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BIS through its core activities of standardization and conformity assessment, has been benefiting the national economy by providing safe, reliable and quality goods; minimizing health hazards to consumers; protecting the environment, promoting exports and imports substitute; controlling over proliferation of varieties etc. The standards and certification scheme of BIS apart from benefitting the consumers and industry also support various public policies especially in areas of product safety, consumer protection, food safety, environment protection, building and construction, etc.

Keeping in view, the interest of consumers as well as the industry, BIS is involved in various activities broadly as given below:

· Standards Formulation

o Formulating & Publishing Indian Standards

o Participation in International Standardization (ISO & IEC work)

· Conformity Assessment

o Product Certification Scheme

o Compulsory Registration Scheme

o Foreign Manufacturers Certification Scheme

· Hall Marking Scheme

· Laboratory Services

o Laboratory Recognition Scheme

· Standards Promotional Activities

· Training Services, National & International level

· Information Services

In recent years, BIS has worked towards specifically addressing various national priorities and other government initiatives like Swacch Bharat Abhiyan, Digital India, Make in India and ease of doing business through its activities of standardization and certification. In standards development, BIS continues to address issues of technology changes and advancements, climate change, environment and energy conservation, conditions of health and safety and facilitation of trade. In the area of conformity assessment BIS is working towards making the processes simpler and faster.

BIS is a founder member of International Organization for Standardization (ISO) and is actively involved in development of International Standards by acting as Participating (P) member or Observer (O) member on various Technical Committees, Sub-Committees, Working Groups, etc. BIS is representing India in International Electro-technical Commission (IEC) also. BIS is actively involved in the Regional and Bi-lateral Co-operation Programmes pertaining to standardization, testing, certification, training etc. BIS is also the National Enquiry Point for Technical Barriers to Trade (WTO –TBT) matters.

CONTENTS

About this handbook

Refrigeration and Air Conditioning is an important subject in course curriculum for Students of Mechanical Engineering in Undergraduate Degree programmes in Indian technical universities. It has also been included as an elective paper for students of Mechanical Engineering pursuing their final year (7th and 8th semester) in some academic institutions.

Broadly this course includes following topics: Basics of Thermodynamics and heat transfer, Refrigeration/Heat Pump Cycles, Elements of a vapor compression refrigeration system: condensers, evaporators, compressors and expansion devices – construction, operation and performance, Design calculations, Refrigerants: designation, desirable properties, environmental considerations, Thermodynamics of moist air, Psychrometry, Load calculations, Solar radiation and interaction with building structures, Introduction to some non-conventional refrigeration systems, Design and constructional details of Unitary air conditioning equipment. Noise level and acoustic control. Automatic controls in air conditioning, cooling tower design and selection, air cleaners and scrubbers, hydronic heating and cooling systems, humidification and dehumidification equipment, automatic controls, noise reduction, Refrigerating appliances- Domestic and Commercial.

There are many good textbooks and reference materials available in the country on this paper. These all books provide the theoretical concepts including the laws of thermodynamics and their practical applications up to some extent by providing numerical problems in this area.

However, this handbook endeavours to introduce the academic fraternity this topic through the eyes of Standards. Standards, as we know are synonyms with quality. Standardization in any area tries to keep pace with the technological advancement taking place in that sector. Use of standards for products help in reaping the benefits of research works and experiments already done for the product. Use of Standards on Code of practice helps to adopt the best practice in carrying out any activity. There are numerous Indian Standards available on Refrigeration and Air Conditioning. These Standards have been formulated by MED 03, Refrigeration and Air Conditioning Sectional Committee under Mechanical Engineering Department of BIS. Through this handbook, faculty members and students will be familiar with the standardization in the field of Refrigeration and Air Conditioning and are expected to get benefit from the information. It is noteworthy that all Indian Standards are dynamic publication and are subject to revision and amendments. Users are advised to refer to the latest version of the Standard.

This handbook has been structured in a manner so as to relate the topics of the course curriculum with the available Indian standards on those topics. It tries to describe the provisions of the Standard in detail while keeping the regular information which may be available in any other text book, to a minimal.

While explaining the provisions of Indian Standards in this handbook, references of various Standards at many places has been made. We should appreciate that the Standards are linked with each other. This practise of linking is adopted extensively in Standard formulation process also by Standard formulation bodies. Detailing the provisions of all referred Standards in this handbook is not possible as it will increase the volume enormously. However, one may easily access all Indian Standards and download the same through BIS Website www.bis.gov.in. Further, since all Indian Standards are dynamic document and are subject to amendment and revision, users are encouraged to refer to the latest version of the Standards.

CHAPTER I
BASIC THEORIES AND LAWS

CHAPTER I

BASIC THEORIES AND LAWS

1. SECOND LAW OF THERMODYNAMICS & REFRIGERATION

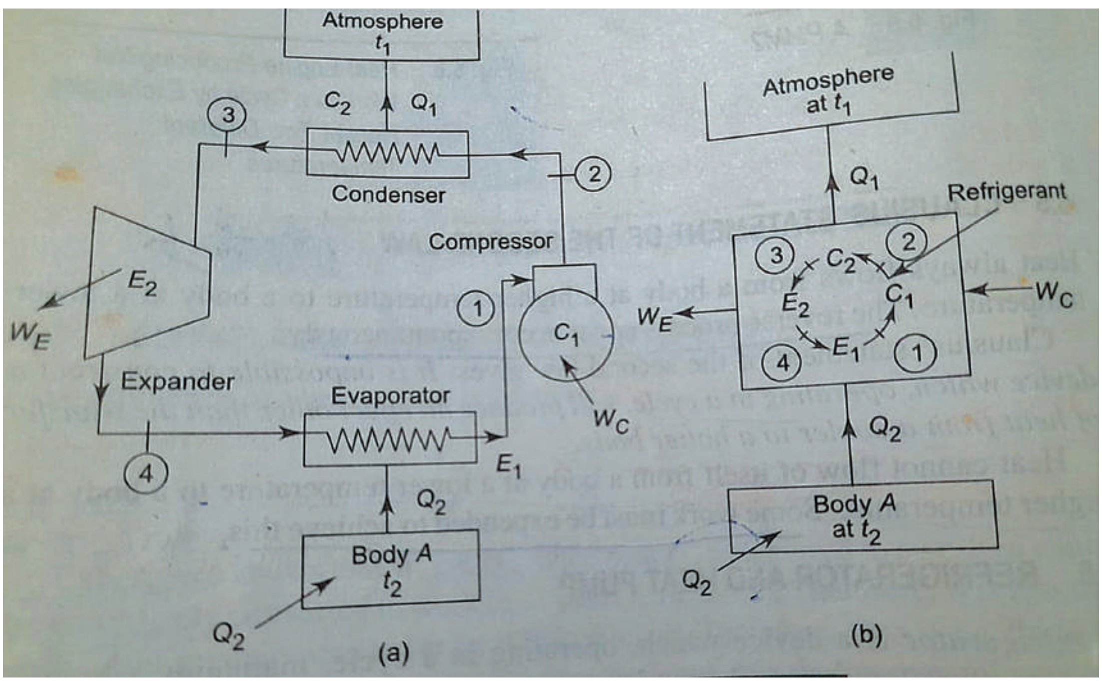
1.1 Second Law of Thermodynamics:

Heat always flows from a body at a higher temperature to a body at a lower temperature. The reverse process never occurs spontaneously.

It is impossible to construct a device which, operating in a cycle, will produce no effect other than the transfer of heat from a cooler to a hotter body. Heat cannot flow of itself from a body at a lower temperature to a body at a higher temperature. Some work must be expended to achieve this.

1.2 Refrigeration:

Refrigeration is the cooling of a system below the temperature of its surroundings. A refrigerator cycle maintains a body at a temperature lower than the temperature of the surroundings.



A Cyclic refrigeration plant

2. REFRIGERATION CYCLES

2.1 REFREGERATION BY NON- CYCLIC PROCESSES

The melting of ice or snow was one of the earliest methods of refrigeration and is still employed. Ice melts at 0p C. So when ice is placed in a given space warmer than 0p C, heat flows into the ice and the space is cooled or refrigerated. The latent heat of fusion of ice is supplied from the surroundings, and the ice changes its state from solid to liquid.

Another medium of refrigeration is solid carbon dioxide or dry ice. At atmospheric pressure CO_2 cannot exist in a liquid state, and consequently, when solid CO_2 is exposed to atmosphere, it sublimate, i.e. it goes directly from solid to vapour, by absorbing the latent heat of sublimation (620kJ/kg at 1 atm,-78.5p C) from the surroundings (Fig. 1.1). Thus dry ice is suitable for low temperature refrigeration.

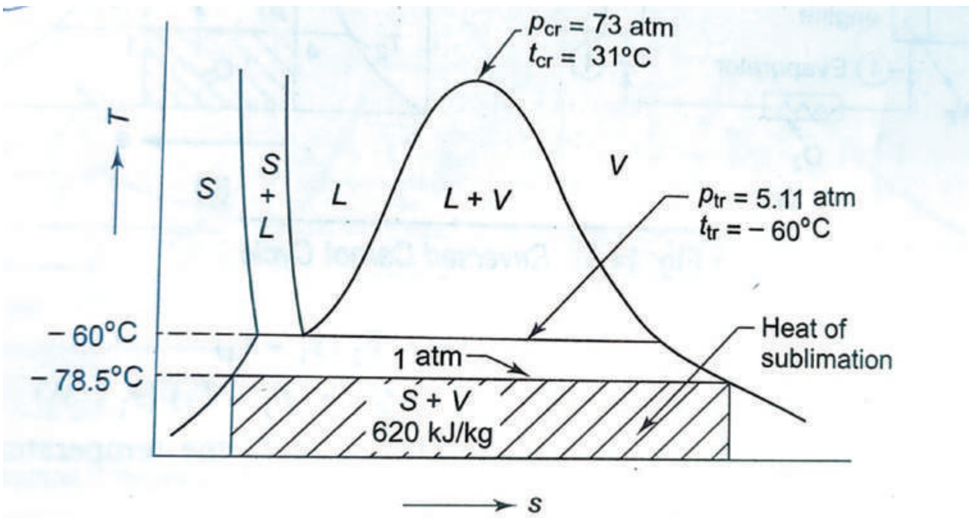


Fig. 1.1. (T-S Diagram for Carbon-dioxide (CO_2))

In these two examples it is observed that the refrigeration effect has been accomplished by non-cyclic processes. Of greater importance, however, are the methods in which the cooling substance is not consumed and discarded, but used again and again in thermodynamic cycle.

2.2 REVESED HEAT ENGINE CYCLE

A reversed heat engine cycle, is visualized as an engine operating in the reverse way, i.e. receiving heat from a low temperature region, discharging heat to a high temperature region, and receiving a net inflow of work (Fig. 1.2). Under such conditions the cycle is called a *heat pump cycle* or a r*efrigeration* cycle.

For a heat pump

$$(COP)H.P. = \frac{Q_1}{W} = \frac{Q_1}{Q_1 - Q_2}$$

And for a refrigerator

$$(COP)_{ref} = \frac{Q_1}{W} = \frac{Q_1}{Q_1 - Q_2}$$

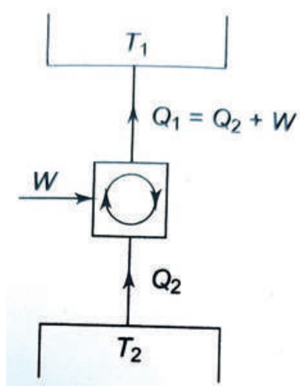


Fig. 1.2 Reversed Heat Engine Cycle

The working fluid in a refrigeration cycle is called a *Refrigerant.* In the reversed Carnot cycle (Fig. 1.3), *Engine Cycle* the refrigerant is first compressed reversibly and adiabatically in process 1-2 where the work input per kg of refrigerant is *W*c.

Then is condensed reversibly and adiabatically in process 2-3 where the heat rejection is Q_1, the refrigerant then expands reversibly and adiabatically in process 3-4 where the work output is W_E, and finally it absorb heat Q_2 reversibly by evaporation from the surroundings in process 4-1.

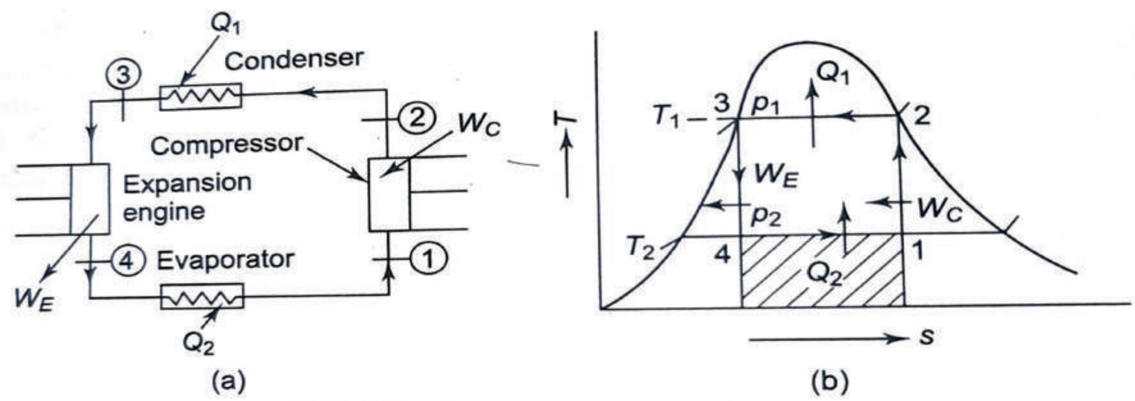


Fig. 1.3 Reversed Carnot Cycle

Here, $Q_1 = T_1 (s_2 - s_3)$, $Q_2 = T_2 (s_1 - s_4)$

and $W_{net} = W_c - W_E = Q_1 - Q_2 = (T_1 - T_2)(s_1 - s_4)$

Where T_1 is the temperature of heat rejection and T_2 the temperature of heat absorption.

$$(Cop_{ref})_{rev} = \frac{Q_2}{W_{net}} = \frac{T_2}{T_1 - T_2}$$

and

$$(Cop_{H.P.})_{rev} = \frac{Q_1}{W_{net}} = \frac{T_2}{T_2 - T_2}$$

These are the maximum values for any refrigerator or heat pump operating between T_1 and T_2. It is important to note that for the same T_1 or T_2, the COP increases with the decrease in the decrease in the temperature difference $(T_1 - T_2)$, i.e. the closer the temperatures T_1 and T_2, the higher the COP.

2.3 VAPOUR COMPRESSION REFRIGERATION CYCLE

In a actual vapour refrigeration cycle, an expansion engine, as shown, as shown in Fig. 1.3, is not used, since power recovery is small and does not justify the cost of the engine. A throttling valve or a capillary tube is used for expansion in reducing the pressure from p_1 *to* p_2. The basic operations involved in a vapour compression refrigeration plant are illustrated in the flow diagram, Fig. 1.4, and the property diagrams, Fig. 1.5.

