subassemblies, the breakdown should be mutually agreed between the manufacturer and purchaser prior to the test date.

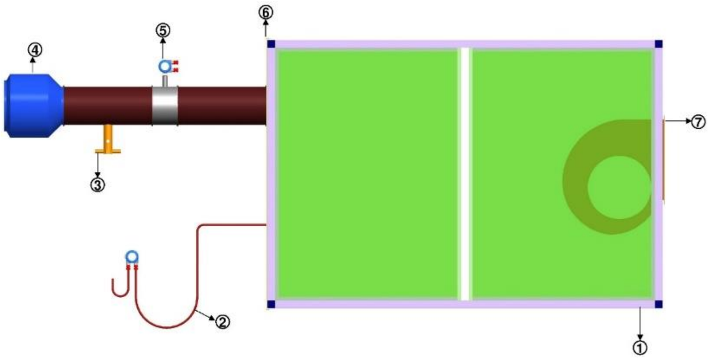
Whenever heat recovery devices are installed, the supply and extract sections shall be tested together as a single unit.

Table 5 Classification of Air Handling Unit

(*Clauses* 7.1.4 *and* D-1)

Sl No. (1)	Casing Class (2)	Maximum Relative Deflection mm/m (3)	Casing Strength Weightage Factor, W_{CS} (4)
i)	MD1	4	1.00
ii)	MD2	10	0.67
iii)	MD3	Above 10	0.33

NOTE — Casing strength weightage shall be used for overall performance calculation as in **11**.



Key

1 AHU under test.

2 AHU test pressure gauge.

3 Bleed valve as alternative variable speed fan.

4 Variable speed fan.

5 Flow measurement device.

6 Inlet plate.

7 Outlet plate.

FIG. 8 TYPICAL EXAMPLE OF APPARATUS FOR TESTING THE CASING AIR LEAKAGE (NEGATIVE PRESSURE TEST)

8.3 Preparation for Test

The unit shall be installed in the intended operating conditions with its sections joined by the method as specified by the manufacturer in the installation instructions. Blanking plates shall be fixed wherever necessary by following a similar method of joining in the installation. All openings for electrical, air, or water services shall be closed prior to testing. Dampers shall be removed before testing or fitted with blanking plates if the damper is inside. The air handling unit shall not be applied with any additional sealing other than the standard design unless agreed by the buyer and supplier on any additional sealing.

8.4 Test Procedure

Turn on the unit under test and adjust the pressure until the static test pressure inside the test unit is within 5 percent of the specified value. The pressure shall be maintained constant for 5 min, and readings shall be recorded after the pressure is stabilized. The leakage flow rate and the test pressure shall be recorded.

8.5 Requirement Units Operating Under Negative Pressure Only

The casing air leakage class designation shall be defined by the maximum leakage rate at the test pressure as specified in Table 6 and Table 7. The air leakage of the assembled air handling unit shall be tested at 400 Pa negative pressure and it shall not exceed the applicable rate given in Table 6.

Table 6 Casing Air Leakage Classes of Air Handling Units, 400 Pa Negative Test Pressure

(*Clauses* 8.5 *and* 8.7)

Sl No.	Casing Leakage Class	Maximum Leakage Rate, Ql_{400} l/m^2.s	Filter Class	Casing Leakage Weightage Factor, W_{LS}
(1)	(2)	(3)	(4)	(5)
i)	CL 1	0.15	Superior to F9	1.00
ii)	CL 2	0.44	F8 to F9	0.75
iii)	CL 3	1.32	G1 to F7	0.50

NOTES

1 For any specific applications the casing leakage class shall be mutually agreed upon by the purchaser and buyer.

2 Refer Annex D for classification interpretation between the above filter class and the filter class as specified in IS 17570 (Part 1 to Part 4).

In the case of units tested at a pressure deviating from 400 Pa, the measured leakage rate shall be converted into a value at a reference pressure, using the following formula:

$$Ql_{400} = Ql_{\mathrm{m}}\left[\frac{400}{\text{Test pressure}}\right]^{0.65}$$

where

Ql_{m} = Measured leakage rate at the actual test pressure; and

Ql_{400} = Derived leakage rate at 400 Pa.

Unless otherwise specified, the applicable rate shall be a function of the efficiency of the air filters within the air handling unit. Where there is more than one stage of air filtration, the classification shall be based on the efficiency of the highest grade of the filter.

8.6 Requirement Units Operating Under Both Negative and Positive Pressure

Air handling units with sections operating under positive pressure shall, in all cases, have the positive pressure sections tested separately from the rest of the unit where the operating pressure immediately downstream of the fan exceeds 250 Pa positive pressure. If the positive pressure does not exceed 250 Pa, a negative pressure test shall be sufficient. The test pressure applied to the positive pressure sections shall be 700 Pa positive pressure or the air handling unit's maximum positive operating pressure, whichever is the greater. The remainder of the unit shall be tested in accordance with **8.5**, with the applicable leakage rate being governed by the efficiency of the filter immediately upstream of the fan. It is also allowed to test the entire unit under positive and negative pressure. The air leakage from the sections subjected to 700 Pa positive pressure shall be in accordance with Table 7.

In the case of units tested at a pressure deviating from 700 Pa the measured leakage rate shall be converted into a value at reference pressure, using the following formula:

$$Ql_{700} = Ql_{\mathrm{m}}\left[\frac{700}{\text{Test pressure}}\right]^{0.65}$$

where

Ql_{m} = Measured leakage rate at the actual test pressure; and

Ql_{700} = Derived leakage rate at 700 Pa.

Air leakage tests on model units shall be performed at both 400 Pa negative pressure and 700 Pa positive pressure.

8.7 Determination of Allowable Leakage Rates

Calculate the casing surface area from the nominal external dimensions, including the area of the blanked inlet and outlet airflow aperture. The area of components which does not form part of the airtight casing shall be excluded, as well as the area of blanking plates on openings of separately tested unit sections. Leakage results obtained from test pressures deviating from the specified standard test pressure (maximum deviation ± 5 percent), shall be converted into leakage rates in accordance with the test pressure classifying the leakage class in Table 6 and/or Table 7. Determine the maximum allowable leakage from Table 6 and Table 7, as appropriate, and relate it to the casing area of the unit under test. The measured leakage rate shall be lesser than the allowable leakage rate. If the unit is tested in sections, the sum of the measured leakage rates for all sections shall be the less than allowable leakage rate as specified in Table 6 and/or Table 7.

9 FILTER BYPASS LEAKAGE

9.1 Requirements

9.1.1 *General*

Air bypass around the filter will decrease the effective efficiency of the filter, especially a high-efficiency one because the bypass air is not filtered. In addition, any inward leakage through the casing downstream of the filter has the same effect. Therefore, for filters located upstream of the fan, the airtightness and area of the casing between the filter and the fan are factors that can affect the filter bypass leakage rate.

9.1.2 *Acceptable Filter Bypass Leakage Rates*

Table 9 gives the acceptable filter bypass leakage rate, related to different filter classes, as percentages of the specified or nominal air flow rate of the air handling unit to be tested. If the filter is upstream of the fan, leakages of the sections between the filter and fan are deemed to be included in the specified values. In the case of downstream filters, the specified values are for the bypass around the filter only. The acceptable filter bypass leakage rate q_{va} shall be calculated by the formula:

$$q_{\mathrm{va}} = \frac{k \times q_{\mathrm{vnom}}}{100}$$

where

q_{vnom} = Airflow rate of the filter section, as given in Table 8; and

k = Filter bypass leakage rate, in percent of nominal volume flow rate, as given in **8**.

For filters located in upstream of the fan, bypass leakage shall be the sum of leakage around filter cells and the casing air leakage of the sections between the filter and the fan. For filters located in downstream of the fan, bypass leakage shall be around the filter cells only. The unit shall be deemed to pass if the specified value for the filter bypass leakage rate, determined in **9.1.2**, is no greater than the acceptable filter bypass leakage rate q_{va}.

9.1.3 *Two or More Filter Sections in the Same Unit*

If two or more filter sections are provided within the air handling unit, the filter bypass leakage shall be tested separately for each filter.

9.2 Testing

9.2.1 *General*

The specified test requirements refer to the complete Air Handling Unit. The filter shall be removed and replaced with blanking plates, for example, as shown in Fig. 9. These plates shall have the same shape, dimensions, and surface finish as the filter in the area relevant to airtightness.

Alternatively, the inlet face of every individual filter may be covered with a plate or a foil. The joints between the filter and frames shall not be covered and any additional fastenings of plates, foils shall not have any influence on the airtightness of the joints. Openings for electrical, air, or water services shall be closed prior to testing. The accuracy of the measuring device for the leakage airflow shall be ± 3.0 percent.

Table 7 Casing Air Leakage Classes of Air Handling Units, 700 Pa Positive Test Pressure

(*Clauses* 8.5, 8.6 *and* 8.7)

Sl No. (1)	Casing Leakage Class (2)	Maximum Leakage Rate, Ql_{700} l/m^2.s (3)	Casing Leakage Weight Age Factor, W_{LS} (4)
i)	CL 1	0.22	1.00
ii)	CL 2	0.63	0.75
iii)	CL 3	1.90	0.50

NOTE — Casing leakage shall be used for calculation of overall performance as in **11**.