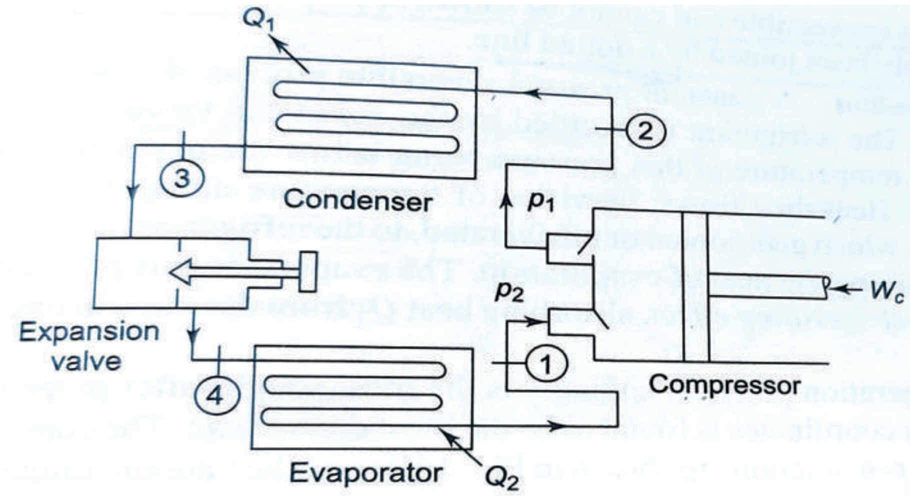


Fig. 1.4 Vapour Compression Refrigeration Plant-flow diagram

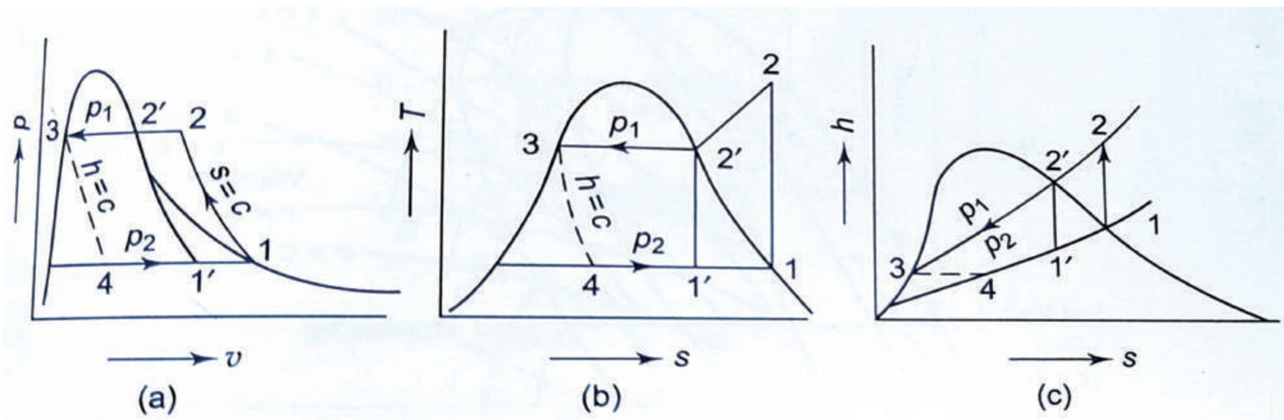


Fig. 1.5 Vapour Compression Refrigeration Cycle- Property daigrams

The operations represented are as follow for an idealized plant:

a. *Compression* A reversible adiabatic process 1-2 or 12 –22 either starting with saturated vapour (state 1), or starting with wet vapour (state 12), *called wet compression*. Dry compression (1-2) is always preferred to wet compression (12 –22), because with wet compression there is a danger of the liquid refrigerant being trapped in the head of the cylinder by the rising piston which may damage the valves or the cylinder head, and the droplets liquid refrigerant may wash away the lubricating oil from the walls of the cylinder, thus accelerating wear

b. *Cooling and Condensing* A reversible constant pressure process, 2-3, first de-superheated and then condensed, ending with saturated liquid. Het Q_1 is transferred out.

c. *Expansion* An adiabatic throttling process 3-4, for which enthalpy remains unchanged. States 3 and 4 are equilibrium points. Process 3-4 is adiabatic (then only $h_3 = h_4$ by S.F.E.E.), but not isentropic.

$$Tds = dh - vdp, \text{ or } s_4 - s_3 = -\int_{P_1}^{P_2} \frac{vpd}{T}$$

Hence it is irreversible and cannot be shown in property diagrams. States 3 and 4 have simply been joined by a dotted line.

d. *Evaporation* A constant pressure reversible process, 4-1, which completes the cycle. The refrigerant is throttled by the expansion valve to a pressure, the saturation temperature at this pressure being below the temperature of the surroundings, Heat then flows, by virtue of temperature dif ference, from the surrounding, which gets cooled or refrigerated, to the refrigerant, which then evaporates, absorbing the heat of evaporation. The evaporator thus produces the cooling or the *refrigerating effect*, absorbing heat Q_2 from the surroundings by evaporation.

In refrigeration practice, enthalpy is the most sought-after property. The diagram in *p-h* coordinates is found to be the most convenient. The constant property lines in the *p-h* diagram are shown in Fig. 1.6, and the vapour compression cycle in Fig. 1.7 (p-h diagram) and 1.8 (T-S diagram).

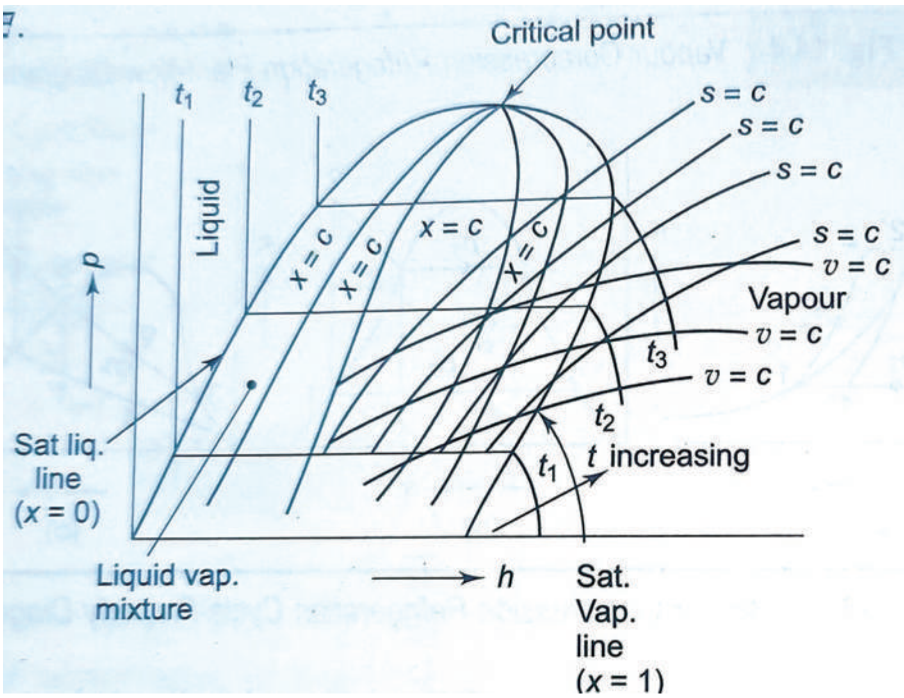


Fig. 1.6 Phase diagram with constant Property lines on p-h plot

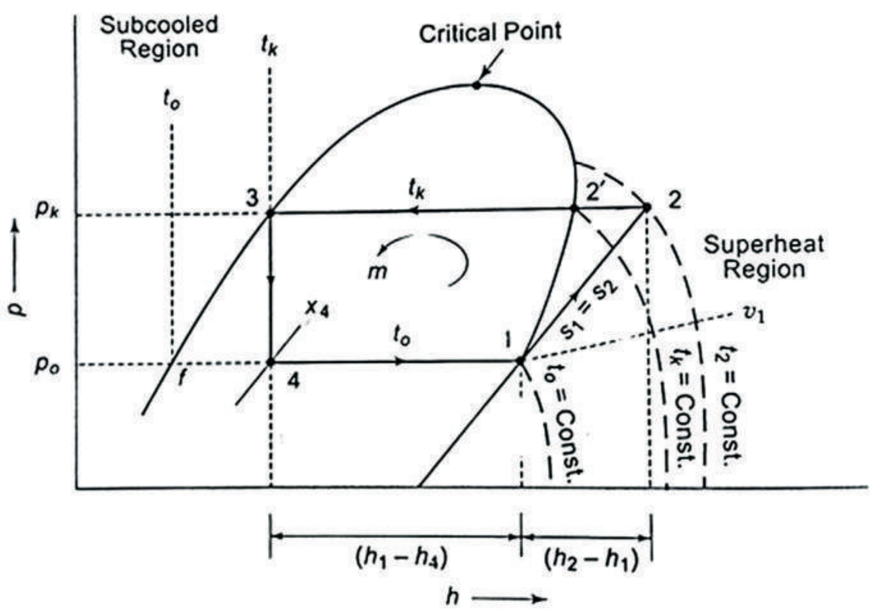


Fig.1.7 Vapour Compression Cycle on p-h Diagram

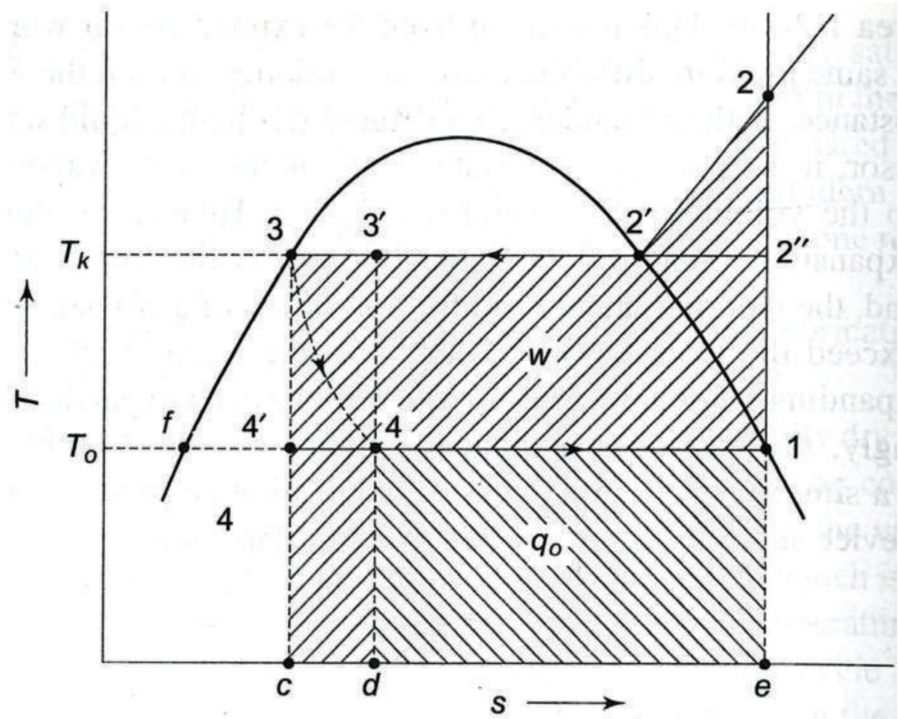


Fig.1.7 Vapour Compression Cycle on T-s Diagram

2.3.1 Performance and Capacity of a Vapour Compression Plant

Figure 1.8 shows the simplified diagram of a vapour compression refrigeration plant.

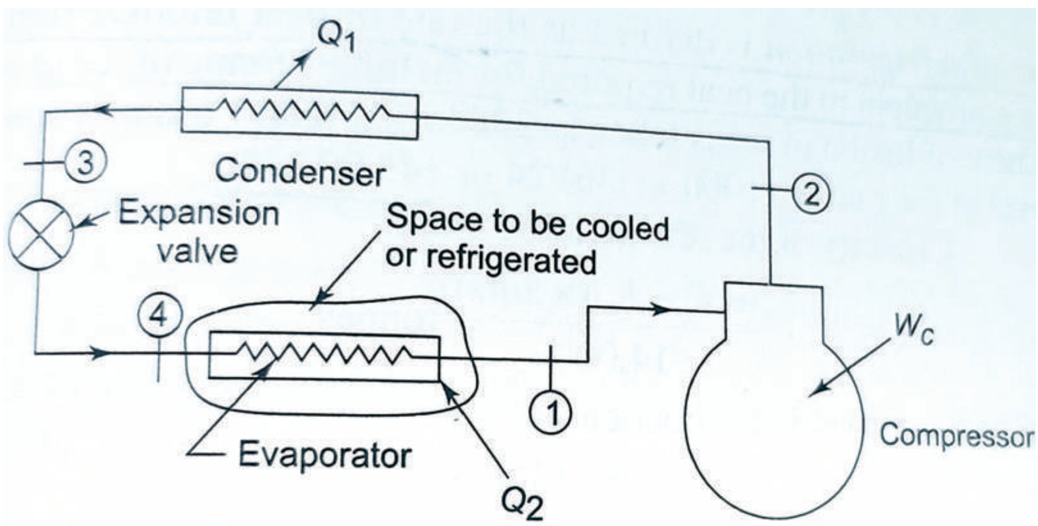


Fig. 1.8 vapour Compression Plant

When steady state has been reached, for 1 kg flow of refrigerant through the cycle, the steady flow energy equations (neglecting K.E. and P.E. changes) may be written for each of the components in the cycle as given below.

Compressor $h_1 + W_c = h_2$

$\therefore \quad Wc = (h_2 - h_1)$ kJ/kg

Condenser $h_2 = Q_1 + h_3$

$\therefore \quad Q1 = (h_2 - h_3)$ kJ/kg

Expansion valve $h_3 = h_4$

Or $(h_f)P_1 = (h_f)P_2 + x_4\ (h_{fg})P_2$

$$\therefore \quad x_4 = \frac{(h_f)P_1 - (h_f)P_2}{(h_f)P_2}$$

This is the quality of the refrigerant at the inlet to the evaporator (mass fraction of vapour in liquid-vapour mixture).

Evaporator

$$h_2 + Q_2 = h_1$$

$$\therefore \quad Q_2 + (h_1 - h_4)\text{kj/kg}$$

This is known as the *refrigerating effect,* the amount of heat removed from the surroundings per unit mas flow of refrigerant.

If the *p-h* chart for a particular refrigerant is available with the given parameters, it is possible to obtain from the chart the values of enthalpy at all the cardinal points of the cycle. Then for the cycle

$$\text{COP} = \frac{Q_2}{W_C} = \frac{h_1 - h_2}{h_2 - h_1}$$

If w is mass flow of refrigerant in kg/s, then the rate of heat removal from the surroundings

$$= w\ (h_1 - h_4)\ \text{kj/s} = w\ (h_1 - h_4) \times 3600\ \text{kj/h}$$

One tonne of refrigeration is defined as the rate of heat removal from the surroundings equinalent to the heat required for melting 1 tonne of ice in one day. If the latent heat of fusion on ice is taken as 336 kJ/kg, then tonne is equivalent to heat revoval at the rate of (1000x336)/24 or 14,000 kJ/h

V Capacity of the refrigerating plant

$$\frac{w\,(h_1 - h_4)\ x3600}{14{,}000}$$

The rate of heat removal in the condenser

$$Q_1 = w\ (h_2 - h_3)\ \text{kJ/s}$$

If the condenser is water-cooled, m_c the flow-rate of cooling water in kg/s, and $(t_{c2}\text{-}t_{c1})$ the rise in temperature of water, then

$$Q_1 = w\ (h_2 - h_3) = m_c c_c\ (t_{c2}\ t_{c2}\ \ t_{c1})\ \text{kJ/s}$$

Provided the heat transfer is confinde only between the refrigerant and water, and there is no heat interaction with the surroundings.

The rate of work input to the compressor

$$W_c = w(h_2 - h_1)\ \text{kJ/s}$$

2.3.2 Actual Vapour Compression Cycle

In order to ascertain that there is no droplet of liquid refrigerant being carried over into the compressor, some superheating of vapour is recommended after the evaporator.

A small degree of sub-cooling of the liquid refrigerant after the condenser is also used to reduce the mass of vapour formed during expansion, so that too many vapour bubbles do not impede the flow of liquid refrigerant through the expansion valve.

Both the superheating of vapour at the evaporator outlet and the sub-cooling of liquid at the condenser outlet contribute to an increase in the refrigerating effect, as shown in Fig. 1.9. The compressor discharge temperature, however, increases, due to superheat, from $t2_2$ to $t2_{2,}$ and the load on the condenser also increases.

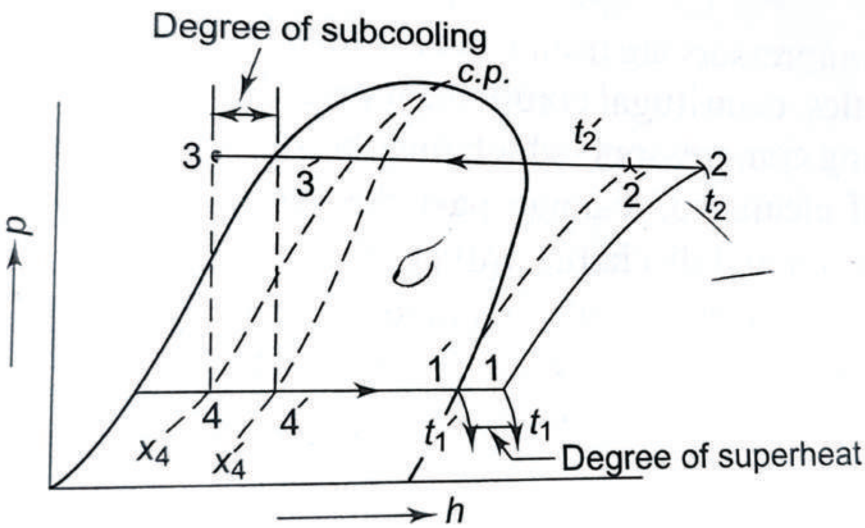


Fig. 1.9 Superheat and sub-cooling in a vapour compression cyle

Sometimes, a liquid-line heat exchanger is used in the plant, as shown in Fig. 1.10. The liquid is subcooled in the heat exchanger, reducing the load on the condenser and improving the COP.

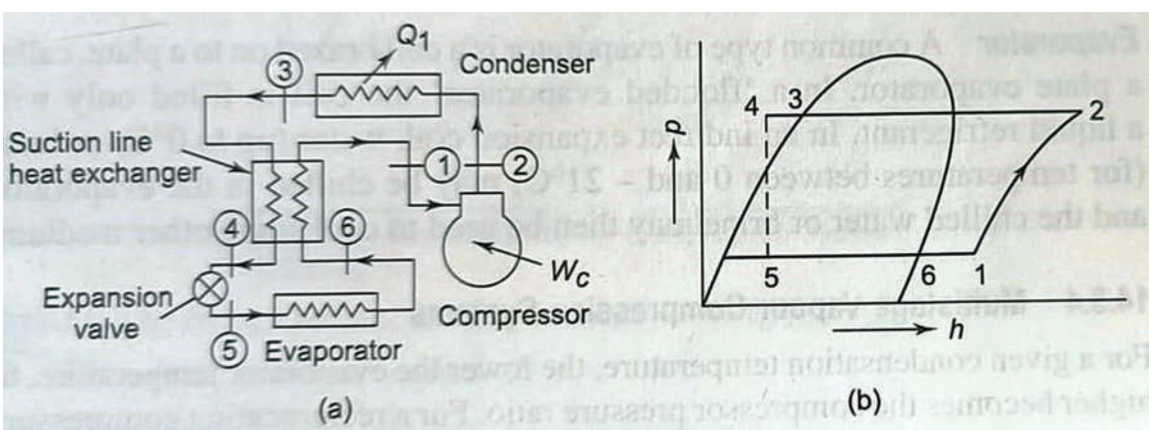


Fig. 1.10 Vapour Compression Cycle with a suction-line heat exchanger

2.3.3 Components in a Vapour Compression Plant

Condenser It must de-superheat and then condense the compressed refrigerant. Condensers may be either air-cooled or water-cooled. An air-cooled condenser is used in small self-contained units. Water-cooled condensers are used in larger installations.

Expansion device It reduces the pressure of the refrigerant, and also regulates the flow of the regrigerant to the evaporator. Two widely used types of expansion devices are: capillary tubes and throttle valves (thermostatic expansion valves). Capillary tubes are used only for small units. Once the size and length are fixed, the evaporator pressure, etc. ets fixed. No modification in operating conditions is possible. Throttle valves are used in larger units. These regulate the flow of the refrigerant according to the load on the evaporator.

Compressor Compressors may be of three types: (1) reciprocating, (b) rotary, and (c) centrifugal. When the volume flow rate of the refrigerant is large, centrifugal compressors are used. Rotary Compressors are used for small units.

Reciprocating compressors are used in plants up to 100 tonnes capacity. For plants of higher capacities, centrifugal compressors are employed.

In reciprocating compressors, which may be single-cylinder or multi-cylinder ones, because of clearance, leakage past the piston and valves, and throttling effects at the suction and discharge valves, the actual volume of gas drawn into the cylinder is less than the volume displaced by the piston. This is accounted for in the term *volumetric efficiency,* which is defined as

$$n_{vol} = \frac{\text{Actual Volume of gas drawn at evaporator pressure and temperature}}{\text{Piston displacement}}$$

∴ Volume of gas handled by the compressor

$= w \cdot v_1 \, (m_3/s) =$

Where w is the refrigerant flow rate.

v_1 is the specific volume of the refrigerant at the compressor inlet,

D and L are the diameter and stroke of the compressor,

n is the number of cylinders in the compressor, and N is the r.p.m

The clearance volumetric efficiency is given by Eq. (19.13)

Where C is the clearance.

Evaporator A common type of evaporator is a coil brazed on to a plate, called plate evaporator. In a flooded evaporator' the coil is filled only with a liquid refrigerant. In an indirect expansion coil, water (up to 0p C) or brine (for temperatures between 0 and – 21p C) may be chilled in the evaporator, and the chilled water or brine may then be used to cool some other medium.

CHAPTER II

REFRIGERATION AND AIR CONDITIONING- A BRIEF INTRODUCTION AND ITS APPLICATION

CHAPTER 2

REFRIGERATION AND AIR CONDITIONING- A BRIEF INTRODUCTION AND ITS APPLICATION

1. Introduction:

As we saw in the previous chapter, it has been endeavor of the mankind to produce temperature lower than the surrounding since many years. While the earlier efforts might be to cool the habitat or to preserve the food stuff, in the modern world production of low temperature is extensively being used in other industrial applications on mass scale.

2. Refrigeration and its application:

Refrigeration may be defined as the process of reducing and maintaining a temperature of a space or material below that of the surroundings. This is accomplished by removing heat from body being refrigerated and transferred it to another body whose temperature is higher than that of the refrigerated body or space. It is evident that refrigerating and heating are actually opposite ends of the same process. Often, it is the desired result that distinguishes one from the other. Refrigeration is basic to the heating, ventilation and air conditioning industry. One of the most important applications of refrigeration has been the preservation of perishable food products, food processing, packaging, storing and transportation by storing them at low temperatures. The effect of storage temperature on useful storage life of food products is given in Table 1. Refrigeration systems are also used extensively for providing thermal comfort to human beings by means of air conditioning

Table 1. *Effect of storage temperature on useful storage life of food products*

Food Product	**Average useful storage life (days)**		
	o0 C	**o22 C**	**o38 C**
Meat	6-10	1	< 1
Fish	2-7	1	< 1
Poultry	5-18	1	< 1
Dry meats and fish	> 1000	> 350 & < 1000	> 100 & < 350
Fruits	2 - 180	1 – 20	1 – 7
Dry fruits	> 1000	> 350 & < 1000	> 100 & < 350
Leafy vegetables	3 - 20	1 – 7	1 – 3
Root crops	90 - 300	7 – 50	2 – 20
Dry seeds	> 1000	> 350 & <	> 100 & <

2.1 Application of refrigeration in food processing, preservation and distribution.

i. Storage of Raw Fruits and Vegetables

It has been established that some bacteria are responsible for degradation of food, and that enzymatic processing cause ripening of the fruits and vegetables. Bacteria and the rate of enzymatic processes are reduced at very low temperature thereby helps to reduce the spoilage rate and thus improve on the shelf life of the food. It can be seen that the storage temperature affects the useful storage life significantly. In general the storage life of most of the food products depends upon water activity, which essentially depends upon the presence of water in liquid form in the food product and its temperature. Hence, it is possible to preserve various food products for much longer periods under frozen conditions. In case of fruits and vegetables, the use of refrigeration starts right after harvesting to remove the post-harvest heat, transport in refrigerated transport to the cold storage or the processing plant. A part of it may be stored in cold storage to maintain its sensory qualities and a part may be distributed to retail shops, where again refrigeration is used for short time storage. Refrigeration helps in retaining the sensory, nutritional and eating qualities of the food. The excess crop of fruits and vegetables can be stored for use during peak demands and off-season; and transported to remote locations by refrigerated transport. In general, the shelf life of most of the fruits and vegetables increases by storage at temperatures between 0 to 10 C. Table 2 shows the typical storage conditions for some fruits and vegetables as recommended by ASHRAE. Nuts, dried fruits and pulses that are prone to bacterial deterioration can also be stored for long periods by this method. The above mentioned fruits and vegetables can be stored in raw state. Some highly perishable items require initial processing before storage. The fast and busy modern day life demands ready-to-eat frozen or refrigerated food packages to eliminate the preparation and cooking time.

Table 2. *Recommended storage conditions for fruits and vegetables*

Fruit & Vegitables	**Storage Temperature, °C**	**Relative Humidity, %**	**Maximum, recommended storage time**	**Storage time in cold Storages forvegetablesIn tropical countries**
Apples	0 – 4	90 – 95	2 - 6 months	
Beetroot	0	95 – 99	4 – 6 months	
Cabbage	0	95 – 99	5 – 6 months	2 months
Carrots	0	98 – 100	5 – 9 months	2 months
Cauliflower	0	95	3 – 4 weeks	1 week
Cucumber	10 - 13	90 – 95	10 – 14 days	
Eggplant	8 - 12	90 – 95	7 days	
Lettuce	0	95 – 100	2 – 3 weeks	
Melons	7 - 10	90 - 95	2 weeks	
Mushrooms	0 - 4	95	2 - 5	1 day
Onions	0	65 - 70	6 – 8 months	
Oranges	0 - 4	85 - 90	3 – 4 months	
Peas, Green	0	95 - 98	1 – 2 weeks	
Pears	0	90 - 95	2 – 5 months	
Potatoes	4 - 16	90 - 95	2 – 8 months	
Pumpkin	10 - 13	70 – 75	6 – 8 months	
Spinach	0	95	1 – 2 weeks	1 week
Tomatoes	13 - 21	85 - 90	1 – 2 weeks	1 week

ii. Fish

Icing of fish according to ASHRAE Handbook on Applications, started way back in 1938. In India, iced fish is still transported by rail and road, and retail stores store it for short periods by this method. Freezing of fish aboard the ship right after catch results in better quality than freezing it after the ship docks. In some ships, it is frozen along with seawater since it takes months before the ships return to dock. Long-term preservation of fish requires cleaning, processing and freezing.

iii. Meat and poultry

These items also require refrigeration right after slaughter during processing, packaging. Short-term storage is done at 0 C. Long-term storage requires freezing and storage at -25 C.

iv. Dairy Products

The important dairy products are milk, butter, buttermilk and ice cream. To maintain good quality, the milk is cooled in bulk milk coolers immediately after being taken from cow. Bulk milk cooler is a large refrigerated tank that cools it between 10 to 15 C. Then it is transported to dairy farms, where it is pasteurized. Pasteurization involves heating it to 73 C and holding it at this temperature for 20 seconds. Thereafter, it is cooled to 3 to 4 C. The dairies have to have a very large cooling capacity, since a large quantity of milk has to be immediately cooled after arrival. During the lean period, the refrigeration plants of dairies are used to produce ice that is used during peak periods to provide cooling by melting. This reduces the required peak capacity of the refrigeration plant. Ice cream manufacture requires pasteurization, thorough mixing, emulsification and stabilization and subsequently cooling to 4 to 5 C. Then it is cooled to temperature of about – 5 C in a freezer where it stiffens but still remains in liquid state. It is packaged and hardened at –30 to –25 C until it becomes solid; and then it is stored at same temperature. Buttermilk, curd and cottage cheese are stored at 4 to 10 C for increase of shelf life.

Use of refrigeration during manufacture of these items also increases their shelf life. There are many varieties of cheese available these days. Adding cheese starter like lactic acid and several substances to the milk makes all of these. The whey is separated and solid part is cured for a long time at about 10 C to make good quality cheese.

v. Beverages

Production of beer, wine and concentrated fruit juices require refrigeration. The taste of many drinks can be improved by serving them cold or by adding ice to them. This has been one of the favourite past time of aristocracy in all the countries. Natural or man-made ice for this purpose has been made available since a very long time. Fruit juice concentrates have been very popular because of low cost, good taste and nutritional qualities. Juices can be preserved for a longer period of time than the fruits. Also, fruit juice concentrates when frozen can be more easily shipped and transported by road. Orange and other citrus juices, apple juice, grape juice and pineapple juice are very popular. To preserve the taste and flavor of juice, the water is driven out of it by boiling it at low temperature under reduced pressure. The concentrate is frozen and transported at –20 C. Brewing and wine making requires fermentation reaction at controlled temperature, for example lager-type of beer requires 8 to12 C while wine requires 27-30 C. Fermentation is an exothermic process; hence heat has to be rejected at controlled temperature.

vi. Candy

Use of chocolate in candy or its coating with chocolate requires setting at 5-10 C otherwise it becomes sticky. Further, it is recommended that it be stored at low temperature for best taste.

vii. Processing and distribution of frozen food

Many vegetables, meat, fish and poultry are frozen to sustain the taste, which nearly duplicates that of the fresh product. Freezing retains the sensory qualities of colour, texture and taste apart from nutritional qualities. The refrigeration systems for frozen food applications are very liberally designed, since the food items are frozen in shortest period of time. The sharp freezing with temperature often below –30 C, is done so that the ice crystals formed during freezing do not get sufficient time to grow and remain small and do not pierce the cell boundaries and damage them. Ready-to-eat frozen foods, packed dinners and bakery items are also frozen by this method and stored at temperatures of –25 to -20 C for distribution to retail stores during peak demands or off-season demands.