Table 8 Airflow Rate of the Filter Section q_{vnom} Subject to the Type of Test Unit

(*Clause* 9.1.2)

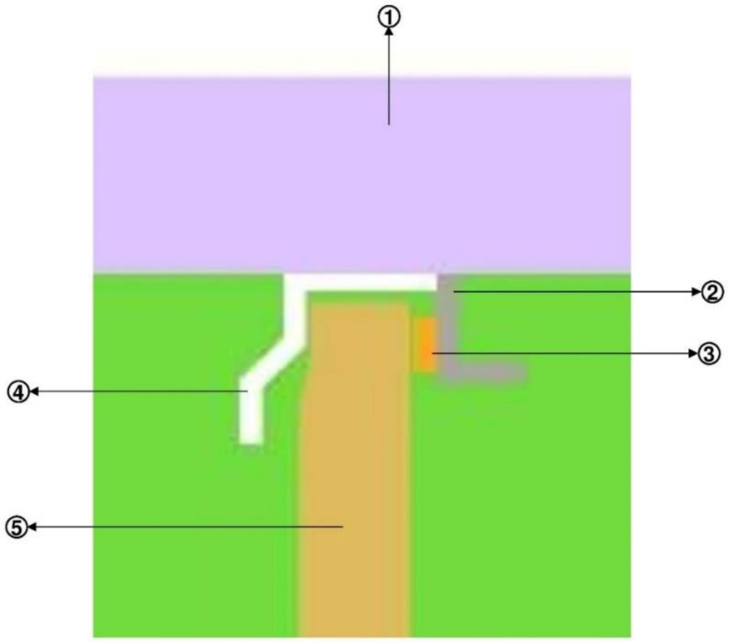
Sl No.	Test Criteria	Type of Test Unit	
		Model Test Unit	Real Unit
(1)	(2)	(3)	(4)
i)	Volume flow rate	Corresponds to a filter face velocity of 2.5 m/s	Normal operating conditions at selected design fan speed

Table 9 Acceptable Filter Bypass Leakage, at Test Pressure of 400 Pa

(*Clauses* 3.9, 9.1.2, 10.2 *and* B-4)

Sl No.	Filter Class	G1 to F5/(MERV 1 to 10)	F6/(MERV 11 and 12)	F7/MERV 13	F8/MERV 14	F9/MERV 15
(1)	(2)	(3)	(4)	(6)	(7)	(8)
i)	Maximum filter bypass leakage rate *k* in percentage of the volume flow rate	6	4	2	1	0.5
ii)	Filter bypass leakage weight age, W_{FB}	0.20	0.40	0.60	0.80	1.00

NOTE — The values in Table 9 are percentage leakage of unfiltered air. Filter bypass leakage shall be used for calculation of overall performance as in **11**.



Key

1 Casing wall
2 Frame
3 Seating
4 Fastener of filter cell
5 Plate

FIG. 9 METHOD OF BLANKING OFF FILTER CELLS

9.2.2 *Filters Downstream of the Fan* (*Positive Pressure*)

For testing, the inlet opening of the test filter section shall be covered with an airtight plate. A leakage test apparatus shall be connected as shown in Fig. 10 and Fig. 11. The outlet for the test filter shall be open. The test shall be carried out in two stages at a positive test pressure of 400 Pa.

Stage 1 — Determination of the total leakage, q_{Lt}. The total leakage shall be calculated by the formula:

$$q_{\mathrm{Lt}} = q_{\mathrm{L}} + q_{\mathrm{Lf}}$$

where

q_{Lt} = Total leakage;

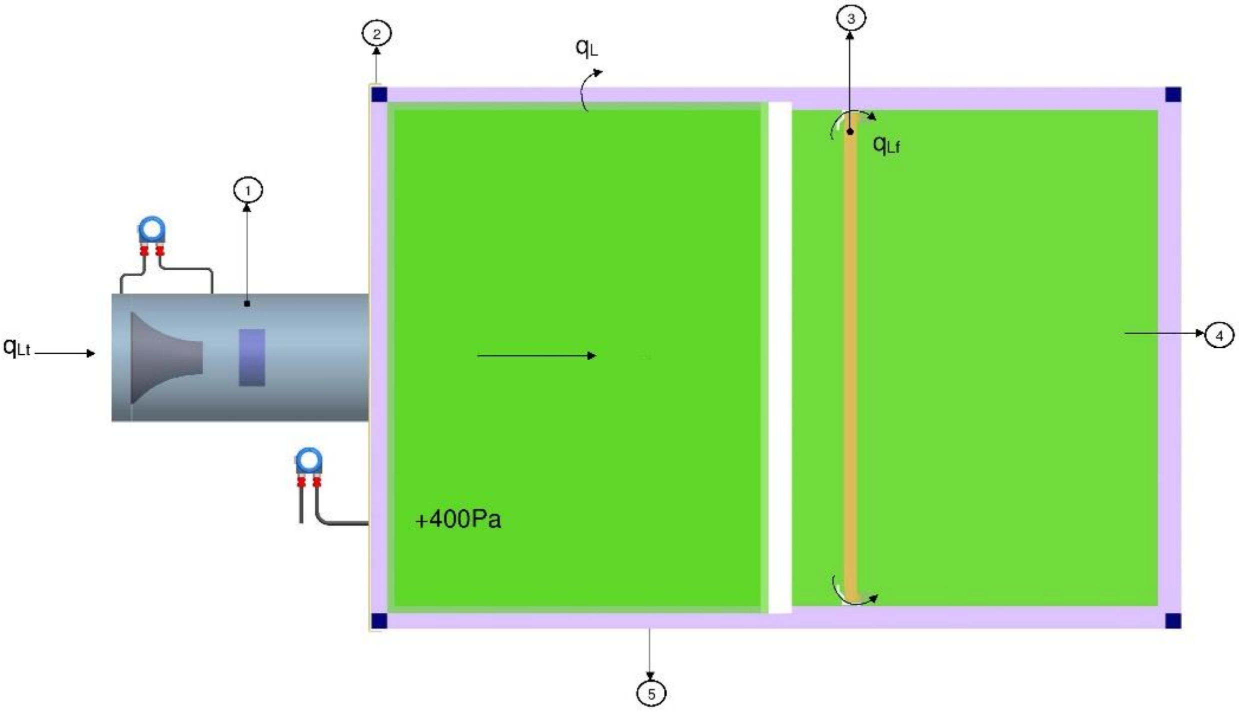
q_{L} = Sum of leakages through casing; and

q_{Lf} = Sum of leakages through the joints between the filter cell, the frame and the casing.

Measurement of the total leakage shall be carried out with blanking plates, replacing or covering individual filter cells in the filter section, as described in **9.2.1**.

Stage 2 — Determination of the leakage through the casing, q_{L}.

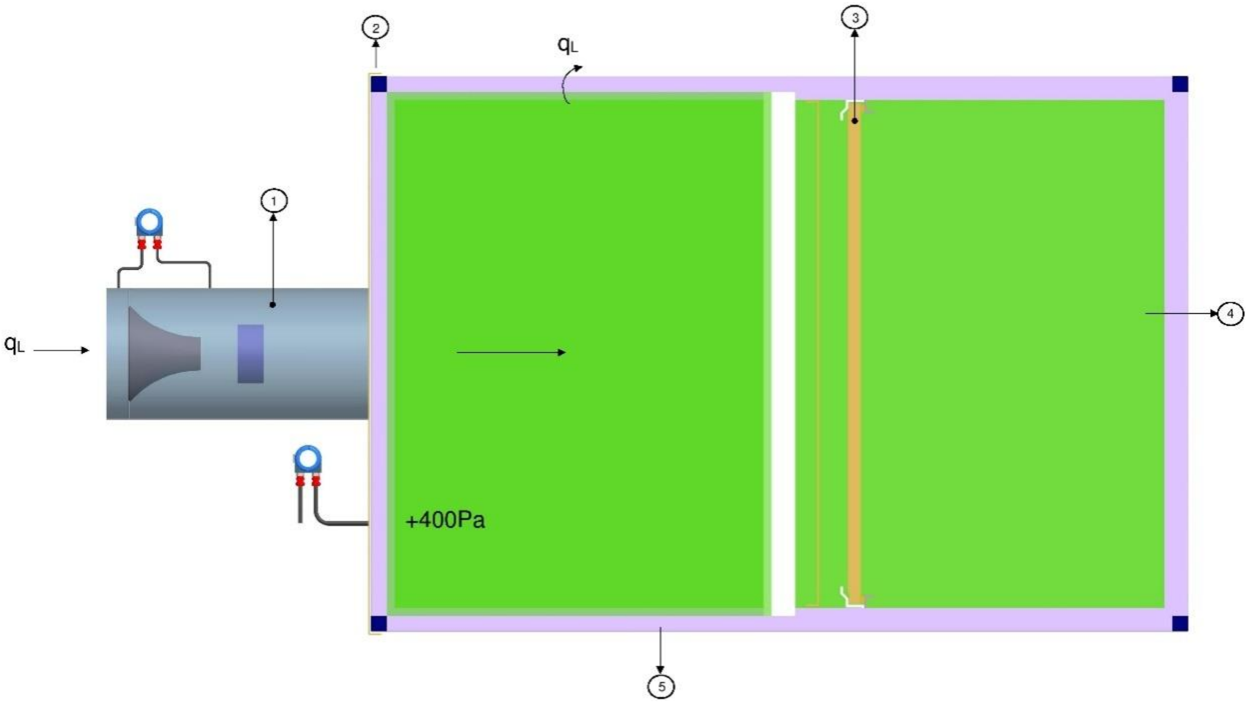
Air leakage through the casing shall be determined by eliminating all possible bypass leakage through the framework around the filter cells. Therefore, the entire frontal face area of filter frames and filter cells shall be blanked off, including the filter frames adjoining the casing panels.



Key

1 Leakage test apparatus
2 Inlet plate
3 Filter cells replaced by blanking plate or with blanking foil
4 Filter Section
5 Casing

FIG. 10 TEST APPARATUS FOR TESTING FILTER SECTIONS DOWNSTREAM OF THE FAN — STAGE 1



Key

1 Leakage test apparatus
2 Inlet plate
3 Filter cells replaced by blanking plate or with blanking foil
4 Filter section
5 Casing

FIG. 11 TEST APPARATUS FOR TESTING FILTER SECTIONS DOWNSTREAM OF THE FAN — STAGE 2

The value used to calculate the leakage is specified by the formula:

$$q_{\mathrm{Lf}} = q_{\mathrm{Lt}} - q_{\mathrm{L}}$$

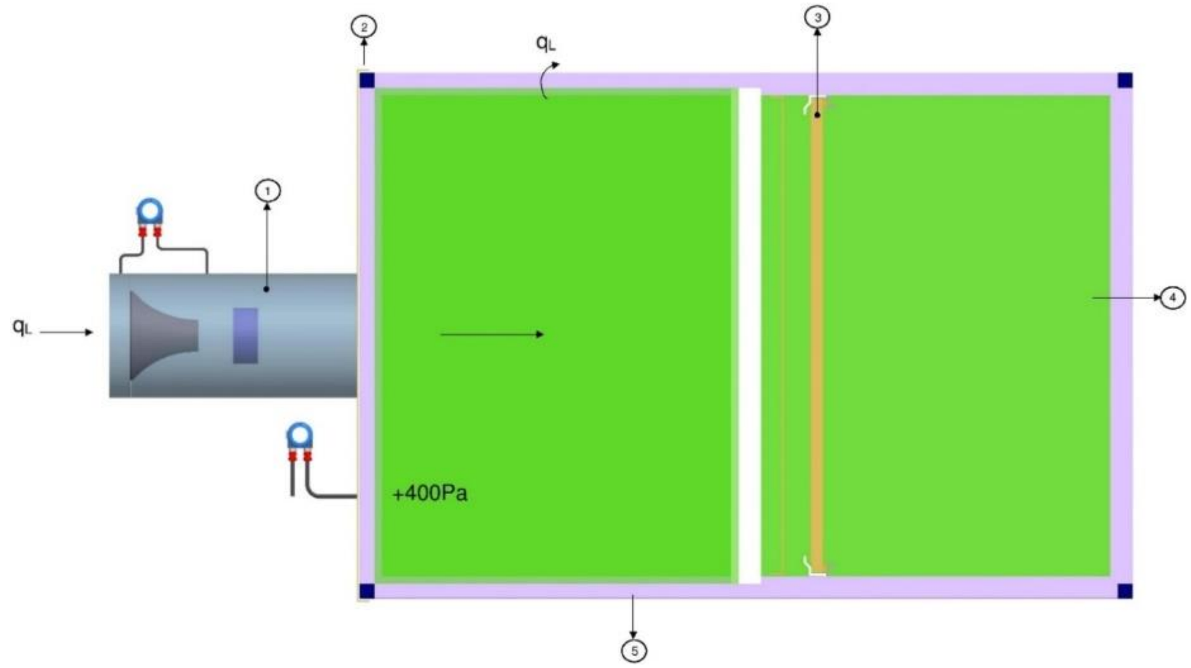
where

q_{Lt} = Total leakage;
q_{L} = Sum of leakages through casing; and
q_{Lf} = Sum of leakages through the joints between the filter cell, the frame and the casing.

9.2.3 *Filters Upstream of the Fan* (*Negative Pressure*)

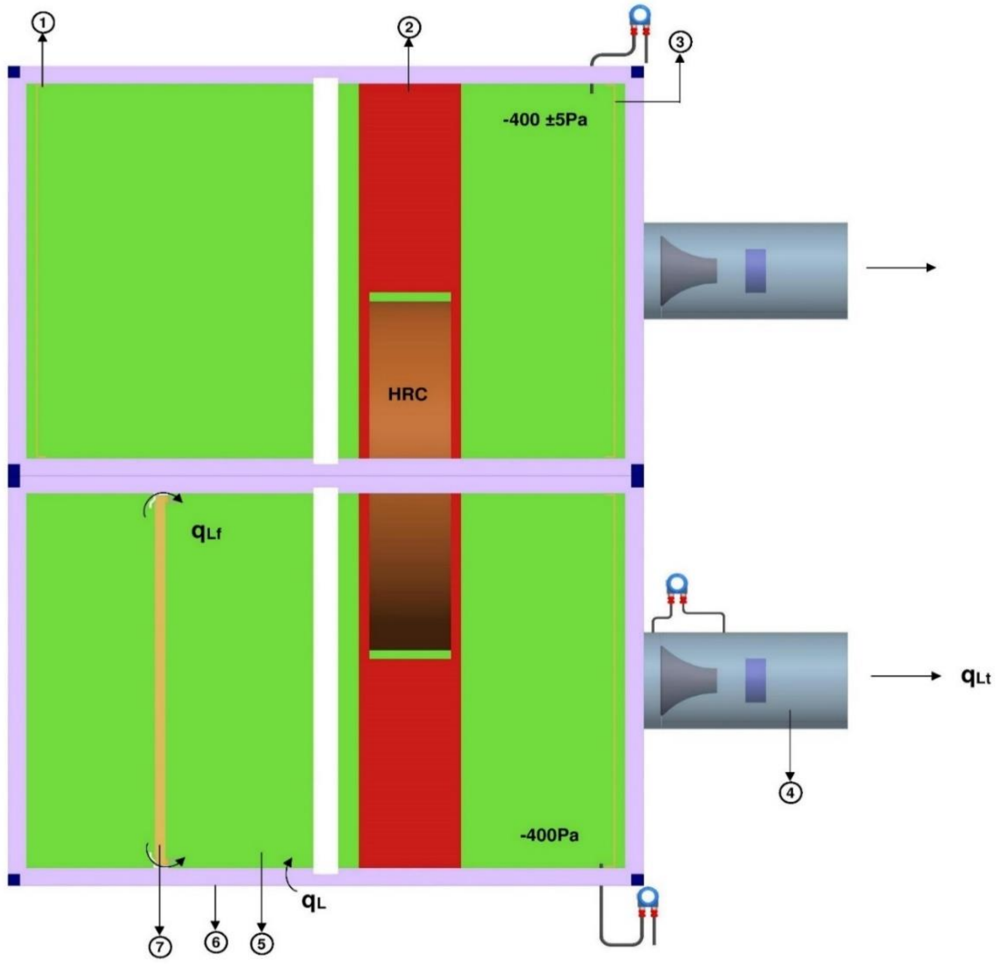
For testing, the outlet opening of the section, which is downstream of the filter under negative pressure, shall be covered with an airtight plate. A leakage test apparatus shall be connected, as shown in Fig. 12. The inlet opening of the test filter section shall be open.

The following steps shall be added if there is a heat recovery section between the filter and the fan. Connect a pressurization fan to one airside opening of the unit part which does not contain the filter to be tested and close all other openings. A second fan shall be connected on the discharge side of the part that contains the filter frame to be tested. Regulate the negative pressure downstream filter to 400 Pa and the pressure difference between the two air sides to ± 5 Pa (*see* Fig. 13).



Key
1 Leakage test apparatus
2 Outlet plate
3 Filter cells replaced by blanking plate or with blanking foil
4 Filter section
5 Casing

FIG. 12 TEST APPARATUS FOR TESTING FILTER SECTIONS UPSTREAM OF THE FAN



Key
1 Inlet plate
2 Heat recovery device
3 Outlet plate
4 Leakage test apparatus
5 Filter section
6 Casing
7 Filter cells replaced by blanking plates or individually covered with foil

FIG. 13 TEST APPARATUS FOR TESTING FILTER SECTIONS WITH HEAT RECOVERY SECTION

The test shall be carried out at a negative test pressure of 400 Pa. The total leakage is specified by the formula:

$$q_{\mathrm{Lt}} = q_{\mathrm{L}} + q_{\mathrm{Lf}}$$

where

q_{Lt} = Total leakage;

q_{L} = Sum of leakages through casing; and

q_{Lf} = Sum of leakages through the joints between the filter cell, the frame and the casing.

This is the value to calculate the filter bypass leakage rate. Filter frames in test units model boxes shall be tested both as filter sections downstream (positive pressure) and upstream (negative pressure) of the fan. The bypass test under positive pressure shall also be conducted in two stages as described in 9.2 to eliminate the casing leakage. For a non–ambiguous interpretation of figures, only the bypass leakage across the filter frame shall be specified.

Example:

A test was performed for a filter section with 4 filters.

Surface section area = 1.49 m^2

Face velocity = 2.5 m/s

Air flow rate = 3.725 m^3/s

The following values were determined:

a) Testing filter sections downstream of the fan (positive pressure).

Total leakage, $q_{Lt} = 27.5 \times 10^{-3}$ m^3/s

Leakage through the casing, $q_L = 14.5 \times 10^{-3}$ m^3/s

Leakage through the filter, $q_{Lf} = 13.0 \times 10^{-3}$ m^3/s

Filter bypass leakage rate = 0.35 percent

b) Testing filter sections upstream of the fan (negative pressure).

Total leakage, $q_{Lt} = 24.5 \times 10^{-3}$ m^3/s

Leakage of unfiltered air, $q_{Lf} = 24.5 \times 10^{-3}$ m^3/s

Filter bypass leakage rate = 0.66 percent

Usable filter class = F8 (MERV 14)

10 THERMAL PERFORMANCE OF CASING

10.1 General

Thermal performance of the casing shall be measured by thermal transmittance as defined in **10.2** and thermal bridging as defined in **10.3**. The test shall be conducted on a model test unit constructed as defined in **7.1.1**.

10.2 Thermal Transmittance Requirements

Mean heat loss coefficient [thermal transmittance (U)] is only measured on model box and is calculated as defined in **10.5** (*see* Table 9).

NOTE — Thermal transmittance is the rate of transfer of heat through the matter. The thermal transmittance of a material or an assembly is expressed as a U-value.

10.3 Thermal Bridging Requirement

Thermal bridging requirement shall be tested on the test model and measurements shall be taken under steady-state conditions. Under the steady-state condition, when the mean temperature difference between internal air and external air temperatures are stabilized at 20 K, the lowest value of temperature difference between any point on the external surface and the mean internal air temperature shall be established. The ratio between the lowest temperature difference and the mean air-to-air temperature difference determines the thermal bridging factor (*see* Table 11).

NOTE — Thermal bridging is an area or component of an object which has higher thermal conductivity than the surrounding materials, creating a path of least resistance for heat transfer. Performance of unit can be compared by defining a thermal bridging factor.

Table 10 Thermal Transmittance

(*Clause* 3.8)

Sl No. (1)	Class (2)	Thermal Transmittance, *U* W/m^2.K (3)	Casing Thermal Transmittance Weightage Factor, W_{TT} (4)
i)	T1	$U \leq 0.5$	1.0
ii)	T2	$0.5 < U \leq 1.0$	0.8
iii)	T3	$1.0 < U \leq 1.4$	0.6
iv)	T4	$1.4 < U \leq 2.0$	0.4

where

W_{TT} = Weightage on basis of thermal transmittance class used for calculating mechanical performance of the AHU as defined in **11**.

Table 11 Thermal Bridging

(*Clause* 10.3)

Sl No.	Class	Thermal Bridging Factor, k_b	Casing Thermal Bridging Weight Age Factor, W_{TB}
(1)	(2)	(3)	(4)
i)	TB1	$0.75 \leq k_b \leq 1.00$	1
ii)	TB2	$0.60 \leq k_b < 0.75$	0.8
iii)	TB3	$0.45 \leq k_b < 0.60$	0.6
iv)	TB4	$0.30 \leq k_b < 0.45$	0.4

where

W_{TB} = Weightage on basis of thermal bridging class used for calculating mechanical performance of the AHU as defined in **11**.

10.4 Testing

The electrical heaters and fans are energized from a stable power source with constant voltage till steady-state conditions are achieved. The conditions are said to be steady-state when the standard deviation of readings of difference between mean external temperature and mean internal temperature is less than or equal to 1.0 K for 30 min.

During measurement, the temperature difference among the measurement points inside the unit shall not exceed 2.0 K nor shall the difference between the three consecutive mean temperature measurements in the inner zones exceed 0.5 K. The difference between the outside air temperatures at measuring points shall not exceed 0.5 K.