Vegetables in this list are beans, corn, peas, carrots, cauliflower and many others. Most of these are blanched before freezing. There are various processes of freezing. *Blast freezers* give a blast of high velocity air at – 30 C on the food container. In *contact freezing*, the food is placed between metal plates and metal surfaces that are cooled to “30 C or lower. *Immersion freezing i*nvolves immersion of food in low temperature brine. *Individual quick freezing* (IQF) is done by chilled air at very high velocities like 5-10 m/s that keeps the small vegetable particles or shrimp pieces floating in air without clumping, so that maximum area is available for heat transfer to individual particles. The frozen particles can be easily packaged and transported. The refrigeration capacities in all the freezers are very large since freezing of large quantities is done in a very short time. Liquid nitrogen and carbon dioxide are also used for freezing.

2.2 Applications of refrigeration in chemical and process industries

The industries like petroleum refineries, petrochemical plants and paper pulp industries etc. require very large cooling capacities. The requirement of each industry-process wise and equipment-wise is different hence refrigeration system has to be customized and optimized for individual application. The main applications of refrigeration in chemical and process industries involve the following categories.

2.2.1. Separation of gases: In petrochemical plant, temperatures as low as –150 C with refrigeration capacities as high as 10,000 Tons of Refrigeration (TR) are used for separation of gases by fractional distillation. Some gases condense readily at lower temperatures from the mixtures of hydrocarbon. Propane is used as refrigerant in many of these plants.

2.2.2. Condensation of Gases: some gases that are produced synthetically, are condensed to liquid state by cooling, so that these can be easily stored and transported in liquid state.

For example, in synthetic ammonia plant, ammonia is condensed at –10 to 10 C before filling in the cylinders, storage and shipment. This low temperature requires refrigeration.

2.2.3. Dehumidification of Air: Low humidity air is required in many pharmaceutical industries. It is also required for air liquefaction plants. This is also required to prevent static electricity and prevents short circuits in places where high voltages are used. The air is cooled below its dew point temperature, so that some water vapour condenses out and the air gets dehumidified.

2.2.4. Solidification of Solute: One of the processes of separation of a substance or pollutant or impurity from liquid mixture is by its solidification at low temperature. Lubricating oil is dewaxed in petroleum industry by cooling it below –25 C. Wax solidifies at about –25 C.

2.2.5. Storage as liquid at low pressure: Liquid occupies less space than gases. Most of the refrigerants are stored at high pressure. This pressure is usually their saturation pressure at atmospheric temperature. For some gases, saturation pressure at room temperature is very high hence these are stored at relatively low pressure and low temperature. For example natural gas is stored at 0.7 bar gauge pressure and –130 C. Heat gain by the cylinder walls leads to boiling of some gas, which is compressed, cooled and expanded back to 0.7 bar gauge.

2.2.6. Removal of Heat of Reaction: In many chemical reactions, efficiency is better if the reaction occurs below room temperature. This requires refrigeration. If these reactions are exothermic in nature, then more refrigeration capacities are required. Production of viscose rayon, cellular acetate and synthetic rubber are some of the examples. Fermentation is also one of the examples of this.

2.2.7. Cooling for preservation: Many compounds decompose at room temperature or these evaporate at a very fast rate. Certain drugs, explosives and natural rubber can be stored for long periods at lower temperatures.

2.2.8. Recovery of Solvents: In many chemical processes solvents are used, which usually evaporate after reaction. These can be recovered by condensation at low temperature by refrigeration system. Some of the examples are acetone in film manufacture and carbon tetrachloride in textile production.

2.3 Special applications of refrigeration

In this category we consider applications other than chemical uses. These are in manufacturing processes, applications in medicine, construction units etc.

i. **Cold Treatment of Metals:** The dimensions of precision parts and gauge blocks can be stabilized by soaking the product at temperature around –90 C. The hardness and wear resistance of carburized steel can be increased by this process. Keeping the cutting tool at –100 C for 15 minutes can also increase the life of cutting tool. In deep drawing process the ductility of metal increases at low temperature. Mercury patterns frozen by refrigeration can be used for precision casting.

ii. **Medical:** Blood plasma and antibiotics are manufactured by freeze-drying process where water is made to sublime at low pressure and low temperature. This does not affect the tissues of blood. Centrifuges refrigerated at –10 C, are used in the manufacture of drugs. Localized refrigeration by liquid nitrogen can be used as anesthesia also.

iii. **Ice Skating Rinks:** Due to the advent of artificial refrigeration, sports like ice hockey and skating do not have to depend upon freezing weather. These can be played in indoor stadium where water is frozen into ice on the floor. Refrigerant or brine carrying pipes are embedded below the floor, which cools and freezes the water to ice over the floor.

iv. **Construction:** Setting of concrete is an exothermic process. If the heat of setting is not removed the concrete will expand and produce cracks in the structure. Concrete may be cooled by cooling sand, gravel and water before mixing them or by passing chilled water through the pipes embedded in the concrete. Another application is to freeze the wet soil by refrigeration to facilitate its excavation.

v. **Desalination of Water:** In some countries fresh water is scarce and seawater is desalinated to obtain fresh water. Solar energy is used in some cases for desalination. An alternative is to freeze the seawater. The ice thus formed will be relatively free of salt. The ice can be separated and thawed to obtain fresh water.

vi. **Ice Manufacture:** This was the classical application of refrigeration. Ice was manufactured in plants by dipping water containers in chilled brine and it used to take about 36 hours to freeze all the water in cans into ice. The ice thus formed was stored in ice warehouses. Now that small freezers and icemakers are available. Hotels and restaurants make their own ice, in a hygienic manner. Household refrigerators also have the facility to make ice in small quantities. The use of ice warehouses is dwindling because of this reason. Coastal areas still have ice plants where it is used for transport of iced fish. Refrigeration systems are also required in remote and rural areas for a wide variety of applications such as storage of milk, vegetables, fruits, food grains etc., and also for storage of vaccines etc. in health centers. One typical problem with many of the rural and remote areas is the continuous availability of electricity.

3. Air Conditioners and its applications

Air Conditioning refers to the treatment of air so as to simultaneously control its temperature, moisture content, cleanliness, odour and circulation, as required by occupants, a process, or products in the space.

Air Conditioners are one of the most utilized appliances of the modern world. They are used worldwide for comfort in residential and commercial establishments. They are also widely used in many industries such as Textile, Paper and Pulp industry etc. where temperature and moisture of air are of critical importance.

4. Looking at Refrigeration and Air Conditioning through Standards' eye :

There are many Indian Standards available on Refrigerators and Air Conditioners and its components. These Indian standards provide the basic terminologies related to the Refrigeration and Air Conditioners. They also provide classifications of different Air Conditioners based upon different parameters viz. Construction, function and mounting arrangement. The Indian standards also specify constructional, performance, energy consumption and marking requirements which the Refrigerators and Air Conditioners as well as their components need to comply. We will see these Standards in detail in coming chapters.

4.1 To begin with the basic terminologies used in Refrigeration and Air Conditioning, let us dive into Indian Standard, **IS 3615: 2020- *Glossary of Terms Used in Refrigeration and Air Conditioning***

IS 3615: 2020- This standard is intended to provide definitions of words and terms employed in all phases of activities connected with refrigeration and air conditioning Air Conditioners- an introduction and application. This glossary of terms has been prepared for the guidance of manufacturers, users of refrigeration and air conditioning equipment and others concerned to assist them in the correct interpretation of the common terms used in this trade. Definitions have been arranged in alphabetical order and cross references have been given wherever necessary.

Few examples of the terminologies which are defined in IS 3615: 2020 are :

a) **Air Conditioning, Comfort** — It is the process of treating air so as to control simultaneously its temperature, humidity, cleanliness, and distribution to meet the comfort requirements of the occupants of the conditioned space.

b) **Air Conditioner, Room — Room Air conditioner**

   Window type: The entire assembly is fitted in the room wall being air-conditioned.

   Split Type: The evaporator unit is fitted inside the conditioned room while the condensing unit comprising of compressor, condenser etc is installed outside the room. Both the units are connected through copper pipe of suitable size.

c) **Compressor, Refrigerant, Welded Hermetic, Sealed Unit (HERMETIC COMPRESSOR**) — A hermetic refrigerant compressor whose housing is permanently sealed by welding or brazing and is not provided with means of access for servicing internal parts in the field. Or, a motor compressor assembly having the compressor contained within a gas-tight casing through which no shaft extends. Drive is usually by a motor within the same casing but may be induced by external means

d) **Heat Exchanger** — A device specifically designed to transfer heat between two physically separated fluids.

e) **Refrigerant** — The fluid used for heat transfer in a refrigerating system, which absorbs heat at a low temperature and a low pressure of the fluid and rejects heat at a higher temperature and a higher pressure of the fluid, usually involving changes of state of the fluid.

4.2 Now, let us try to understand the **basic safety and environmental requirements of various refrigerating system and heat pumps** specified in Indian Standards.

Safety and Environmental requirements of Refrigerating systems and Heat Pumps have been in particular specified in IS 16678: 2018.

This Standard specifies the requirements for the safety of persons and property, provides guidance for the protection of the environment, and establishes procedures for the operation, maintenance, and repair of refrigerating systems and the recovery of refrigerants.

This Standard is identical with international Standard ISO 5149 and has been published in following 4 parts:

Part 1 Definition, Classification and Selection Criteria

Part 2 Design, construction, testing, marking and documentation.

Part 3 Installation site

Part 4 Operation, maintenance, repair and recovery

a) IS 16678 (Part 1) specifies the classification and selection criteria applicable to the refrigerating systems and heat pumps. These classification and selection criteria are used in Other 3 parts of the Standard i.e. IS 16678 (Part 2), IS 16678 (Part 3), IS 16678 (Part 4)

b) IS 16678 (Part 2) specifies the design, construction, and installation of refrigerating systems, including piping, components, materials, and ancillary equipment directly associated with such systems, which are not covered in other parts of IS 16678. It also specifies requirements for testing, commissioning, marking, and documentation. Requirements for secondary heat-transfer circuits are excluded except for nay safety devices associated with the refrigerating system. It is applicable to new refrigerating systems, extensions or modifications of already existing systems, and for used systems, being transferred to and operated on another site.

c) IS 16678 (Part 3) specifies requirements for the site for safety, which could be needed because of, but not directly connected with, the refrigerating system and its ancillary components. It is applicable to new refrigerating systems, extensions or modifications of existing systems, and for used systems being transferred to and operated on another site. It also applies in the case of the conversion of a system for another refrigerant.

Specifications with respect to following may be of interest for the user of this Standard who may be Designer of the refrigerating system, installation engineers and the customer itself who is getting the system installed at its site:

Location of the refrigerating equipment- This Standard specifies that for different locations of the refrigerating equipment , like for Equipment located in open air, located in a machinery room, located in a occupied space etc. what safety features have to be taken care. For example, for Refrigerating systems sited in the open air it shall be positioned to avoid refrigerant leaking into the building or endangering people. If sited on the roof, the refrigerant shall not be able to flow across the roof into any ventilation fresh air opening, doorway, trap door, or similar opening in the event of a leak. Where a shelter is provided for refrigerating equipment sited in the open air, it shall have natural or forced ventilation.

Requirements for Machinery Room- The standard prescribes the provisions for ventilation from or through the machinery room. It also specifies that where a piece of combustion equipment is located in a machinery room containing refrigerating equipment, the combustion air supply for combustion engines, boilers, or the supply air for air compressors shall be drawn from a place where there is no refrigerant gas. If such a piece of equipment is installed in a machinery room, the combustion air for combustion engines or the supply air for air compressors shall be ducted from outside in such a manner as to prevent any refrigerant leakage from entering the combustion chamber. Other safety precautions and guidelines like Open (naked) flames shall not be permitted in machinery rooms and that Machinery rooms shall not be used for storage with the exception of tools, spare parts, and compressor oil for the installed equipment etc. are also specified in this Standard.

Other important provisions which are specified in IS 16678 (Part 3) include Requirements Electrical installations, requirements of Safety alarms and requirements of Detectors.

d) **IS 16678 (Part 4)** is another important Indian standard in this series which specifies requirements for safety and environmental aspects in relation to operation, maintenance and repair of refrigerating systems and the recovery, reuse and disposal of all types of refrigerant, refrigerant oil, heat transfer fluid, refrigerating system and part thereof.

These requirements are intended to minimize risks of injury to persons and damage to property and the environment resulting from improper handling of the refrigerants or from contaminants leading to system breakdown and resultant emission of the refrigerant.

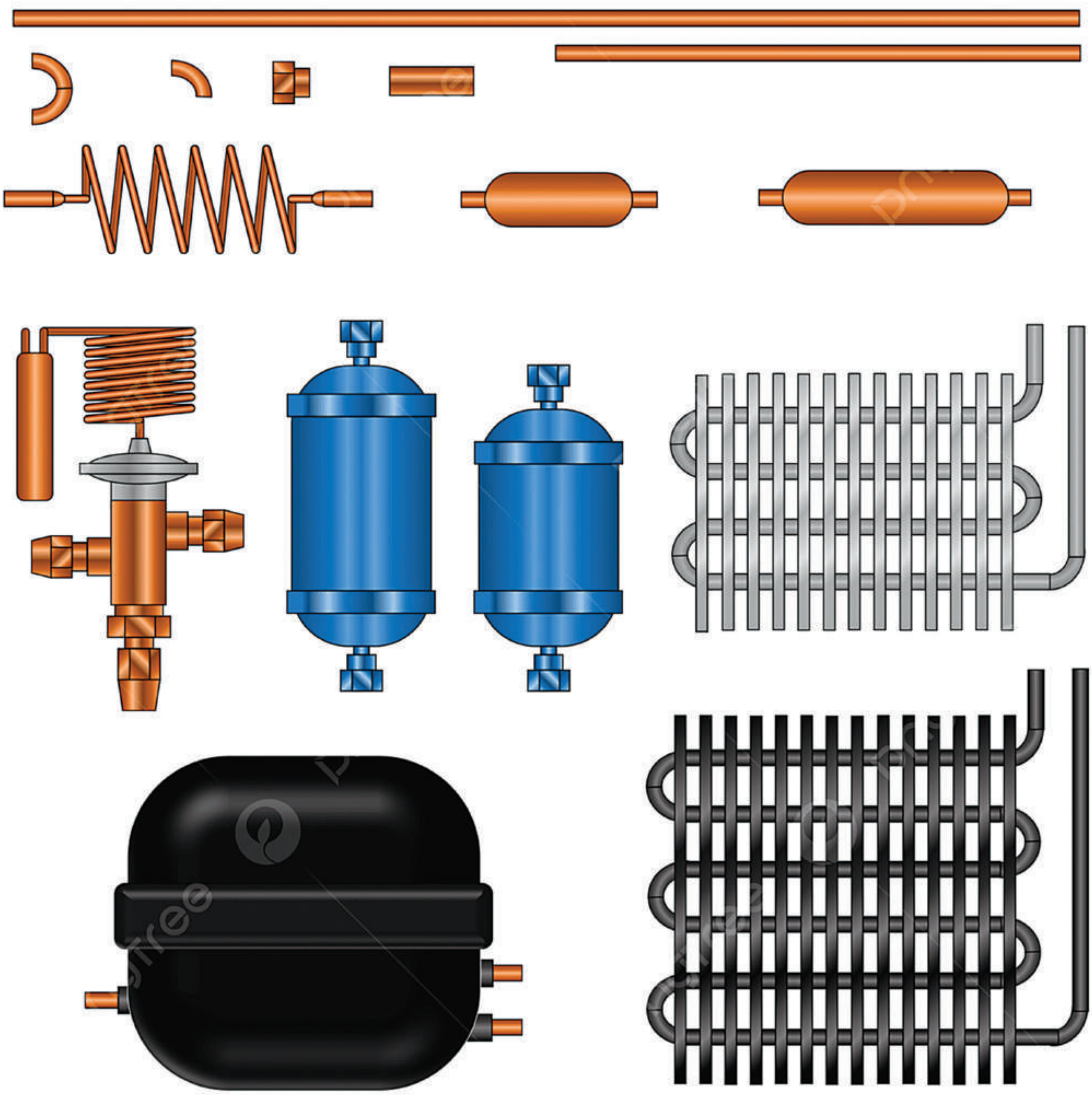
Maintenance and Repair requirements: This Standard stipulates the purpose and procedure of maintenance and repair of the installed system. It requires that the extent and time schedule for maintenance shall be fully described in the instruction manual. It also details the order in which the repair activity shall be carried out.