The power input to heaters and fans is measured when the difference between the mean internal and mean external temperatures is at least 20 K shall be used to determine Thermal Transmittance, U.

NOTE — The instrument with an accuracy of ± 1 percent of the measured value shall be used for power measurement.

To thermal bridging factor shall be calculated by the measurement of mean internal temperature at the eight points limiting each section, together with the maximum outside temperature, measured under steady-state conditions. The thermal bridging factor, k_b, shall be calculated by taking the lowest value for the three sections for defining the temperature class.

NOTE — The diameter of surface temperature measuring instrument shall be 7 mm to 9 mm, and the maximum uncertainty of temperature measurement shall be ± 0.2 K. Infrared imaging can assist in locating the maximum external surface temperatures.

10.5 Calculations

Thermal transmittance shall be calculated by using equation below:

$$U = \frac{P_{el}}{A \times \Delta t_{air}}$$

where

U = Thermal transmittance, W/m^2.K;

P_{el} = Electrical power input for heater(s) and circulating fans, W;

A = External surface area, m^2; and

Δt_{air} = Air to air differential temperature, K.

Thermal bridging factor k_b, shall be calculated by using the equation below.

$$k_b = \frac{\Delta t_{min}}{\Delta t_{air}} = \frac{t_i - t_{s-max}}{t_i - t_a}$$

where

k_b = Thermal bridging factor;

Δt_{min} = Least differential temperature (internal air-casing), K;

Δt_{air} = Air to air differential temperature, K;

t_i = Mean internal air temperature, °C;

t_{s-max} = Measured maximum external surface temperature, °C; and

t_a = Mean external air temperature, °C.

Terms in the applicable equations (either measured or calculated) shall be rounded off to the number of decimal places as specified below:

P_{el}, Δt_{air}, Δt_{min}, t_i and t_a shall be rounded off to 1 decimal place and A (Area) shall be rounded off to 2 decimal places.

To calculate an average temperature, readings with more decimal places may be used. Rounded off terms shall be used in the relevant formulas to calculate the U value and k_b factors. Calculated values for thermal transmittance and thermal bridging factors shall be rounded off to two decimal places.

11 OVERALL MECHANICAL PERFORMANCE

11.1 To determine the overall mechanical performance weights are assigned to each performance criteria and these weights are assigned on basis of their importance in energy consumption. As shown in the below Table 12, 5 percent weightage is assigned to casing strength class and filter bypass class, 15 percent weightage is assigned to casing leakage class and 30 percent weightage is assigned to thermal transmittance class and thermal bridging class.

11.2 Acoustic Performance Level

The sound power level shall be measured as per ISO 3744 and shall be 80 dB or less.

12 ENERGY EFFICIENCY CLASS

In this method the impacts of the various factors are weighted together to establish the final energy class. Energy to air handling units (AHUs) is divided into two main groups:

a) Thermal energy (for cooling); and
b) Electrical energy for fans.

NOTE — Different levels for thermal energy consumption for cooling are covered by the consideration of the heat recovery system (HRS) efficiency. The climate dependency for the thermal energy consumption is considered and the difference in primary energy between thermal energy and electrical energy is taken into account to evaluate the impact of the pressure drops across the HRS.

13 RATING AND PERFORMANCE OF AIR HANDLING UNIT

13.1 Testing of Aerodynamic Performance

The test as defined in this clause shall determine the performance of entire AHU.

13.1.1 *Characteristics*

a) External Total Pressure Difference of the Unit — The difference in total pressure between outlet and inlet of the air handling unit related to the air volume flow at the measurement plane; and
b) Electrical motor input power — The power input to the fan motor related to the air volume flow.

NOTE — If a speed adjustment device is needed, for example, frequency inverter, the electrical motor input power shall include the power of speed control devices.

13.1.2 *Quantities*

13.1.2.1 Air volume flow rate (q_v) shall be measured by any method which is in accordance with ISO 5801, for example, a nozzle, an orifice plate or a pitot-static tube.

13.1.2.2 External total pressure difference of the unit (P_{tu}) shall be calculated from the pressure measurements defined in **13.1.1** and is the difference between the total pressure at the outlet of the air handling unit and the total pressure at the inlet.

NOTE — The transition duct sizes shall be as defined by the manufacturer.

The external total pressure difference of the unit is:

$$P_{tu} = P_{tu2} - P_{tu1}$$

where

P_{tu1} = Sum of the static and the dynamic pressure at inlet, Pa; and

P_{tu2} = Sum of the static and dynamic pressure at outlet, Pa.

13.1.2.3 Density of air (ρ) shall be calculated as below.

$$\rho = \frac{P_a - 0.378\,P_v}{287\,(278 + t_a)}\ \text{kg/m}^3$$

where

P_a = Atmospheric pressure, Pa;

P_v = Partial pressure of water vapor in the air, Pa;

287 = Gas constant of dry air, J/kg.K; and

t_a = Dry-bulb temperature, °C

13.1.2.4 Temperature of the air (t_a), shall be measured at the point of flow measurement.

13.1.2.5 Rotational speed of the fan (n_F), shall be measured at each test point.

13.1.2.6 Electrical motor input power (P_E), the power to the fan motor, shall be measured at each test point. The applied voltage and the current to each phase shall also be recorded when measured.

13.2 Test Method

Tests shall be carried out in accordance with either by chamber test method or ducted test method shown in ISO 5801. For ducted test installation, Types B, C, or D shall be adopted as best suited to the geometry of the air-handling unit and the test facilities available.

NOTE — When a standardized test chamber is used it shall conform to the requirements of **31** of ISO 5801.

The three installation types are:

a) Type B, free inlet, ducted outlet;

b) Type C, ducted inlet, free outlet; and

c) Type D, ducted inlet, ducted outlet.

NOTES

1 Free inlet or outlet means that air enters or leaves the air handling unit directly from or to the un-obstructed free atmosphere.

2 Ducted inlet or outlet signifies that air enters or leaves the unit through a duct directly connected to the unit inlet or outlet.

13.2.1 *Ducted Test Method*

The common parts of a ducted system, for Types B, C, or D installations, shall conform to the requirements of **30** of ISO 5801. The cross-sectional dimensions of the air outlet shall be used to determine the dimensions of the outlet ducting required in a Type B or Type D installation, and the inlet ducting required in a Type C or Type D installation.

13.2.2 *Measurement Procedure*

13.2.2.1 *Conditions for measurements*

Airflow control dampers of the air handling unit to be tested shall be fully open. Other dampers that form part of a different air circuit, for example, bypass and recirculation dampers, shall be fully closed.

All elements included in the design of the air handling unit shall be fitted as intended with filters and dry coils. If there is no negative influence on the internal pressure of the unit, the average filter pressure drop shall be simulated by increasing the external total pressure difference of the unit with a value equal to the difference between the rated average and initial filter pressure drop.

Where the duty specified is for an initial or final filter condition, the simulated external total pressure difference applied shall be the rated design value or shall be increased by the difference between the rated final and initial filter pressure drop (as appropriate).

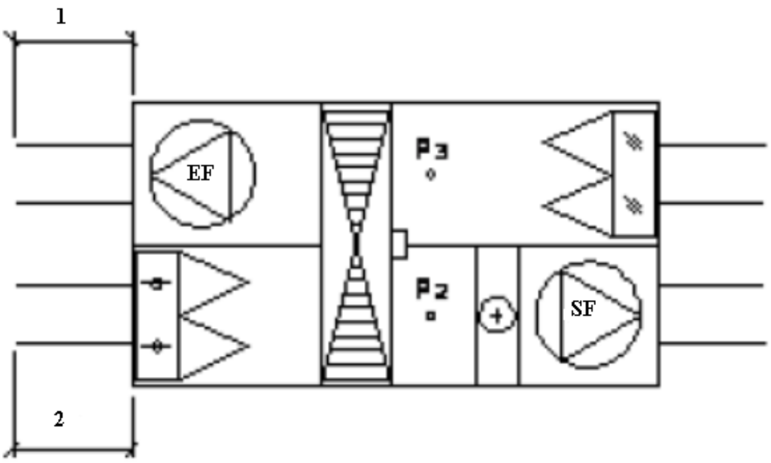
13.3 Testing of Unit with Heat Recovery

Testing shall be performed considering the leakage between the air streams.

Table 12 Overall Mechanical Performance Value

(*Clauses* 11.1 *and* C-1)

Sl No.	Weightages for Overall Mechanical Performance Value, MPV	
(1)	(2)	(3)
i)	Casing strength class	5 % (W_{CS})
ii)	Casing leakage class–Positive pressure	15 % (W_{CL+})
iii)	Casing leakage class–Negative pressure	15 % (W_{CL-})
iv)	Filter bypass class	5 % (W_{FB})
v)	Thermal transmittance class	30 % (W_{TT})
vi)	Thermal bridging class	30 % (W_{TB})
vii)	Overall mechanical performance value, MPV	(5 %) W_{CS} + (15 %) W_{CL+} + (15 %) W_{CL-} + (5 %) W_{FB} + (30 %) W_{TT} + (30 %) W_{TB}



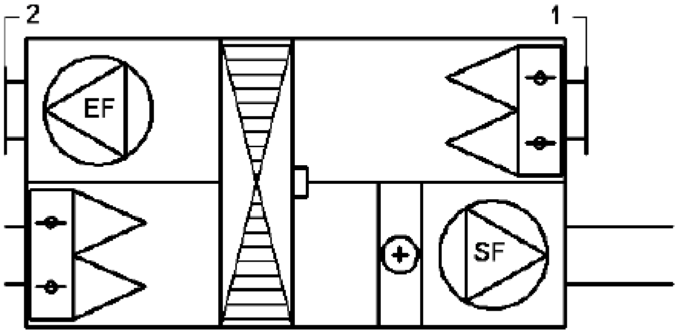
Key

1 Pressure drop measurement point on exhaust air side.
2 Pressure drop measurement point on supply air side.
EF – Exhaust air fan
SF – Supply air fan

FIG. 14 TESTING OF COMPLETE UNIT

The airflow shall be measured at the supply air side and at the extract airside. The external pressures shall be set to design pressure conditions. Unless otherwise stated, the pressure drop on the outdoor airside and exhaust airside is set to 50 Pa. The remainder of the external pressures shall be set on the supply and extract air openings. In order to avoid leakages from the extract air stream to the supply air stream, the pressure P_2 should be higher than the pressure P_3. The two pressures P_2 and P_3 shall be measured. The leakage and the extra pressure drop are the responsibility of the manufacturer (*see* Fig. 14).