This standard also describes planning and execution steps which shall be taken in the event of a change of the refrigerant type used in the refrigerating system.

This Standard also specifies Requirements for recovery, reuse and disposal of refrigerating system and parts including specially the refrigerant.

CHAPTER III

ELEMENTS/COMPONENTS OF VAPOR COMPRESSION SYSTEMS



CHAPTER III

ELEMENTS/COMPONENTS OF VAPOR COMPRESSION SYSTEMS

1. Recap of Fundamentals:

As we know modern refrigerating and air conditioning appliances employ modified Vapor compression system to produce the desired cooling effect. These appliances need to use highly efficient and safe components.

The main components of a refrigerating and air conditioning system are:

a) Compressor

b) Evaporator

c) Condenser

d) Expansion device, and above all

e) The refrigerant, which undergoes the operation of compression, expansion and through phase changes in Evaporator and Condenser

Both Evaporator and Condenser are essentially the Heat Exchangers carrying out the function of Heat transfer through the refrigerant and maintaining the flow through the refrigerant circuit.

Types of Compressors: The compression of suction vapor from evaporator to the condenser pressure can be achieved by mechanical compression, ejector compression or by a process combination of absorption of vapor, pumping and desorption. Of these all means, mechanical compression is the most widely used method in the refrigeration and air conditioning system.

There are mainly two types of mechanical compressors:

a) Positive Displacement compressors: Reciprocating, Rotary, Scroll and Screw compressors.

b) Non-positive displacement compressors viz. Centrifugal compressors

Compressors employed in modern domestic and commercial refrigerating and air conditioning systems are mostly Hermetically sealed type. Hermetically sealed compressor- A machine consisting of an electrically driven refrigerant pump housed in a container which is welded or brazed together to form a gas tight shell also called as housing. The machine cannot be taken apart without cutting open the container housing and has no access to internal moving parts. The electrical windings are exposed to both the refrigerant and the compressor lubricating oil. There are various types of hermetically sealed compressors using different pumping mechanisms: Reciprocating, Rotary, Scroll , linear.

Types of Condensers: The type of a condenser is generally characterized by the cooling medium used. Considering this, there are three types of condensers:

a) Air cooled condensers

b) Water cooled condensers

c) Evaporative condensers

Types of Evaporators: Evaporators are mainly classified as Flooded and Dry. The flow of refrigerant is inside the tubes in dry evaporators and outside tubes in flooded evaporators. Most of the household refrigerators and air conditioners employ Dry type of evaporators with some using extended surfaces of Fins also.

Expansion Valves: An expansion device in a refrigeration system normally serves two purposes. One is the thermodynamic function of expanding the liquid refrigerant from the condenser pressure to the evaporator pressure. The other is the control function which may involve the supply of the liquid to the evaporator at the rate at which it is evaporated. Basically there are two types of expansion devices:

a) Variable-restriction type

b) Constant-restriction type

In the variable-restriction type, the extent of opening or area of flow keeps on changing depending upon the type of control. There are two common types of such control devices, viz. the automatic expansion valve and the thermostatic expansion valve. The constant-restriction type device is the capillary tube which is merely a long tube with a narrow diameter bore.

There are multiple aspects which need to be taken into account for a component in order to obtain safe and efficient refrigeration and air conditioning system. These aspects include material, design, construction, safety and performance of the component. Finally, once the component has been designed, it is required to be evaluated against the specified parameters to check whether the intended purpose is being met or not.

Indian Standards beautifully cover these all aspects. Let us see how.

2. Establishing requirements and assessing compliance of components through Indian Standards:

Indian standards available on components:

MED 03, Refrigeration and Air Conditioning Sectional Committee under the Mechanical Engineering Department in BIS is responsible for formulation of Standards for refrigeration and air- conditioning equipment and appliances including terminology, definitions and symbols, designation of refrigerants, testing of refrigerating systems; and refrigerating units. Under this technical committee, following Indian standards on various components have been formulated, which are considered relevant here :

Indian Standards for components under MED 3- Refrigeration and Air Conditioning		
Sl. No.	**IS No.**	**TITLE**
1.	IS 10594 : 2021	Specification for Thermostatic Expansion Valves
2.	IS 10617 : 2018	Hermetic compressors
3.	IS 11327 : 2022	Requirements for Refrigerants Condensing Units
4.	IS 11329 : 2018	Finned type heat exchanger for room air conditioner
5.	IS 16656 : 2017	Refrigerants - Designation and safety classification
6.	IS/ISO 17584 : 2022	Refrigerant properties

7.	IS 5111 : 1993 ISO 917 : 1999	Testing of refrigerant compressors
8.	IS/IEC 60730 : Part 2 : Sec 9 : 2010	Automatic Electrical Controls for Household and Similar Use Part 2 Particular Requirements Section 9 Temperature Sensing Controls

Now, we will go through these Standards in brief.

2.1 IS 10617: 2018- Hermetic Compressors

2.1.1 Scope of the Standard: This Standard deals with the safety and performance requirements of hermetic sealed type standalone motor-compressors operating on vapor compressor cycle, suitable for low, medium and high temperature applications based on reciprocating (including linear), rotary and scroll pump mechanisms, their protection system, if any, which are intended for use in equipment for house hold, industrial and commercial purposes.

2.1.2 Classification of compressors as per IS 10617: 2018:

The Hermetic compressors covered in IS 10617 are classified based on the evaporating range as given in Table 1below.

Table 1- classification of Compressors as per IS 10617

Sl No.	**Category**	**Usage**	**Evaporating Temperature Range (°C)**
(1)	(2)	(3)	(4)
i)	Low back pressure (LBP)	Refrigerating and freezing domestic and commercial applications	-35 to -10
ii)	Commercial back pressure/Medium back pressure (CBP/MBP)	Commercial applications	-20 to +10

iii)	High back pressure (HBP)	a) Air-conditioning application b) Commercial/Heat pump application	-5 to +13.9 -23.3 to 12.8

2.1.3 Performance requirements and tests specified in IS 10617 for Hermetic Compressors:

Following performance parameters and tests for Hermetic Compressors are specified in IS 10617:

Cold and Hot Startability:- The cold start test shall be carried out with the conditions mentioned in Table 2 below and ambient temperature at 25~35°C. The compressor shall start and run at 85 percent of the rated voltage. In Hot startability test, The compressor shall be run at rated voltage and frequency till steady state is achieved as defined at Clause 5.1 of IS 10617 (that is, three successive readings of the temperature, taken at approximately 10 min intervals), then switched OFF to achieve pressures at saturated temperatures mentioned in Table2 or Table 3 as applicable to particular class of Compressor and then switched ON. The compressor shall start and run at minimum voltage, as per the compressor specification. Test shall be repeated 3 times for consistency in results after achieving pressure as specified in Cl. 5.1 of IS 10617.

Table 2 Normal Load Conditions LBP
(*Clause* 5.1)

Sl No.	Item	Unit	Household and Commercial Refrigeration Applications	Commercial and Industrial Refrigeration Applications
(1)	(2)	(3)	(4)	(5)
i)	Evaporating temperature[1]	°C	-23.3	-35
ii)	Condensing temperature[1]	°C	54.4	40
iii)	Ambient temperature	°C	32.2	35
iv)	Compressor suction gas temperature	°C	32.2	20
v)	Temperature of sub-cooled liquid	°C	32.2	40
vi)	External cooling of compressor	Natural convection or any other system specified by the manufacture		
vii)	Voltage	V	Rated voltage ±1 percentage	
viii)	Frequency	Hz	Rated frequency ± 1 percentage	

Table 3 Normal Load Conditions (CBP/MBP)
(*Clause* 5.1)

Sl No.	Item	Unit	Household and Commercial Refrigeration Applications	Commercial / Industrial Refrigeration Applications
(1)	(2)	(3)	(4)	(5)
i)	Evaporating temperature[1]	°C	-6.7	-10
ii)	Condensing temperature[1]	°C	54.4	45
iii)	Ambient temperature	°C	35.0	35.0
iv)	Compressor suction gas temperature	°C	35.0	20
v)	Temperature of sub- cooled liquid	°C	46.1	45
vi)	External cooling of compressor	Natural convection or any other system specified by the manufacture		
vii)	Voltage	V	Rated voltage ±1 percentage	
viii)	Frequency	Hz	Rated frequency ± 1 percentage	

High Voltage withstand ability: The compressor shall be able to withstand 1.5 kV AC voltage for 1 min/s without breakdown. The leakage current measured shall not exceed 5 mA.

Pneumatic Test of Shell: The shells shall be tested pneumatically (dry air/nitrogen) at a test pressure of 1MPa (gauge) and shall not show any leakage.

Ability to withstand the pressure expected in normal use (Burst test):

Housing shall be subjected to low side pressure or high side pressure or both pressure in normal use as per the design of hermetic compressors. The evaluation shall be carried out determining which part of the shell is subjected to high or low side or both 2 pressures as per the compressor design. Wherever needed, specially built samples with or without assembly inside are subjected to this test, the high pressure side shell or portion of shell is to be subjected to high side test pressure and low pressure side shell or portion of shell is to be subjected to low side test pressure.

Running overload test: The compressor shall have built in protection system. It may be bi-metallic thermal overload protection or electronically controlled protection system. The protection system can be either internal to the compressor or placed externally. The compressor shall be capable of withstanding the overload test (Overload test conditions given in Table 9 of IS 10617).

The motor-compressor including the motor-compressor protection system or motor-compressor control system, if any, is operated under the appropriate conditions given in Table 9 so as to cause the motor-compressor protection system to operate or to reach steady conditions with the motor-compressor in the stalled or running condition. The testing shall be conducted at rated voltage and stabilized for 2 h.

After stabilization, the test voltage shall be increased to 1.06 times of rated voltage to stabilize and the motor protection system shall not trip. In case of dual rated voltage, highest voltage is to be considered as the test voltage.3

The test is then repeated with voltage reduced to 0.94 times of rated voltage and 0.85 times of rated voltage. In case of dual rated voltage, lowest voltage is to be considered as the test voltage.

During test, if the motor-compressor protection system does not operate, the voltage is decreased (or increased in case the protector trips at 0.85 times rated voltage to find the start voltage) in steps of 4 percent ± _1 percent of the rated voltage, at a rate of approximately 2 V/min, until steady conditions are reached at each step. This procedure is continued until one of the following conditions occurs:

a) the motor-compressor protection system operates; or
b) the motor-compressor stalls and steady conditions are reached.

NOTE — _Stabilized conditions are considered to be obtained when three successive readings of the temperature, taken at approximately 10 min intervals, at the same point of any operating cycle, does not differ by more than -273°C (1 K).

At the time of trip, the winding temperature shall not exceed 150°C for compressors with cellulosic insulation and 160°C for compressors with synthetic insulation. For other insulating material winding temperature limit may be defined by the manufacturer. This test is not applicable to variable speed and DC compressors.

Locked Rotor Test: The compressor with overload protection system shall undergo locked rotor testing as a design verification test. This test is applicable to compressors with self-resetting motor protector only. The locked rotor condition is obtained by blocking the movement of rotor and/or piston on specimen compressor. The compressor shall be charged with oil and if necessary, with vapour refrigerant. The rated voltage is to be applied when the compressor is kept under ambient temperature not exceeding 35°C. The system shall be tested for 2 000 cycles or for 15 days which is applicable as below.

At the end of this test following requirement shall be met:

a) Motor-compressor protection system shall be able to operate;
b) Temperature of the housing and the temperature of the accessible surfaces of associated components shall not exceed 150°C;
c) Leakage current, at 1.06 times the rated voltage for single phase and 1.06 times the rated voltage divided by root 3 for three-phase shall not exceed 3.5 mA; and
d) Compressor shall withstand high voltage test.

Resistance to rusting: To check the efficacy of paint and or rust preventive coating applied on compressor shell, Test for resistance to rusting is carried out. Following 3 tests are done as part of this test: Dry film thickness, Paint adhesion by cross cut test, and Paint cure test. The compressor must pass these tests to be declared to conforming to this requirement.

2.1.4 Marking requirements for Hermetic Compressors as per IS 10617 : The compressor shall have the following information marked on a nameplate in a permanent and legible manner in a location, where it is accessible and visible:

a) Name of manufacturer and country of origin;
b) Type or model number and serial number of the unit;
c) Month and year of manufacture;
d) Rated voltage, phase and frequency: product rated for dual voltage / dual frequency to be marked as dual voltage and dual frequency;
e) Locked rotor current;
f) Current at rated conditions or maximum continuous current (optional); and
g) Refrigerant or refrigerant group

Another important Indian standard which is of relevance here is IS 5111/ISO 917 which prescribes methods of tests on Hermetic Compressor.

2.1.5 IS 5111/ ISO 917- Testing of Refrigerant Compressors-

While the specification of Hermetic Compressors are prescribed in IS 10617, The performance testing of hermetic compressors are required to be carried out by any of the methods given in IS 5111 depending on construction of test equipment.

IS 5111/ISO 917 specifies test methods for determination of following performance characteristics of Hermetic Compressors as per IS 10617: Refrigerating capacity, Determination of Power and Coefficient of Performance.

IS 5111/ISO 917 specifies test methods for determination of other properties such as Volumetric efficiency and Isentropic efficiency as well, which are also useful for compressors.

We can see here that how the Standards are linked with each other. This practise is adopted extensively in Standard formulation process by Standard formulation bodies. This greatly reduces the volume of the document particularly in a Standard which is product specification by only giving reference to the Standard for Test method for determining those specified requirements. For example, a user needs to know only the specified requirements for his product and does not need to go into detail of how those requirements are determined. That is why, we can find REFERENCE clause in Standards at the beginning itself wherein it is declared that the referred standards contain provisions, which through reference in the parent Standard, constitute provisions of this standard. Since, all standards are subject to revisions/amendment, **users are encouraged to refer to the latest version of the referred.**

2.2 Thermostatic Expansion Valves:

IS 10594: 2021- Thermostatic Expansion Valves

2.2.1 Scope of the Standard: This standard specifies the terms, definitions, types, basic parameters, requirements, testing, marking, packing, transportation and storage of thermostatic refrigerant expansion of various types. This standard is applicable to the thermostatic expansion valves for refrigeration with R22, R134a, R404A, R407C, R410A, R507, R290, R32 and R23 evaporating at the temperature of – 60 °C to 15 °C. This standard may be used as a reference for other thermostatic expansion valves with other refrigerants.

2.2.2 Types of Thermostatic Expansion valves: Thermostatic expansion valves are classified based on following criteria:

a) Equalization Method: Internal equalization and external equalization.

b) Flow Direction: Unidirectional flow and bidirectional flow.

c) Refrigerant: R22, R134a, R404A, R407C, R410A, R507, R507A,R290, R23 and R32.

d) Flow Opening Type: Single flow opening and equalized flow opening.

e) Connection Method: Welding, thread, and flange.

f) Flow-through Method: Straight-through flow and angle type.

g) Pressure-limiting Method: General and pressure limiting.

h) Installation Method of Temperature-sensing Element: Remote temperature-sensing element and internal temperature-sensing element.

i) Orifice Type: Exchangeable orifice and unexchangeable orifice.

j) Super Heat Setting Adjustment Type: Adjustable and non-adjustable.

k) Balance Port: With balance port and non-balance port.

l) Check Valve: With check valve and without check valve.

m) Bleed Hole: With internal bleed hole and without internal bleed hole.

2.2.3 Performance requirements and tests specified in IS 10594 for Thermostatic Expansion Valves

Following performance parameters and tests for *Thermostatic Expansion Valves* are specified in IS 10594:

General requirements and material of construction

a) Material: All working parts of expansion valve shall be compatible to meet with the product functional requirements and all test requirements and typically be constructed using brass, bronze, copper, carbon steel, stainless steel etc (see IS 292, IS 410, IS 6911 etc.).

b) Hydraulic Strength Test:

- Pressure Test: Expansion valve shall be pressure tested without leakage. There shall be no visual deformation and cracks.
- Burst Test: Expansion valve shall be pressure tested and free of leakage or cracking.

c) Tightness Test: The tightness can be tested by helium. The leakage rate of expansion valves shall be less than 6.4 × 10 – 6 mbar·L/s, and the leakage rate of the power head shall be less than 1 × 10 – 6 mbar·L/s.

d) Corrosion Test: Thermostatic expansion valve shall be constructed of any corrosion-resistant materials and shall conform to the Salt Spray test specified in IS 9844 for duration not less than 72 h.

e) Environmental Heat Resistance: During the test of environmental heat resistance, the temperature-sensing element of expansion valves shall be free from leakage.

f) Leakage Rate of External Equalizer: The leakage rate of external equalization pipe for expansion valves shall comply with the specifications in Table 2 of IS 10594 or the contractual specifications.

g) Ex-factory Static Superheat: The static superheat of expansion valves shall conform to the requirements of static superheat given in IS 10594 or the contractual specifications.

h) Internal Leakage of Throttle Opening: The actual leakage rate of the throttle opening of expansion valves shall be not more than 1 percent of the nominal flow rate or the contractual specifications

i) Nominal Cooling Capacity: The measured cooling capacity of expansion valves shall not be less than 95 percent of the nominal cooling capacity. The forward and reverse cooling capacity of bidirectional expansion valves shall not be less than 95 percent of the nominal cooling capacity. The maximum measured cooling capacity shall not be less than 120 percent of the nominal cooling capacity.

j) Extended Cooling Capacity: For expansion valve of each model, it is required to provide the extended cooling capacity data, namely, the cooling capacity at different evaporating temperatures and pressure drops (or different condensing temperatures).

k) Hysteresis: The measured hysteresis of the expansion valves shall not be more than 2K or shall comply with the contractual specification.

l) Vibration Resistance: After vibration resistance test, the expansion valves shall function properly and the retested static superheat shall reach the original default value with in the specified tolerance.

m) Working Life: After the working life test, the expansion valves shall function properly and the retested static superheat shall reach the original default value with in the specified tolerance.

n) Lifetime of Capillary: The capillary should withstand minimum seven bending cycles without any rupture or crack.

1.3 Refrigerant in Vapour Compression system:

Refrigerant is the working fluid in a vapour compression system which flows through the circuit and undergoes phase changes and thereby executing the desired function of cooling.

Indian standards on refrigerant

A. IS 16656: 2017/ISO 817: 2014- REFRIGERANTS DESIGNATION AND SAFETY CLASSIFICATION

2.3.1 Scope: This Standard provides an unambiguous system for assigning designation to Refrigerants. It also establishes a system for assigning safety classification to

Refrigerants based on toxicity and flammability data and provides means for determining refrigerant concentration limit.

It initially defines the terminologies like Isomers, acute toxicity, Concentration limits, Critical point, Flammable etc. which are relevant for the purpose of this Standard.

2.3.2 Numbering of refrigerants

2.3.2.1 An identifying number shall be assigned to each refrigerant.

2.3.2.2 The identifying numbers assigned to the hydrocarbons, halocarbons and ethers of the methane, ethane, ethene, propane, propene and cyclobutane series are such that the chemical composition of the compounds can be explicitly determined from the refrigerant numbers, and vice versa, without ambiguity. The molecular structure can be similarly determined for the methane, ethane, ethene and most of the propane and propene series from only the identification number.

2.3.2.2.1 The first digit on the right is the number of fluorine (F) atoms in the compound.

2.3.2.2.2 The second digit from the right is one more than the number of hydrogen (H) atoms in the compound.

2.3.2.2.3 The third digit from the right is one less than the number of carbon (C) atoms in the compound. When this digit is zero, it is omitted from the number.

2.3.2.2.4 The fourth digit from the right is equal to the number of carbon-carbon double bonds in the compound. When this digit is zero, it is omitted from the number.

2.3.2.2.5 In those instances where bromine (Br) or iodine (I) is present the same rules apply, except that the upper case letter B or I after the designation determined according to 2.3.2.2.1 to 2.3.2.2.4 as above shows the presence of bromine or iodine. The number following the letter B or I shows the number of bromine or iodine atoms present.

2.3.2.2.6 The number of chlorine (Cl) atoms in the compound is found by subtracting the sum of fluorine (F), bromine (Br), iodine (I) and hydrogen (H) atoms from the total number of atoms that can be connected to the carbon (C) atoms. For saturated organic compounds, this number is $2n + 2$, where n is the number of carbon atoms. The number is $2n$ for compounds with one double bond and saturated cyclic compounds.

2.3.2.2.7 The carbon atoms shall be numbered with the number 1 assigned to the end carbon with the greatest number of halogen atoms, and the following carbon atoms are numbered sequentially as they appear on a straight chain. In the case where both end carbons contain the same number of (but different) halogen atoms, the number 1 shall be assigned to the end carbon having the largest number of bromine then chlorine then fluorine, and then iodine atoms. If the compound is an olefin, then the end carbon nearest to the double bond will be assigned the number 1, as the presence of a double bond in the back bone of the molecule has priority over substituent groups on the molecule.

2.3.2.2.8 For cyclic compounds, the letter C is used before the identifying refrigerant numbers. (e.g. R-C318, PFC-C318).

2.3.2.2.9 In the case of isomers in the ethane series, each shall have the same number, with the most symmetrical one indicated by the number alone. As the isomers become more and more unsymmetrical, successive lower case letters (i.e. a, b, or c) are appended. Symmetry is determined by first summing the atomic mass of the halogen and hydrogen atoms attached to each carbon atom. One sum is subtracted from the other; the smaller the absolute value of the difference, the more symmetrical the isomer.

2.3.2.2.10 In the case of isomers in the propane series, each shall have the same number, and the isomers shall be distinguished by two appended lower case letters. The first appended letter indicates the substitution on the central carbon atom (C2) as indicated in Table 1.

Table 1 — Propane isomer appended letters

Isomer	Appended letter
CCl2	a
CClF	b
CF2	c
CHCl	d
CHF	e
CH2	f

For halogenated derivatives of cyclopropane, the carbon atom with the largest sum of attached atomic masses shall be considered the central carbon atom; for these compounds, the first appended letter is omitted. The second appended letter indicates the relative symmetry of the substituents on the end carbon atoms (C1 and C3). Symmetry is determined by first summing the atomic masses of the halogen and hydrogen atoms attached to the C1 and C3 carbon atoms. One sum is subtracted from the other; the smaller the absolute value of this difference, the more symmetrical the isomer. In contrast to the ethane series, however, the most symmetrical isomer has a second appended letter of a (as opposed to no appended letter for ethane isomers); increasingly asymmetrical isomers are assigned successive letters. Appended letters are omitted when no isomers are possible, and the number alone represents the molecular structure unequivocally; for example, $CF_3CF_2CF_3$ is designated R-218, not R218ca. An example of this system is given in Annex A. Propane series isomers containing bromine are not covered by the appended letters given in 2.3.2.11 and Table 2.

2.3.2.2.11 In the case of isomers in the propene series, each has the same number, with the isomers distinguished by two appended lower case letters. The first appended letter designates the one atom attached to the central carbon atom and shall be x, y, or z for Cl, F, and H, respectively. The second letter designates the substitution on the terminal methylene carbon as indicated in Table 2.

Table 2 — Propene isomer appended letters

Isomer	Appended letter
CCl2	a
CClF	b
CF2	c
CHCl	d
CHF	e
CH2	f

In the case where stereoisomers can exist, the opposed (Entgegen) isomer will be identified by the suffix (E) and the same side (Zusammen) isomer will be identified by the suffix (Z).

2.3.3 Ether-based refrigerants shall be designated with the prefix "E" (for "ethers") immediately preceding the number. Subclause 2.3.2.2 applies except for the following differences.

2.3.3.1 Two-carbon, dimethyl ethers (e.g. R-E125, CHF_2-O-CF_3) require no suffixes other than those specified in 2.3.2.2.9, as the presence of the "E" prefix provides an unambiguous description.

2.3.3.2 For straight chain, three carbon ethers, the carbon atoms shall be numbered with the number 1 assigned to the end carbon with the highest number of halogens, and the following carbon atoms are numbered sequentially as they appear on a straight chain. In the case where both end carbons contain the same number of (but different) halogen atoms, the number 1 shall be assigned to the end carbon having the largest number of bromine, then chlorine, then fluorine and then iodine atoms. For ethers with more than three carbons, the compound shall be assigned a number in the 600 series, miscellaneous organic compounds, as described in 2.3.5.

2.3.3.2.1 An additional integer identifying the first carbon to which the ether oxygen is attached shall be appended to the suffix letters (e.g. R-E236ea2, CHF_2-O-CHF-CF_3).

2.3.3.2.2 In the case of otherwise symmetric hydrocarbon structures, the ether oxygen shall be assigned to the carbon which has the leading position in the formula.

2.3.3.2.3 In those cases where only a single isomer exists for the hydrocarbon portion of the ether structure, such as CF_3-O-CF_2-CF_3, the suffix letters described in 4.2.9, 4.2.10 and 4.2.11 shall be omitted. In this cited example, the correct designation shall be R-E218.

2.3.3.2.4 Structures containing two oxygen atoms, di-ethers, shall be designated with two suffix integers to designate the positions of the ether oxygen atoms.

2.3.3.3 For cyclic ethers carrying both the "C" and "E" pre-fixes, the "C" shall precede the "E," as "CE," to designate "cyclic ethers." For four-membered cyclic ethers, including three carbon and one ether oxygen atom, the basic number designations for the hydrocarbon atoms shall be constructed according to the current standard for hydrocarbon nomenclature, as described in 3.2.

2.3.4 Blends are assigned a refrigerant number in the 400 or 500 series.

2.3.4.1 Zeotropes shall be serially assigned an identifying number in the 400 series. In order to differentiate among the different zeotropes having the same components but in different proportions, an upper case letter (A, B, C, ...) is added after the number.

2.3.4.2 Azeotropes shall be serially assigned an identifying number in the 500 series. In order to differentiate among the different azeotropes having the same components but in different proportions, an upper case letter (A, B, C, ...) is added after the number.

2.3.4.3 Blends shall have tolerances specified for individual components. Those tolerances shall be specified to the nearest 0,1 % mass fraction. The maximum tolerance above or below the nominal shall not exceed 2,0 % mass fraction. The tolerance above or below the nominal shall not be less than 0,1 % mass fraction. The difference between the highest and the lowest tolerances shall not exceed one-half of the nominal component composition.

2.3.5 Miscellaneous organic compounds shall be assigned numbers in the 600 series in decadal groups, as outlined in Table E.4 of IS 16656, in serial order of designation within the groups. For the saturated hydrocarbons with 4 to 8 carbon atoms, the number assigned shall be 600 plus the number of carbon atoms minus 4. For example, butane is R-600, pentane is R-601, hexane is R-602, heptane is R-603, and octane is R-604. The straight chain or “normal” hydrocarbon has no suffix. For isomers of the hydrocarbons with 4 to 8 carbon atoms, the lower case letters “a”, “b”, “c”, etc., are appended to isomers according to the group(s) attached to the longest carbon chain as indicated in Table 3. For example, R-601a is assigned for 2-methylbutane (isopentane) and R-601b would be assigned for 2,2-dimethylpropane (neopentane). Mixed isomers where the concentration of one isomer is greater than or equal to 4 % shall be assigned a number in the 400 or 500 series.

Table 3 — Miscellaneous organic compound suffixes

Attached group	**Suffix**
none (straight chain)	No suffix
2-methyl-	a
2,2-dimethyl-	b
3-methyl-	c
2,3-dimethyl-	d
3,3-dimethyl-	e
2,4-dimethyl-	f
2,2,3-trimethyl-	g
3-ethyl-	h
4-methyl-	i
2,5-dimethyl-	j
3,4-dimethyl-	k
2,2,4-trimethyl-	l
2,3,3-trimethyl-	m
2,3,4-trimethyl-	n
2,2,3,3-tetramethyl	o
3-ethyl-2-methyl-	p
3-ethyl-3-methyl-	q

2.3.6 Inorganic compounds shall be assigned identifying numbers in the 700 series and 7000 series.

2.3.6.1 For compounds with relative molar masses less than 100, the number shall be the sum of 700 and the relative molar mass, rounded to the nearest integer.

2.3.6.2 For compounds with molar masses equal to or greater than 100, the identifying number shall be the sum of 7 000 and the relative molar mass, rounded to the nearest integer.

2.3.6.3 When two or more inorganic refrigerants have the same molar masses, upper case letters (i.e. A, B, C, etc.) shall be added in serial order of designation to distinguish among them starting with the letter A for the second identified inorganic refrigerant of the given molar mass.