13.4 Testing of One Air Stream



Key

1 Inlet plate.
2 Outlet plate.
EF – Exhaust air fan
SF – Supply air fan

FIG. 15 TESTING OF ONE AIR STREAM

If just one air stream is to be tested, then the connections of the opposite airstream shall be closed with airtight plates (*see* Fig. 15).

13.5 Measurements

Atmospheric pressure and temperature shall be measured at the beginning of the test. Pressure measurements, at the locations and in the manner described in ISO 5801, shall be recorded at a sufficient number of test points enabling the characteristic curve to be plotted through the specified duty point or over the full operating range, whichever is required. The rotational speed of the fan and the electrical input to the fan motor shall be recorded at each of the test points.

13.6 Evaluation of Results

For each operating point, the external total pressure of the unit and air volume flow shall be calculated in accordance with ISO 5801. It is sufficient, in most circumstances, to adopt the simplified procedures applicable when the mach number is less than 0.15 and the fan pressure ratio is less than 1.02 (corresponding to a pressure rise less than 2 000 Pa in ambient air).

13.6.1 *Tolerances*

The air performance quoted or specified shall be the most probable, not the minimum or maximum acceptable value. The test for the specified duty shall be conducted in accordance with **16.7** of ISO 5801.

The tolerance shall be applied to a specified duty or duties, not to every point on the air handling unit characteristic. The characteristic is drawn from the measured data and mathematically converted to the standard density of 1.2 kg/m^3 (*see* Table 13).

The permissible deviation of the specified duty point from the operating point on the air handling unit characteristic is the sum of the tolerance range of the specified duty point and the uncertainty range of the measured data. This uncertainty range derives from the measuring uncertainty of the methods of measurement and the measuring instruments and is to be stated for a confidence level (probability) of 95 percent.

$$q_{\mathrm{vm}} - q_{\mathrm{vs}} = \Delta q_{\mathrm{v}} \leq t \times q_{\mathrm{vs}} + u \times q_{\mathrm{vm}}$$

where

Δq_{v} = Allowable difference in air volume flow, m^3/s;

t = Tolerance range of duty point, in percent;

u = Uncertainty range of measured data, in percent;

Δ = Admissible deviation;

q_{vs} = Specified (design) air volume flow, m^3/s; and

q_{vm} = Measured and converted air volume flow, m^3/s.

Table 13 Air Handling Unit Performance Tolerances

(*Clause* 13.6.1)

Sl No.	**Working values**	**Tolerance Range**	**Remarks (*see* Fig. 16)**
(1)	(2)	(3)	(4)
i)	Air volume flow, q_{v} in m^3/s	± 5 percent	$\Delta q_{\mathrm{v}} = (t_{\mathrm{qv}}/100 \text{ percent}) \times q_{\mathrm{v}}$
ii)	External total pressure difference, p_{tu} in Pa	± 5 percent	$\Delta p_{\mathrm{tu}} = (t_{\Delta \mathrm{p}}/100 \text{ percent}) \times p_{\mathrm{tu}}$
iii)	Electrical motor input power P_{E} in W	8 percent	$\Delta P_{\mathrm{E}} = (t_{\mathrm{P}}/100 \text{ percent}) \times P_{\mathrm{E}}$

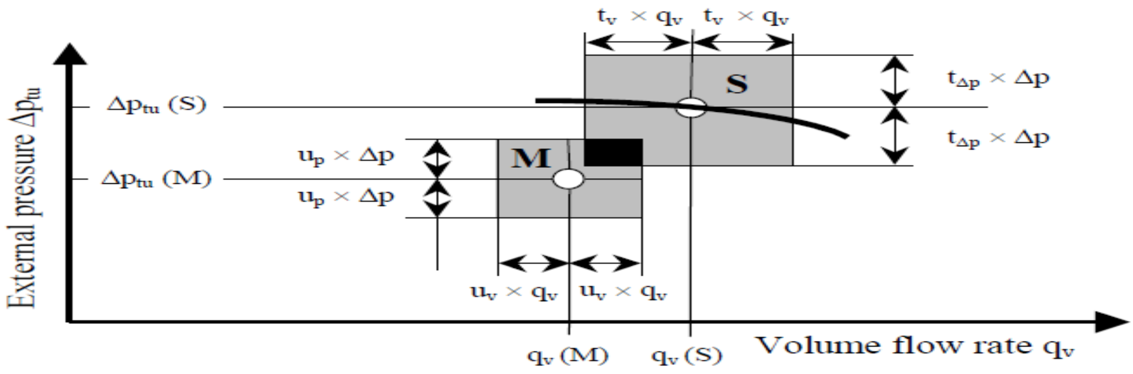


FIG. 16 ADMISSIBLE TOLERANCES

NOTE — Tolerance of 5 percent on air flow rate and external total pressure difference is allowed. Tolerance of + 8 percent on absorbed motor power is allowed.

13.7 Rated cooling and heating capacity shall be within negative tolerance of 5 percent of the value declared by the manufacturer.

13.8 Rated water pressure drop shall be within positive tolerance of 10 percent of the value declared by the manufacturer or 2.98 kPa which is higher.

14 RATING AND PERFORMANCE OF INDIVIDUAL COMPONENTS OF AIR HANDLING UNIT

14.1 Fan Section

14.1.1 *Air Velocity Class*

14.1.1.1 *General*

For hygiene reasons and to reduce maintenance expenditure, it is recommended to arrange supply air fans in such a way that the suction-side leakage air flows are minimized. The arrangement of the fan in the air handling unit casing shall ensure an even inflow and outflow of air. Additional inflow and outflow devices should be fitted for this purpose if necessary.

The air velocity in the unit has a large influence on energy consumption. The velocities are calculated for air velocity in the AHU cross-section. The velocity is based on the square area of the filter section of a unit, or if no filter is installed, it is based on the square area of the fan section. Velocity class should be determined according to Table 14.

Table 14 Classes of Air Velocity Levels

(*Clause* 14.1.1.1)

Sl No. (1)	Class (2)	Air Velocity m/s (3)
i)	V_f1	$v \leq 1.2$
ii)	V_f2	$1.2 < v \leq 1.4$
iii)	V_f3	$1.4 < v \leq 1.6$
iv)	V_f4	$1.6 < v \leq 1.8$
v)	V_f5	$1.8 < v \leq 2.4$
vi)	V_f6	$2.4 < v \leq 2.8$
vii)	V_f7	$2.8 < v \leq 3.4$
viii)	V_f8	$3.4 < v \leq 4.0$
ix)	V_f9	$v > 4.0$

Fans with blades curved backwards shall be provided on energy reasons. To reduce the consumption of electric power even further, energy-saving motors with increased efficiency should preferably be fitted.

14.1.2 *Fan Power Consumption Class*

$$Pm_{\text{ref}} = \left(\frac{\Delta P_{\text{stat}}}{450}\right)^{0.925} \times (q_{\text{v}} + 0.08)^{0.95}$$

where

Pm_{ref} = Reference value absorbed power, kW (*see* Table 15);

ΔP_{stat} = Available static pressure (p_{internal} + p_{external}), Pa; and

q_{v} = Air flow rate of the fan, m^3/s.

Table 15 Classification of Power Consumption Fan

(*Clause* 14.1.2)

Sl No. (1)	Class (2)	***Pm Max*** kW (3)
i)	*P*1	$\leq Pm_{ref} \times 0.85$
ii)	*P*2	$\leq Pm_{ref} \times 0.90$
iii)	*P*3	$\leq Pm_{ref} \times 0.95$
iv)	*P*4	$\leq Pm_{ref} \times 1.00$
v)	*P*5	$\leq Pm_{ref} \times 1.06$
vi)	*P*6	$\leq Pm_{ref} \times 1.12$
vii)	*P*7	$> Pm_{ref} \times 1.12$

14.2 Heat Recovery Section

Table 16 Energy Efficiency of Heat Recovery System

(*Clause* 14.2)

Sl No. (1)	Class (2)	Temperature Efficiency (η_t) (3)	ΔP_{HRS} Pa (4)	COP ε (5)	Energy Efficiency (η_e) (6)
i)	*H*1	0.75	2 × 280	19.5	0.71
ii)	*H*2	0.67	2 × 230	21.2	0.64
iii)	*H*3	0.57	2 × 170	24.2	0.55
iv)	*H*4	0.47	2 × 125	27.3	0.45
v)	*H*5	0.37	2 × 100	26.9	0.36

To determine the HRS energy efficiency two parameters pressure drop (ΔP) and temperature efficiency (η_t) are used (*see* Table 16).

Temperature efficiency, η_t

$$= \frac{t_{ODA} - t_{SUP}}{t_{ODA} - t_{ETA}}$$

Pressure drop, ΔP_{HRS}

$$= \Delta P_{Supply} + \Delta P_{exhaust}$$

Electric power consumption, P_{el}

$$= \frac{q_v \times \Delta P_{HRS}}{\eta_{el}} + P_{aux}$$

where

Standard value for η_{el} = 0.6;

P_{aux} = Power consumption of other auxiliaries such as any moving mechanical assembly;

ΔP_{HRS} = According to Table 16 (energy efficiency of heat recovery system); and

t_{ODA} = Outdoor air temperature, that is, ambient temperature, in °C.

HRS performance,

$$Q_{HRS} = q_v \times \rho \times c_p \times \eta_t (t_{ODA} - t_{ETA})$$

Coefficient of performance, $\varepsilon = \frac{Q_{HRS}}{P_{el}}$

Energy Efficiency, $\eta_e = \eta_t \times \left(1 - \frac{1}{\varepsilon}\right)$

Classification based on energy efficiency of heat recovery system is given in the Table 17.

Table 17 Classes of Heat Recovery

(*Clauses* 14.2 *and* 14.3)

Sl No.	Class	η_e %
(1)	(2)	(3)
i)	*H*1	≥ 71
ii)	*H*2	≥ 64
iii)	*H*3	≥ 55
iv)	*H*4	≥ 45
v)	*H*5	≥ 36

14.3 Mixing Sections

The mixing section can have a major influence on the air flows and pressure balance within the ventilation or air conditioning system and hence the building. The quality of mixing is characterized by the temperature mixing efficiency specified in Table 18. The mixing efficiency shall be measured at recirculation flow damper positions 90 percent open, 50 percent open, and 20 percent open. Mean temperature of mixed flow can be calculated using,

$$t_M = \frac{t_H \cdot \rho_H \cdot q_{vH} + t_L \cdot \rho_L \cdot q_{vL}}{\rho_{tot} \cdot q_{vtot}}$$

Mean velocity is calculated using,

$$V_M = \frac{q_v}{A_{tot}}$$

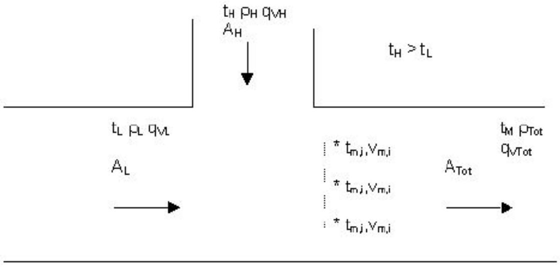


FIG. 17 QUANTITIES TO DEFINE MIXING EFFICIENCIES

The temperature mixing efficiency is calculated from,

$$\eta_{mix} = \left[1 - \frac{t_{max} - t_{min}}{t_H - t_L}\right] \times 100\ \%$$

where

η_{mix} = Mixing efficiency, in percent (*see* Table 17);

t_{max} = Highest temperature in the measuring plane downstream the mixing section, °C;

t_{min} = Lowest temperature in the measuring plane downstream the mixing section, °C;

t_H = Higher temperature of entering air, °C; and

t_L = Lower temperature of entering air, °C.

Table 18 Mixing Temperature Efficiency

(*Clause* 14.3)

Sl No.	Class	Mixing Efficiency, in percent
(1)	(2)	(3)
i)	M_x1	$\eta_{mix} \geq 95$
ii)	M_x2	$85 \leq \eta_{mix} < 95$
iii)	M_x3	$70 \leq \eta_{mix} < 85$
iv)	M_x4	$50 \leq \eta_{mix} < 70$
v)	M_x5	$\eta_{mix} < 50$

NOTE — Dampers used for above may be as per National/International standards. The relevant Indian Standard is under preparation.

14.4 Filter Sections

The task of air filters in heating, ventilation, and air conditioning (HVAC) systems is not only to protect the ventilated rooms from a severe level of contamination but also to protect the HVAC system itself. This is guaranteed by the use of fine filters of filter Class F5 to F9. The first filter stage is to be fitted on the intake side, as close as possible to the outer air intake aperture to keep the air treatment elements as clean as possible. Additional coarse filters G1 to G4 are also permissible. The sidewall on the service side of the filter section shall be equipped with an inspection door. The width and height of the door shall be greater than the external dimensions of the replaceable filter elements. If a single-stage filter system is used, a minimum of filter Class G4 shall be fitted. If two-stage filtering is used, the supply air fan shall be arranged between the first and second filter stage. (*see* Table 19).

Table 19 Maximum Final Pressure Drop for Filters

(*Clause* 14.4)

Sl No.	Filter Class as per IS 17570 (Part 1 to 4), MERV	Final Pressure Drop Pa
(1)	(2)	(3)
i)	G1 – G4 (MERV 1 – 8)	150
ii)	F5 – F7 (MERV 8 – 14)	200
iii)	F8 – F9 (MERV 14 – 16)	300

15 MARKING, LABELS AND MANUALS

15.1 A name plate of corrosion-resistant material shall be affixed on the AHU with the following details:

a) Manufacturer’s name and address;
b) Model number designation;
c) Serial number;
d) Rated capacity;
e) Rated voltage, phase and frequency;
f) Rated air volume;
g) Rated power consumption;
h) Overall mechanical performance value; and
j) Thermal performance value.

15.2 The operation and maintenance manual shall be supplied with the AHU. The operation and maintenance manual shall provide minimum of following:

a) Exploded view drawing of the unit with component naming;

b) Operation and safety instructions;

c) Installation instructions, precautions, warnings and drawings;

d) Internal electrical circuit diagram and field connection drawings;

e) Instructions for safe use in service and maintenance;

f) Instructions for starting and closing down the equipment;

g) Instructions for monitoring equipment and instrumentation, periodical inspections; recommendations for inspection intervals;

h) Description of normal operation of the unit, instructions concerning protection and control equipment, instructions for fault finding;

j) Service and cleaning instructions including drawings; for components which require periodical servicing or changing, an estimated service schedule and a list of spare parts and accessories are required;

k) Estimated schedule for periodical inspections; and

m) For each functional section of the air-handling unit, appropriate instructions for operation and maintenance are required.

15.3 BIS Certification Marking

The product conforming to the requirements of this standard may be certified as per the conformity assessment schemes under the provisions of the *Bureau of Indian Standards Act*, 2016 and the Rules and Regulations framed there under, and the product may be marked with the Standard Mark.

ANNEX A

(*Clause* 2)

LIST OF REFERRED STANDARDS

IS/Other Standards	*Title*
IS 3615 : 2020	Glossary of terms used in refrigeration and air conditioning (*second revision*)
IS 9844 : 1981	Methods of testing corrosion resistance of electroplated and anodized aluminium coatings by neutral salt spray test
IS 17570	Air filters for general ventilation:
(Part 1) : 2021/ ISO 16890-1 : 2016	Technical specifications, requirements and classification system based upon particulate matter efficiency (ePM)
(Part 2) : 2021	Measurement of fractional efficiency and air flow resistance (ISO 16890-2 : 2016, MOD)
(Part 3) : 2021/ ISO 16890-3 : 2016	Determination of the gravimetric efficiency and the air flow resistance versus the mass of test dust captured
(Part 4) : 2021/ ISO 16890-4 : 2016	Conditioning method to determine the minimum fractional test efficiency
ISO 3744 : 2010	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 5801 : 2017	Fans — Performance testing using standardized airways

To access Indian Standards click on the link below:

https://www.services.bis.gov.in/php/BIS_2.0/bisconnect/knowyourstandards/Indian_standards/isdetails/

ANNEX B

(*Clause* 7.1.1.4)

GUIDANCE FOR PERFORMANCE EVALUATION METHOD FOR COMPOSITE AIR HANDLING UNIT

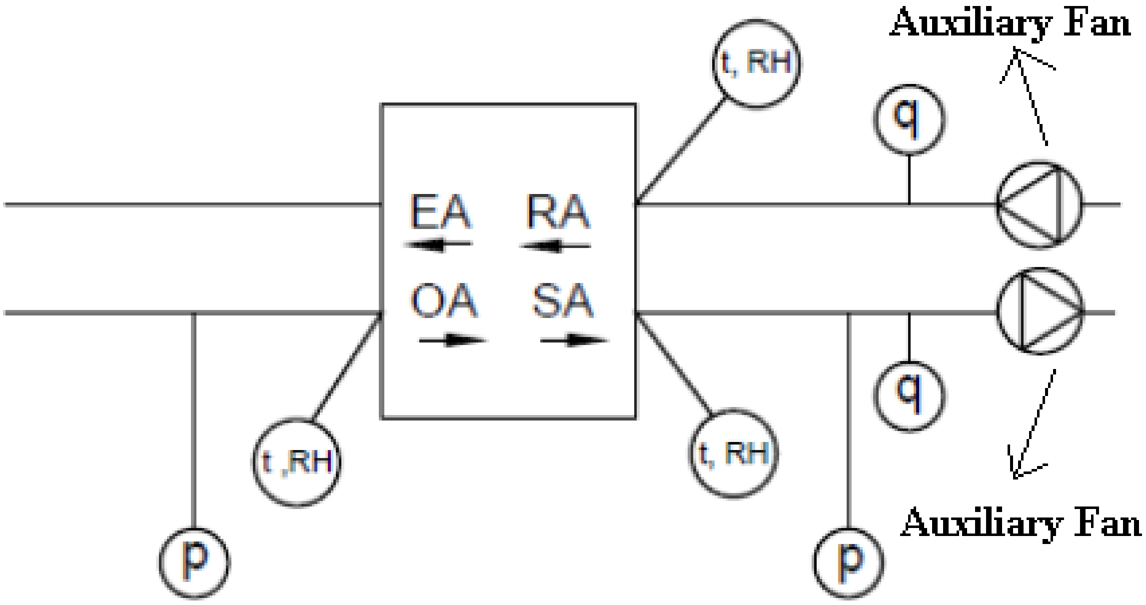
B-1 TEST PROCEDURES FOR ESTABLISHING PERFORMANCE EVALUATION

This annex specifies methods to be used for laboratory testing of air handling units with air-to-air heat recovery devices or those recovering heat to obtain rating data. It gives test requirements and procedures for performing such tests and specifies input criteria required for tests to verify performance data as declared. This procedure applies to the following:

a) Non-hygroscopic recovery device; and

b) Hygroscopic recovery device.

This is intended to be used as a basis for testing heat recovery devices for HVAC systems, consist of the heat exchanger itself installed in a casing having the necessary air duct connecting elements and in some cases the fans and pumps, but without any additional components of the HVAC system. (*See* Fig. 18).



Key

T, RH — Measurement of temperature and RH
p — Measurement of static pressure
q — Measurement of air flow
OA — Outside air
SA — Supply air
RA — Return air
EA — Exhaust air

FIG. 18 TEST SETUP

a) Reference condition for air is air with density 1.2 kg/m^3, a dynamic viscosity if 18.2×10^{-6} (kg/m.s) and an absolute pressure of 101.3 kPa.

b) Typical summer design thermal conditions shall be:

   1) DBT = 27 °C; and

   2) WBT = 19 °C.

c) Absolute pressure is used for air and fluids properties calculation.

B-1.1 Test

a) The calculations shall be made with standard air density = 1.2 kg/m^3;

b) In the calculations for classification evaluation, the design conditions for summer time shall be used for air flows, outdoor temperature, mixing ratio, heat recovery efficiency, etc;

c) The velocities in the calculations are the air velocities in the AHU cross-section based on the inside unit area for supply, respectively extract air flow of the air handling unit. The velocity is based on the area of the filter section of the respective unit, or if no filter is installed, it is based on the area of the fan section;

d) The relationship between velocity in the cross section of the unit and internal static pressure drop is considered to be exponential to the power of 1.4,

$$\Delta P_{\mathrm{st-1}} = \left(\frac{v_1}{v_0}\right) \times \Delta P_{\mathrm{st-0}}$$

e) The heat recovery dry efficiency at balanced air volume flows shall be used. If the exhaust air volume flow diverges from supply air volume flow, then for heat recovery efficiency is calculated by considering both air volume flows equal to the supply air volume flow. Here dry efficiency is temperature ratio calculated for dry air without considering condensation;

f) For efficiency evaluation the supply air volume for the heat recovery section, summer time shall be taken (the supply air volume flow of the unit can be higher in case of a mixing section); and

g) Pressure drop increase due to condensation shall not be considered. Air pressure drop shall be considered for standard air density at 1.2 kg/m^3.