2.3.7 Designation prefixes

2.3.7.1 General prefixes

The identifying number, as determined by 2.3.2, shall be preceded by the letter R or the word Refrigerant(s) unless composition designating prefixes, as described in 2.4.3 are being used. Between the letter R or the word Refrigerant and the designation number, no space, a blank or a dash is used. Examples include: R134a, Refrigerant 134a, R 134a, and R-134a.

2.3.7.2 Composition-designating prefixes

For the fluorocarbon and the hydrocarbon families, the identifying number, as determined by 2.3.2, may be prefixed by a letter sequence which designates the elements which constitute the specific compound. The composition-designating prefix shall consist of the first letter of elements contained in the compound. The first element listed shall be H for hydrogen if present and the last shall be C for carbon. The intermediate letters shall represent the halogens listed in the following order: I for iodine, B for bromine, C for chlorine and F for fluorine.

NOTE 1 Halogenated compounds that contain hydrogen have increased deterioration potential before reaching the stratosphere.

The compositional designating prefixes for ethers shall substitute an “E” for “C” (carbon), such that HFE, HCFE, and CFE refer to hydrofluoroether, hydrochlorofluoroether, and chlorofluoroether, respectively. E in the identifying number shall be omitted when composition-designating prefixes are used. The composition designating prefixes for halogenated olefins shall be either CFC, HCFC, or HFC to refer to chlorofluorocarbon, hydrochlorofluorocarbon, or hydrofluorocarbon, respectively, or with substitution of an O for the carbon C as CFO, HCFO, or HFO to refer to chlorofluoro-olefin, hydrochlorofluoro-olefin, or hydrofluoro-olefin, respectively.

NOTE 2 Halogenated olefins are a subset of halogenated organic [or carbon containing] compounds having significantly shorter atmospheric lifetimes than their saturated counterparts.

In addition, when a refrigerant compound is fully fluorinated the notation PFC is used. Examples are shown in Table 4.

Table 4 — Examples of composition-designating prefixes

Refrigerant	Composition	Prefix and designation
Chlorofluorocarbon 12	CCl2F2	CFC-12
Hydrochlor of luorocarbon 22	CHClF2	HCFC-22
Hydrofluor ocarbon 134a	CH2FCF3	HFC-134a
Perfluorocarbon 116	CF3CF3	PFC-116
Hydrocarbon 600a	(CH3)2CH CH3	HC-600a
Perfluoro carbon C318	-(CF2)4-	PFC-C318
Hydrofluoroether E125	CHF2OCF3	HFE-125
Hydrofluoro-olefin 1234yf	CF3CF=CH2	HFO-1234yf

Blends with assigned numbers may be identified by linking the appropriate composition-designating prefixes of individual components (e.g. R-500 [CFC-12/HFC-152a]). Blend components shall be listed in order of increasing normal boiling point. Blends without assigned numbers can be identified using appropriate composition-designating prefixes for each component (e.g. HCFC-22/HFC-152a/CFC-114 [36,0/24,0/40,0]). Here [36,0/24,0/40,0] represents the mass fraction of each component, expressed as a percentage.

2.3.8 Safety Classifications

2.3.8.1 Safety classification — Composition

The safety classification shall consist of two alphanumeric characters (e.g. A2 or B1) with a third character L designating low burning velocity. The capital letter indicates the toxicity as determined by 2.3.8.2 ; the Arabic numeral denotes the flammability as determined by 2.3.8.3. Blends shall be assigned a dual safety group classification, with the two classifications separated by a slash (/). The first classification listed shall be the classification of the worst-case formulation (WCF) of the blend. The second classification listed shall be the classification of the worst-case fractionated formulation (WCFF).

2.3.8.2 Toxicity classification

Refrigerants shall be assigned to one of two classes, A or B, based on allowable exposure:

— class A (lower chronic toxicity) signifies refrigerants that have an occupational exposure limit of 400 ppm1) or greater;

— class B (higher chronic toxicity) signifies refrigerants that have an occupational exposure limit of less than 400 ppm.

NOTE The occupational exposure limit is based on the OSHA PEL, ACGIH TLV-TWA, TERA WEEL, or the MAK.

2.3.8.3 Flammability classification — General

2.3.8.3.1 Flammability classification

Refrigerants shall be assigned to one of four classes (1, 2L, 2 or 3) based on lower flammability limit testing conducted in accordance with ASTM E681 as specified in is

Annex –B of 16656, the maximum burning velocity measurement conducted in the method as described hereafter, and the heat of combustion determined in accordance with Cl. 6.1.3.7 of IS 16656.

It is to be noted that such safety classification of refrigerants greatly help in selection of refrigerants for various applications.

2.3.9 Matrix diagram of safety group classification system

The toxicity and flammability classifications described as above yield eight separate safety classifications (A1, A2L, A2, A3, B1, B2L, B2, and B3) for refrigerants. These classifications are represented by the matrix shown in Figure 1.

	Safety group	
Higher Flammability	A3	B3
Flammable	A2	B2
Lower flammability	A2L	B2L
No flame Propagation	A1	B1
	Lower Toxicity	Higher Toxicity

Figure 1 — Safety groups as determined by flammability and toxicity

2.3.10 Classifications of some commonly used Refrigerants as per Indian Standard IS 16656

Classification of some commonly used Refrigerants is given below :

Refrigerant designations

Refrige-rant number	**Compo-sition desig-nating prefix**	**Chemical name**[b]	**Chemical formula**	**Relative molar mass** a g/mol	**Normal boiling point** a°C	**Safety group**[d]	**LFL** (ppm by volume)	**ATEL** (ppm by vol-ume)	**RCL** (ppm by vol-ume)
		Methane series							
R-11	CFC	trichlorofluoro methane	CCl3F	137,4	24	A1		1 100	1 100
R-12	CFC	dichlorodifluoro methane	CCl2F2	120,9	-30	A1		18 000	18 000
R-14	PFC	tetrafluoromethane	CF4	88,0	-128	A1		110 000	110 000
		(carbon tetrafluoride)							
R-22	HCFC	chlorodifluoro methane	CHClF2	86,5	-41	A1		59 000	59 000
R-23	HFC	trifluoromethane	CHF3	70,0	-82	A1		51 000	51 000
R-32	HFC	difluoromethane (methylene fluoride)	CH2F2	52,0	-52	A2L	144 000	220 000	29 000
		Ethane series							
R-125	HFC	pentafluoroethane	CHF2CF3	120,0	-49	A1		75 000	75 000
R-134a	HFC	1,1,1,2-tetrafluoroethane	CH2FCF3	102,0	-26	A1		50 000	50 000
R-142b	HCFC	1-chloro-1,1-difluoroethane	CH3CClF2	100,5	-10	A2	80 000	25 000	16 000
R-143a	HFC	1,1,1-trifluoroethane	CH3CF3	84,0	-47	A2L	82 000	170 000	16 000
R-290	HC	propane	CH3CH 2CH3	44,0	-42	A3	21 000	50 000	4 200

Annex A

Examples of isomer designation

A.1 Ethane series isomers

Table A.1 illustrates the designation of isomers for the ethane series with three isomers of dichlorotrifluoroethane.

Table A.1 — Ethane series isomers

Isomer	Chemical formula	M1[a]	M2	| M1 – M2 |
R-123	$CHCl2CF3$	57,0	71,9	14,9
R-123a	$CHClFCClF_2$	73,4	55,5	17,9
R-123b	$CHF2CCl2F$	89,9	39,0	50,9

a Mi is the sum of the atomic mass of halogens and hydrogens attached to carbon atom *i*. (C1 is assigned to the rightmost carbon.)

A.2 Propane series isomers

Table A.2 illustrates the designation of isomers for the propane series with nine isomers of dichloropentafluoro propane.

Table A.2 — Propane series isomers

Isomer	Chemical formula	C2 group [a]	M_1 [b]	M_3	| M_1–M_3 |
R-225aa	$CHF2CCl2CF3$	CCl2	57,0	39,0	18,0
R-225ba	$CHClFCClFCF_3$	CClF	57,0	55,5	1,5
R-225bb	$CHF_2CClFCClF_2$	CClF	73,4	39,0	34,4
R-225ca	$CHCl2CF2CF3$	CF2	57,0	71,9	14,9
R-225cb	$CHClFCF_2CClF_2$	CF2	73,4	55,5	17,9
R-225cc	$CHF2CF2CCl2F$	CF2	89,9	39,0	50,9
R-225da	$CF_3CHClCClF_2$	CHCl	73,4	57,0	16,4
R-225ea	$CClF_2CHFCClF_2$	CHF	73,4	73,4	0,0
R-225eb	$CF3CHFCCl_2F$	CHF	89,9	57,0	32,9

a C2 is the central (second) carbon atom.

b Mi is the sum of the atomic mass of halogens and hydrogens attached to carbon atom *i*. (C1 is assigned to the rightmost carbon.)

A.3 Propene series isomers

Table A.3 illustrates the designation of isomers of the propene series with seven isomers of tetrafluoro-1-propene.

Table A.3 — Propene series isomers

Isomer	Chemical formula	Stereoisomer
R-1234yc	CH_2F-CF=CF_2	
R-1234zc	CHF_2-CH=CF_2	
R-1234ye(E)	CHF_2-CF=CHF	Entgegen
R-1234ye(Z)	CHF_2-CF=CHF	Zusammen
R-1234ze(E)	CF_3-CH=CHF	Entgegen
R-1234ze(Z)	CF_3-CH=CHF	Zusammen
R-1234yf	CF_3-CF=CH_2	

A.4 Example of stereoisomers

The configuration of atoms around the double bond is specified by using "E" or "Z" organic nomenclature rules. The letters "E" or "Z" are appended at the end of the refrigerant number to show the precedence of the atoms or groups, which are attached to the carbon atoms at either end of the double bond; see Figures

A.1 and A.2. "E" for *Entgegen* is similar to trans, where priority atoms or groups are across the double bond from each other. "Z" for *Zusammen* is similar to cis, signifying that priority atoms or groups are on the same side of a double bond. Priority order of atoms connected to either of the unsaturated carbons is determined by standard CIP (Cahn-Ingold-Prelog) rules of organic nomenclature. In essence, attached atoms of higher atomic number have higher priority. Hence, in order of priority, I > Br > Cl > F > O > C > H. In case of a priority tie, the next attached atoms or substituents on the next attached carbon atom are considered, until a priority is determined. In the case of refrigerants, it is better to use atomic mass rather than atomic numbers of the atoms. This is because the sum of the atomic numbers of substituents on CHF_2 and CH_2CI are the same, while the summed atomic masses do differentiate.

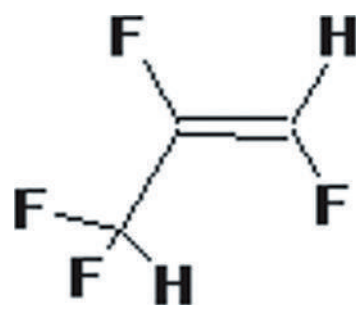


Figure A.1 — 1(E)-1,2,3,3-tetrafluoroprop-1-ene, or HFO-1234ye(E)

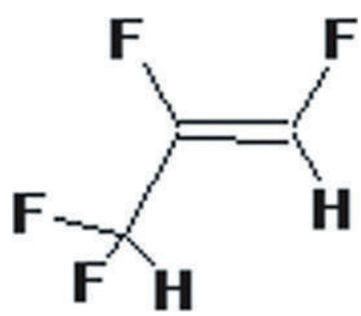


Figure A.2 — 1(Z)-1,2,3,3-tetrafluoroprop-1-ene, or HFO-1234ye(Z)

B. IS/ISO 17584: 2022- REFRIGERANT PROPERTIES

This Standard is intended to complement IS 16656 (Standard for REFRIGERANTS DESIGNATION AND SAFETY CLASSIFICATION). The purpose of this Standard is to address the differing performance ratings due to the differences between multiple property formulations, which is a problem especially in international trade.

Scope: This Standard specifies the thermophysical properties of several commonly used refrigerants and refrigerant blends. This Standard is applicable to refrigerants R12, R22, R32, R123, R125, R134a, R143a, R152a, R290, R600a, R717 (ammonia), R744 (carbon dioxide), R1233zd(E), R1336mzz(Z), R1234yf and R1234ze(E) and to the refrigerant blends R404A, R407C, R410A, and R507A. The following properties are included in this Standard: density, pressure, internal energy, enthalpy, entropy, heat capacity at constant pressure, heat capacity at constant volume, speed of sound, and the Joule-Thomson coefficient, in both single-phase states and along the liquid-vapour saturation boundary. The numerical designation of these refrigerants is defined in IS 16656, as we saw in the previous segment in this chapter.

The standard gives method and equations for calculation of Refrigerant properties for any pure fluid equation of state and mixture equation of state. The Standard also gives the property values using the calculation equations for specific refrigerants like R744 (Carbon dioxide), R717 (Ammonia), R12 (Dichlorodifluoromethane), R22 (Chlorodifluoromethane), R32 (Difluoromethane), R134a (1,1,2,2 tetrafluroethane) etc.