An empirical formula for the equivalence between the efficiency and the pressure drop of a heat recovery system, as a function of the outdoor climate, has been derived from numerous energy consumption calculations all over India for enthalpy wheel and sensible wheel separately.

$$f_{\mathrm{pe}}\left(\frac{Pa}{\%}\right)$$

$$= -\,0.000\,3\, t_{\mathrm{ODA}}^2 + 0.016\,3\, t_{\mathrm{ODA}} + 2.879\,2$$

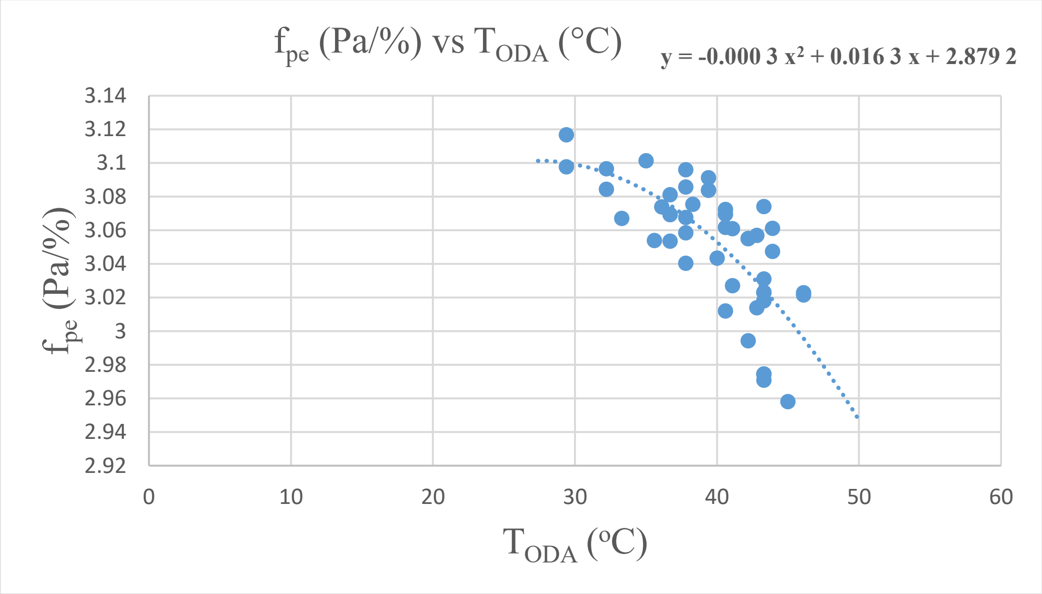


FIG. 19 EQUIVALENCE EFFICIENCY/PRESSURE DROP FOR HEAT RECOVERY WHEEL

These correlation are valid for summer condition that is, when outdoor air temperature in range of 28 °C to 50 °C.

$$f_{\mathrm{pe}}\ (Pa/\%) = \frac{\text{HRS } Pressure\ drop\ (\Delta P)}{100 \times \text{HRS } Efficiency(\eta)}$$

where

f_{pe} (Pa/%) = Pressure efficiency factor;
T_{ODA}(°C) = Outdoor air temperature, that is, ambient temperature;
ΔP = Pressure drop across heat recovery system; and
η = Efficiency of heat recovery system.

B-2 AIR HANDLING UNIT SUBGROUPS

Three subgroups, with different label signs, are defined:

a) Units for full or partial outdoor air at design summer temperature < 27 °C DBT/19 °C WBT

This subgroup will consider the velocity in the filter cross-section, the HRS efficiency and pressure drop, and the mains power consumption to the fan(s). The class signs are A+ to E. This subgroup comprises units connected to outdoor air with the design outdoor temperature, summertime > 30 °C. The unit can be extract only, supply only, or supply and extract unit, and can be with or without HRS. If it is a supply-only unit, there shall be no consumption and no pressure drop on the extract side. If the unit does not have a HRS, the heat recovery efficiency shall be considered as zero.

b) Recirculation units or units with design inlet enthalpy conditions always < 27 °C DBT/ 19 °C WBT

This subgroup will only consider the cross-section velocity of the filter section and mains power consumption to the fan(s). The class signs are from A+↷ to E↷. This subgroup includes units with 85 percent recirculation air, units connected to outdoor air for which the design outdoor temperature during summertime < 27 °C DBT/19 °C WBT. If it is a supply only unit, there shall be no consumption and no pressure drop on the extract side. Even if the heat recovery efficiency is not taken into account in the calculation, the unit can be with or without HRS.

c) Stand-alone extract air units

This subgroup will only consider the cross-section velocity of the filter section and mains power consumption to the fan(s). The class signs are from A+↑ to E↑. This subgroup is for pure extract air units (first reason to allocate an energy label to this kind of unit application is that they could not include heat recovery. Another reason is that the design outdoor temperature has no relevance for such units).

B-3 REFERENCE TABLE

For energy efficiency calculations, the Table 20 shall be referred.

Table 20 Reference Table for Energy Efficiency Calculations

(*Clauses* B-3, B-4 *and* C-1)

Sl No.	**Class**	**Velocity, V_{class}** m/s	**Heat Recovery System**		**Fan Efficiency Grade $\text{NG}_{\text{ref-class}}$** [-]	**Thermal Performance Value, TPV**
			ηclass percent	Δpclass Pa		
(1)	(2)	(3)	(4)	(5)	(6)	(7)
i)	A+ /A+↷/A+↑	1.4	83	250	64	1
ii)	A /A↷/A↑	1.6	78	230	62	0.8
iii)	B /B↷/B↑	1.8	73	210	60	0.6
iv)	C /C↷/C↑	2.0	68	190	57	0.4
v)	D /D↷/D↑	2.2	63	170	52	0.2
vi)	E /E↷/E↑	No requirement				0

where

+ = Units for full or partial outdoor air;
↑ = Standalone extract units; and
↷ = Recirculation units.

B-4 METHODOLOGY

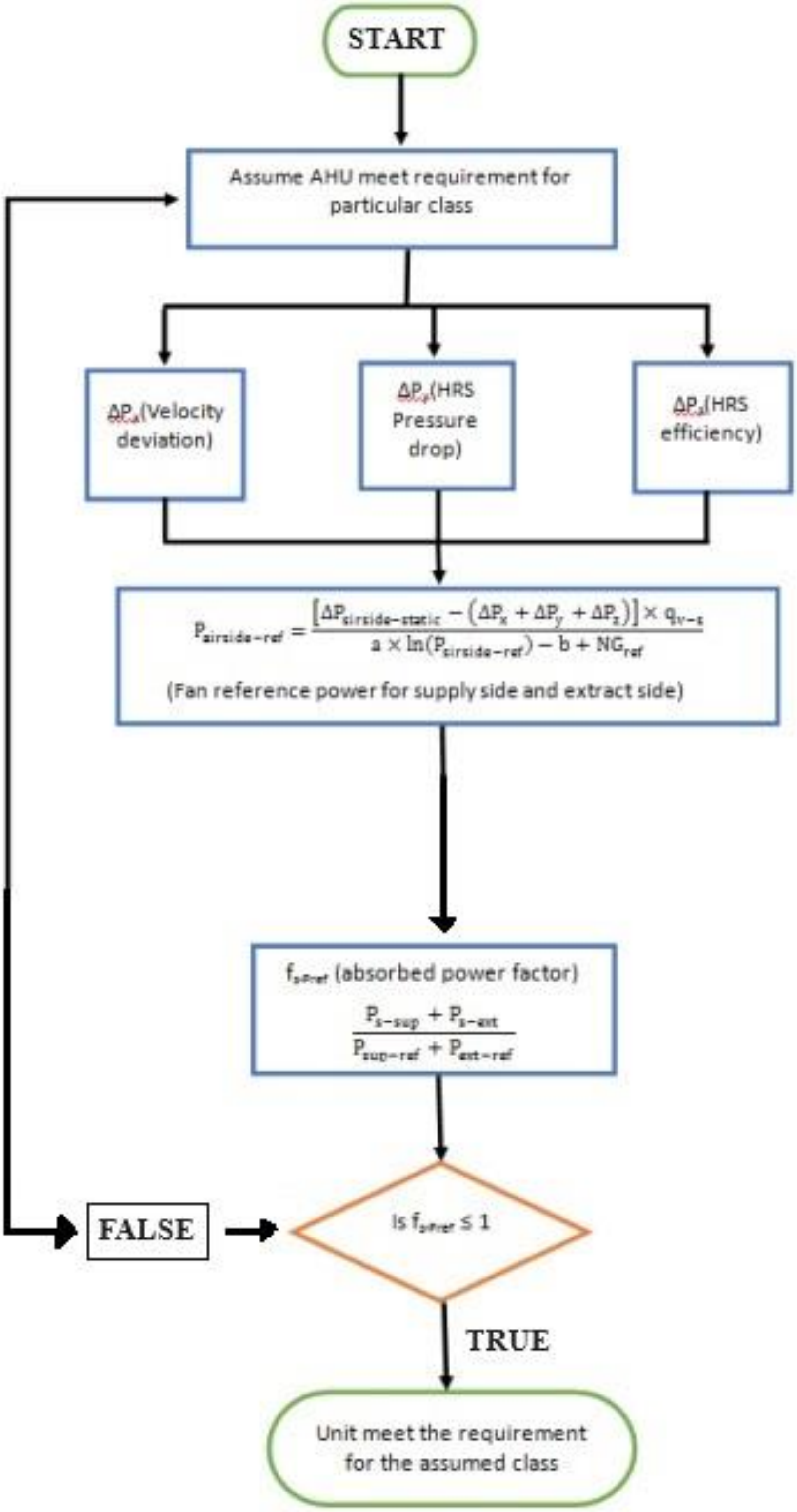


FIG. 20 FLOW CHART FOR ASCERTAINING THE CLASS OF AHU

The principle is to establish whether the selected unit with different energy parameters will consume no more energy than a unit that would exactly meet the requirements for the aimed class in Table 9 (*see* Fig. 20).

Perform the four following steps for respective air sides, supply and/or extract:

a) Assume an AHU is designed to meet the requirements for a particular class, so apply the corresponding class values (subscript 'class') from Table 9:

   1) For velocity, v_{class}; and
   2) For fan efficiency grade, $NG_{ref\text{-}class}$.

      If subgroup 1 (units for full or partial outdoor air at design summer temperature > 30 °C), apply also:

      i) Heat recovery efficiency, η_{class}; and
      ii) Pressure drop, Δp_{class}.

b) Use, for the real air handling unit to be classified at design air flow, summer time, the actual selection values (subscript 's') values:

   1) Fan static pressure increase, $\Delta p_{s\text{-static}}$;
   2) External pressure drop, $\Delta p_{s\text{-external}}$;
   3) Velocity, v_s; and
   4) Power supplied from mains to selected fan, $P_{s\text{-sup}}$, if supply air side else, $P_{s\text{-ext}}$.

      If subgroup 1 use also:

      i) HRS dry efficiency, η_s; and
      ii) HRS pressure drop, $\Delta p_{s\text{-HRS}}$.

c) Calculate the pressure correction due to velocity, Δp_x.

   If subgroup 1, then calculate:

   1) Pressure correction due to HRS pressure drop, Δp_y; and
   2) Pressure correction due to HRS efficiency, Δp_z.

d) Calculate fan reference power Pair side-ref for the real air handling unit side, that is, $P_{sup\text{-ref}}$ if supply air side or $P_{ext\text{-ref}}$ if extract air side.

Final check consists in verifying whether the selected unit meets the absorbed power consumption criterion for the aimed class. So, calculate the absorbed power factor; $f_{s\text{-Pref}}$. If the value $f_{s\text{-Pref}}$ is equal or lower than 1, the unit meets the requirements for the class. If not, the same calculation procedure shall be repeated for a lower class.

Pressure correction due to velocity, Δp_x is given as below.

$$\Delta P_x = (\Delta P_{s-internal} - \Delta P_{s-HRS}) \times \left\{1 - \left(\frac{V_{class}}{V_s}\right)^{1.4}\right\}$$

where

Δp_x = Pressure correction due to velocity, Pa;

$\Delta p_{s\text{-internal}}$ = $\Delta p_{s\text{–static}} - \Delta p_{s\text{–external}}$ internal pressure drop across components, exclusive system effect pressure drops, Pa;

$\Delta p_{s\text{-static}}$ = Useful fan static pressure increase measured between fan Inlet and fan outlet, Pa;

$\Delta p_{s\text{-external}}$ = External (ductwork system) pressure drop, Pa;

$\Delta p_{s\text{-HRS}}$ = HRS pressure drop, Pa, (0 if no HRS or subgroup 2 or 3);

v_{class} = Value from Reference table, m/s; and

v_s = Velocity in AHU filter (fan if no. filter) cross section, m/s.

With pressure drop correction for velocity, the equivalence figures for primary energy, and the corrections for heat recovery it is possible to make a conversion to static pressure surplus or deficit compared to a unit fully compliant with the energy class. A surplus of static pressure means that the real unit demands a higher static pressure; a deficit of static pressure means that the real unit needs a lower static pressure than the class-compliant unit. Hence, a surplus of static pressure means higher energy consumption while a deficit of static pressure will mean lower energy consumption.

Pressure correction due to HRS pressure drop, Δp_y is given as below.

$$\Delta P_y = \Delta P_{s-HRS} - \Delta P_{class}$$

where

ΔP_y = Pressure correction due to HRS pressure drop, Pa;

$\Delta P_{s\text{-HRS}}$ = HRS pressure drop (0 if no HRS or subgroup 2 or 3), Pa; and

ΔP_{class} = Value from Table 9, Pa, (0 if subgroup 2 or 3).

Pressure correction due to HRS efficiency, Δp_z is given as below.

$$\Delta P_z = (\eta_{\text{class}} - \eta_s + 5 \times cf_{\text{heater}}) \times \left(1 - \frac{mr}{100}\right) \times f_{\text{pe}}$$

where

ΔP_z = Pressure correction due to HRS efficiency, Pa;

η_s = HRS dry efficiency summer, in percent, (0 if no HRS or subgroup 2 or 3);

η_{class} = Value from reference class, in percent, (0 if subgroup 2 or 3);

mr = Mixing ratio, summer (recirculation air/supply air; maximum), allowed range 0 to 85, in percent;

f_{pe} (pressure–efficiency factor) for enthalpy wheel

$= -0.000\,3 \times t^2_{\text{ODA}} + 0.016\,3 \times t_{\text{ODA}} + 2.879\,2$

t_{ODA} = Design outdoor temperature, summer, °C; and

cf_{heater} = Correction for electrical heater (that is, reheater)

= 0, when there is no electrical heater

= 1, when there is an electrical heater.

Fan reference power ($P_{\text{sup-ref}}$) if supply air side or $P_{\text{ext-ref}}$.

The total static pressure correction $\Delta p_x + \Delta p_y + \Delta p_z$ has a negative or positive value. A negative value means that the required static pressure for the selected unit is lower than the static pressure for the class-compliant unit would be. For a positive pressure value, it is just the other way round. Now the fan reference power for a class-compliant unit has to be derived from the available static pressure of the selected unit by taking into account the calculated pressure corrections.

$$P_{\text{sup-ref}} = \frac{[\Delta P_{\text{s-static}} - (\Delta P_x + \Delta P_y + \Delta P_z)] \times q_{\text{v-s}}}{a \times \ln(P_{\text{sup-ref}}) - b + NG_{\text{ref}}}$$

$$P_{\text{ext-ref}} = \frac{[\Delta P_{\text{e-static}} - (\Delta P_x + \Delta P_y + \Delta P_z)] \times q_{\text{v-s}}}{a \times \ln(P_{\text{ext-ref}}) - b + NG_{\text{ref}}}$$

where

$P_{\text{airside-ref}}$ = Fan reference power, kW (use $P_{\text{sup-ref}}$ for supply air side or $P_{\text{ext-ref}}$ for extract air side) (*see* Table 20);

$P_{\text{sup-ref}}$ = Fan reference power for supply air side, kW;

$P_{\text{ext-ref}}$ = Fan reference power for extract air side, kW;

$\Delta p_{\text{s-static}}$ = Useful fan static pressure increase measured between fan Inlet and fan outlet in supply side, Pa;

$\Delta p_{\text{e-static}}$ = Useful fan static pressure increase measured between fan Inlet and fan outlet in extract side, Pa;

$q_{\text{v-s}}$ = Air volume flow rate, m³/s;

NG_{ref} = Fan efficiency grade corresponding to the class value; and

a, b = Coefficients as per Table 21.

Table 21 Coefficients for the Calculation of $P_{\text{air side-ref}}$

(*Clause* B-4)

Sl No. (1)	$P_{\text{air side-ref}}$ kW (2)	a (3)	b (4)	NG_{ref} (5)
i)	≤ 10	4.56	10.5	$N_{\text{gref class}}$
ii)	> 10	1.1	2.6	$N_{\text{gref class}}$

Absorbed power factor, $f_{\text{s-Pref}}$ is calculated as below:

$$f_{\text{s-Pref}} = \frac{P_{\text{s-sup}} + P_{\text{s-ext}}}{P_{\text{sup-ref}} + P_{\text{ext-ref}}} \leq 1$$

where

$f_{\text{s-Pref}}$ = Absorbed power factor;

$P_{\text{s-sup}}$ = Active power supplied from the mains, including any motor control equipment, to selected supply air fan, kW;

$P_{\text{s-ext}}$ = Active power supplied from the mains, including any motor control equipment, to selected extract air fan, kW;

$P_{\text{sup-ref}}$ = Supply air fan reference power, kW; and

$P_{\text{ext-ref}}$ = Extract air fan reference power, kW.

ANNEX C

(*Foreword*)

OVERALL RATING OF AHU

C-1 Overall rating is based on both mechanical performance as well as thermal performance. Below formula can be used to calculate overall performance value (OPV):

Overall Performance Value (OPV)

= 50 percent of (MPV) + 50 percent of (TPV)

where

MPV = Mechanical performance value calculated as in Table 12; and

TPV = Thermal performance value calculated as in Table 20.

Based on the overall performance value, the rating is decided and the below table shows the ratings such as A-rating is provided if the overall performance value is greater than 0.8. Similarly, B-rating is provided if OPV is greater than and equal to 0.6 and less than 0.8 and so on (*see* Table 22).

The overall performance value that results in the assignment of rating may get revised in the future, taking into consideration the enhanced energy performance and indoor air quality as major criteria of evaluation.

Table 22 Overall Rating for Air Handling Unit

(*Clause* C-1)

Sl No. (1)	Rating Based on Overall Performance (2)	Overall Performance Value (OPV) (3)
i)	A	$OPV \geq 0.8$
ii)	B	$0.6 \leq OPV < 0.8$
iii)	C	$0.4 \leq OPV < 0.6$
iv)	D	$0.2 \leq OPV < 0.4$
v)	E	$OPV < 0.2$

ANNEX D

(*Clause* 8.5)

GUIDANCE FOR CLASSIFICATION INTERPRETATION FOR FILTER CLASS

D-1 It is to be noted that it is not possible to make a direct comparison between the filter class as per Table 5 and the filter class as specified in IS 17570 (Part 1 to 4) since their test measurements and classification criteria are different. However, the following guiding table shows the classification interpretation between these filter classes.

Sl No. (1)	*Filter Class* (2)	*ePM$_1$ as per IS* 17570 (*Part* 1 *to Part* 4) (3)	*ePM$_{2.5}$ as per IS* 17570 (*Part* 1 *to Part* 4) (4)	*ePM$_{10}$ as per IS* 17570 (*Part* 1 *to Part* 4) (5)	*Coarse as per as per IS* 17570 (*Part* 1 *to Part* 4) (6)
i)	G1	-	-	-	-
ii)	G2	-	-	-	30 % to 50 %
iii)	G3	-	-	-	45 % to 65 %
iv)	G4	-	-	-	60 % to 85 %
v)	M5	5 % to 35 %	10 % to 45 %	40 % to 70 %	80 % to 95 %
vi)	M6	10 % to 40%	20 % to 50 %	45 % to 80 %	> 90 %
vii)	F7	40 % to 65%	50 % to 75 %	80 % to 90 %	> 95 %
viii)	F8	65 % to 90%	75 % to 95 %	90 % to 100 %	> 95 %
ix)	F9	80 % to 90%	85 % to 95 %	90 % to 100 %	> 95 %

NOTE — The above information is for guidance only.

For example, G3 filters will achieve separation values in the coarse 45 percent to 65 percent range. F7 filters will achieve approximately efficiencies of ePM2.5, 50 percent to 75 percent and ePM1 to 40 percent to 65 percent.

ANNEX E

(*Foreword*)

COMMITTEE COMPOSITION

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