Now, let us see the **properties of a common refrigerant R 134a** which have been specified in IS/ISO 17584 in the Table given below:

R134a property values along the liquid-vapour saturation boundary

	Temp. °C	Pressure MPa	Density kg/m3	Internal energy kJ/kg	Enthalpy kJ/kg	Entropy kJ/(kgK)	Cv kJ/(kgK)	Cp kJ/(kgK)	Sound speed m/s	J-Tco efficient K/MPa
liquid	–103,30a	0,000 390	1 591,1	71,45	71,46	0,412 6	0,792 2	1,183 8	1 120,0	–0,381 5
vapour			0,028 17	321,11	334,94	1,963 9	0,503 0	0,585 3	126,79	373,57
liquid	–100,00	0,000 559	1 582,4	75,36	75,36	0,435 4	0,791 2	1,184 2	1 103,2	–0,379 3
vapour			0,039 69	322,76	336,85	1,945 6	0,510 7	0,593 2	127,87	318,13
liquid	–95,00	0,000 939	1 569,1	81,29	81,29	0,469 1	0,791 0	1,186 1	1 077,7	–0,375 3
vapour			0,064 79	325,29	339,78	1,920 1	0,522 4	0,605 2	129,47	253,65
liquid	–90,00	0,001 52	1 555,8	87,22	87,23	0,502 0	0,792 0	1,189 2	1 052,3	–0,370 7
vapour			0,102 4	327,87	342,76	1,897 2	0,534 1	0,617 3	131,03	206,26
liquid	–85,00	0,002 40	1 542,5	93,18	93,18	0,534 1	0,794 0	1,193 3	1 027,0	–0,365 6
vapour			0,157 0	330,49	345,77	1,876 6	0,545 7	0,629 4	132,56	170,88
liquid	–80,00	0,003 67	1 529,0	99,16	99,16	0,565 4	0,796 8	1,198 1	1 001,8	–0,359 9
vapour			0,234 3	333,15	348,83	1,858 0	0,557 3	0,641 7	134,04	144,05
liquid	–75,00	0,005 48	1 515,5	105,16	105,17	0,596 1	0,800 2	1,203 6	976,8	–0,353 6
vapour			0,341 2	335,85	351,91	1,841 4	0,568 9	0,654 0	135,47	123,38
liquid	–70,00	0,007 98	1 501,9	111,19	111,20	0,626 2	0,804 0	1,209 6	952,0	–0,346 9
vapour			0,485 7	338,59	355,02	1,826 4	0,580 6	0,666 5	136,84	107,19
liquid	–65,00	0,011 4	1 488,2	117,26	117,26	0,655 7	0,808 2	1,216 1	927,4	–0,339 6
vapour			0,677	341,35	358,16	1,813 0	0,592 3	0,679 3	138,16	94,32
liquid	–60,00	0,015 9	1 474,3	123,35	123,36	0,684 6	0,812 7	1,223 0	903,0	–0,331 8
vapour			0,927	344,15	361,31	1,801 0	0,604 0	0,692 4	139,41	83,91
liquid	–55,00	0,021 8	1 460,4	129,48	129,50	0,713 1	0,817 5	1,230 4	878,8	–0,323 4
vapour			1,246	346,96	364,48	1,790 2	0,615 9	0,705 8	140,59	75,36

liquid vapour	–50,00	0,029 5	1 446,3 1,650	135,65 349,80	135,67 367,65	0,741 0 1,780 6	0,822 4 0,628 0	1,238 1 0,719 7	854,7 141,69	–0,314 3 68,25
liquid vapour	–45,00	0,039 1	1 432,1 2,152	141,86 352,65	141,89 370,83	0,768 5 1,772 0	0,827 6 0,640 2	1,246 2 0,734 1	830,9 142,70	–0,304 6 62,23
liquid vapour	–40,00	0,051 2	1 417,7 2,769	148,11 355,51	148,14 374,00	0,795 6 1,764 3	0,832 8 0,652 6	1,254 6 0,749 0	807,2 143,63	–0,294 1 57,08
liquid vapour	–35,00	0,066 1	1 403,1 3,521	154,40 358,38	154,44 377,17	0,822 3 1,757 5	0,838 2 0,665 2	1,263 5 0,764 6	783,7 144,45	–0,282 8 52,63
liquid vapour	–30,00	0,084 4	1 388,4 4,426	160,73 361,25	160,79 380,32	0,848 6 1,751 5	0,843 8 0,678 1	1,272 9 0,780 9	760,3 145,18	–0,270 6 48,74
liquid vapour	–26,07b	0,101 3	1 376,7 5,258	165,74 363,51	165,81 382,78	0,869 0 1,747 2	0,848 2 0,688 4	1,280 5 0,794 2	742,0 145,67	–0,260 2 46,01
liquid vapour	–25,00	0,106 4	1 373,4 5,506	167,11 364,12	167,19 383,45	0,874 6 1,746 1	0,849 4 0,691 2	1,282 7 0,797 9	737,0 145,79	–0,257 3 45,31
liquid vapour	–20,00	0,132 7	1 358,3 6,784	173,54 366,99	173,64 386,55	0,900 2 1,741 3	0,855 1 0,704 6	1,293 0 0,815 8	713,8 146,28	–0,242 8 42,26
liquid vapour	–15,00	0,163 9	1 342,8 8,287	180,02 369,85	180,14 389,63	0,925 6 1,737 1	0,860 9 0,718 3	1,304 0 0,834 6	690,7 146,65	–0,227 0 39,54
liquid vapour	–10.00	0.200 6	1 327.1 10,041	186.55 372,69	186.70 392,66	0.950 6 1,733 4	0.866 9 0,732 2	1.315 6 0,854 4	667.6 146,89	–0.209 6 37,11
liquid vapour	–5,00	0,243 3	1 311,1 12,077	193,13 375,51	193,32 395,66	0,975 4 1,730 0	0,872 9 0,746 4	1,327 9 0,875 2	644,6 146,99	–0,190 5 34,92
liquid vapour	0,00	0,292 8	1 294,8 14,428	199,77 378,31	200,00 398,60	1,000 0 1,727 1	0,879 1 0,760 8	1,341 0 0,897 2	621,6 146,94	–0,169 5 32,95
liquid	5,00	0,349 7	1 278,1	206,48	206,75	1,024 3	0,885 4	1,355 2	598,7	–0,146 1
vapour			17,131	381,08	401,49	1,724 5	0,775 5	0,920 6	146,74	31,17
liquid vapour	10,00	0,414 6	1 261,0 20,226	213,25 383,82	213,58 404,32	1,048 5 1,722 1	0,891 8 0,790 4	1,370 4 0,945 5	575,7 146,38	–0,120 0 29,57
liquid vapour	15,00	0,488 4	1 243,4 23,758	220,09 386,52	220,48 407,07	1,072 4 1,720 0	0,898 3 0,805 6	1,386 9 0,972 1	552,7 145,85	–0,090 7 28,12
liquid vapour	20,00	0,571 7	1 225,3 27,780	227,00 389,17	227,47 409,75	1,096 2 1,718 0	0,905 0 0,821 0	1,404 9 1,000 7	529,6 145,15	–0,057 8 26,81
liquid vapour	25,00	0,665 4	1 206,7 32,350	233,99 391,77	234,55 412,33	1,119 9 1,716 2	0,911 9 0,836 7	1,424 6 1,031 6	506,5 144,26	Š0,020 4 25,64
liquid vapour	30,00	0,770 2	1 187,5 37,535	241,07 394,30	241,72 414,82	1,143 5 1,714 5	0,918 9 0,852 7	1,446 5 1,065 5	483,2 143,16	0,022 3 24,58
liquid	35,00	0,887 0	1 167,5	248,25	249,01	1,167 0	0,926 2	1,470 9	459,9	0,071 4
vapour liquid	40,00	1,016 6	43,416 1 146,7	396,76 255,52	417,19 256,41	1,712 8 1,190 5	0,869 1 0,933 6	1,102 8 1,498 4	141,86 436,4	23,63 0,128 5
vapour liquid	45,00	1,159 9	50,085 1 125,1	399,13 262,91	419,43 263,94	1,711 1 1,213 9	0,885 8 0,941 4	1,144 5 1,529 8	140,34 412,8	22,78 0,195 3
vapour liquid	50,00	1,317 9	57,657 1 102,3	401,40 270,43	421,52 271,62	1,709 2 1,237 5	0,902 9 0,949 4	1,191 7 1,566 1	138,57 389,0	22,02 0,274 6
vapour liquid	55,00	1,491 5	66,272 1 078,3	403,55 278,09	423,44 279,47	1,707 2 1,261 1	0,920 5 0,957 9	1,246 1 1,608 9	136,55 364,9	21,36 0,369 8
vapour			76,104	405,55	425,15	1,705 0	0,938 7	1,309 9	134,25	20,77
liquid vapour	60,00	1,681 8	1 052,9 87,379	285,91 407,38	287,50 426,63	1,284 8 1,702 4	0,966 8 0,957 7	1,660 2 1,386 8	340,5 131,66	0,486 1 20,27
liquid vapour	65,00	1,889 8	1 025,6 100,398	293,92 408,99	295,76 427,82	1,308 8 1,699 3	0,976 4 0,977 5	1,723 4 1,482 2	315,7 128,74	0,630 8 19,83
liquid vapour	70,00	2,116 8	996,2 115,572	302,16 410,33	304,28 428,65	1,333 2 1,695 6	0,986 9 0,998 6	1,803 9 1,605 1	290,3 125,46	0,815 7 19,46

liquid vapour	75,00	2,364 1	964,1 133,494	310,68 411,32	313,13 429,03	1,358 0 1,690 9	0,998 8 1,021 2	1,911 5 1,771 4	264,1 121,80	1,059 9 19,14
liquid vapour	80,00	2,633 2	928,2 155,078	319,55 411,83	322,39 428,81	1,383 6 1,685 0	1,012 9 1,046 0	2,064 8 2,012 2	236,6 117,69	1,397 3 18,86
liquid vapour	85,00	2,925 8	887,2 181,853	328,93 411,67	332,22 427,76	1,410 4 1,677 1	1,030 8 1,073 9	2,306 4 2,397 1	207,4 113,09	1,893 6 18,57
liquid vapour	90,00	3,244 2	837,8 216,761	339,06 410,45	342,93 425,42	1,439 0 1,666 2	1,055 6 1,106 8	2,755 9 3,120 7	175,9 107,90	2,693 6 18,20
liquid vapour	95,00	3,591 2	772,7 267,139	350,60 407,23	355,25 420,67	1,471 5 1,649 2	1,093 8 1,148 9	3,938 5 5,019 5	141,2 101,91	4,191 6 17,51
liquid vapour	100,00	3,972 4	651,2 373,011	367,20 397,03	373,30 407,68	1,518 8 1,610 9	1,173 7 1,218 0	17,591 5 25,350 3	101,0 93,95	8,198 5 15,30
critical	101,06	4,059 3	511,9	381,71	389,64	1,562 1	c	c	c	11,931 2

a Triple point.

b Normal boiling point.

c The values of *Cv*, *Cp*, and *w* at the critical point are not included as part of this document.

2.4 Automatic electric Control: Auto mode in air conditioners is a feature that **allows the air conditioner to act as a smart thermostat**. In other words, the system will automatically adjust the temperature and fan speed to maintain the desired room temperature. Automatic electric control serves this function.

Indian standards available on Automatic Electrical Controls

IS/IEC 60730 (Part 2): Section 9- Automatic Electrical Controls for Household and Similar Use Part 2 Particular Requirements Section 9 Temperature Sensing Controls

Scope: This Standard specifies safety requirements for automatic electrical temperature sensing controls for use in, on or in association with equipment for household and similar use, including electrical control for heating, air-conditioning and similar applications. The equipment may use electricity, gas, oil, solid fuel, solar thermal energy, etc., or a combination thereof. This part of IS/IEC 60730 is to be used in conjunction with IS/IEC 60730 Part 1, which is for General Safety requirements for all such appliances in general.

CHAPTER IV

TYPES AND CLASSIFICATIONS OF AIR CONDITIONERS

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TYPES AND CLASSIFICATIONS OF AIR CONDITIONERS

1. Types and Classifications of Air Conditioners:

Air conditioners may be classified based upon their construction, function and mounting arrangement.

1.1 Classification based on construction:

a) **Ducted Air Conditioners**: An encased factory- made assembly or assemblies designed primarily to deliver conditioned air to enclosed space (s) through a duct.

b) **Non-ducted Air conditioners** i.e. which delivers the conditioned air the indoor unit. Non-ducted Air conditioners may further be classified as Unitary Air Conditioner and Split Air Conditioner

Unitary Air Conditioner, or commonly known as Window Air Conditioners- An encased assembly designed as a self-contained unit primarily for mounting in a window or through the wall or as a console. All components of the appliance viz. compressor, heat exchangers (Evaporator and condensers), and air handling system are installed in one cabinet as a single unit.

Split Air Conditioner- Split air conditioner comprises of indoor unit (i.e. which is inside the room or space required to be cooled or heated) and outdoor unit (which is outside the room or the space). The indoor and outdoor units consist of compressor, heat exchangers, fan motors and air handling system installed in two separate cabinets, and hence name is split ac.

1.2 Classification based on function:

a) **Cooling only**- AC with Only cooling mode during which it performs cooling and dehumidification

b) **Cooling and heating**- AC with both cooling as well as heating mode. AC performs Cooling and dehumidification during cooling mode and heating during heating mode.

1.3 Classification based on mounting arrangement:

a) Floor mounting type

b) Ceiling mounting type (Cassette type)

c) Wall mounting type

2. Glance of the subject through Standards' eye

2.1 Most of the aforementioned types of air conditioners have been covered in following 3 Indian Standards:

- IS 1391 (Part 1): 2023- Room Air Conditioners- Part 1- Unitary Air Conditioners
- IS 1391 (Part 2): 2023- Room Air Conditioners- Part 2- Split Air Conditioners
- IS 8148: 2018- Ducted and Packaged Air Conditioners

2.2 Scope of these standards:

a) IS 1391 (Part 1): 2023- Room Air Conditioners- Part 1- Unitary Air Conditioners- This standard (Part 1) specifies safety and performance requirements of single-phase non- ducted unitary with single-stage, two-stage, multistage, fixed and variable speed air conditioners and heat pumps for household and similar application of rated capacity up to and including 10 500 W (i.e. 3TR) their rated voltage not more than 250 V a.c., 50 Hz for single-phase employing air cooled condensers and test methods for determination of various ratings. This standard is limited to systems utilizing a single refrigeration circuit, having one evaporator and one condenser.

   This standard covers Unitary Room AC which performs both types of functions viz. Cooling only, and Cooling and heating.

b) IS 1391 (Part 2): 2023- Room Air Conditioners- Part 2- Split Air Conditioners- This standard specifies safety and performance requirements of single or three phase non-ducted split with single stage, two stage, multistage, fixed and variable speed air conditioner and heat pumps (residential, commercial, and industrial) of rated capacity up to and including 18 000 W(i.e. 5TR) their rated voltage up to and including 250 V a.c., 50 Hz for single-phase and up to and including 415 V a.c., 50 Hz for three-phase power supply employing air cooled condensers and test methods for determination of various ratings. This standard is limited to systems utilizing a single refrigeration circuit, having one evaporator and one condenser.

   This standard covers Split Room AC which performs both types of functions viz. Cooling only, and Cooling and heating.

c) IS 8148: 2018- Ducted and Packaged Air Conditioners- This Standard specifies performance testing, the standard conditions and the test methods for determining the capacity and efficiency ratings of air-cooled air-conditioners and air-to-air heat pumps. This Standard is applicable unitary and split ducted air conditioners having air-cooled and water cooled condenser, and ducted air to air heat pumps.

   This standard is applicable for:

   i) Residential and commercial unitary and split air conditioners and heat pumps;

   ii) Utilizing single stage, two stage, multi stage and variable capacity components;

iii) Single refrigeration system having nominal cooling capacity 3 500 W and above with one evaporator and one condenser, controlled by a single thermostat/controller; and

iv) Multiple split system utilizing one or more refrigeration systems controlled by a single thermostat/controller:

- One outdoor and one or more indoor units, or
- One or more outdoor and one indoor unit.

CHAPTER V

MAJOR COMPONENTS OF AIR CONDITIONERS

CHAPTER 5

MAJOR COMPONENTS OF AIR CONDITIONERS

1. Introduction:

As we know modern air conditioning appliances employ modified Vapor compression system to produce the desired cooling effect. These appliances need to use highly efficient and safe components.

We have seen in Chapter 3 that the main components of an air conditioning system are:

a) Compressor
b) Evaporator
c) Condenser
d) Expansion device, and above all
e) The refrigerant, which undergoes the operation of compression, expansion and through phase changes in Evaporator and Condenser

While we have seen in detail the other components (viz. Compressor, Expansion device, Controls and refrigerant), in this chapter we will see the two remaining components, which are Evaporator and Condenser. Both Evaporator and Condenser are essentially the Heat Exchangers carrying out the function of Heat transfer through the refrigerant and maintaining the flow through the refrigerant circuit.

2. Indian standard available on Heat Exchangers for Air Conditioners

2.1 Following Indian standard is available on Heat Exchangers for Air Conditioners:

IS 11329: 2018- Finned type Heat exchangers for Room Air Conditioners

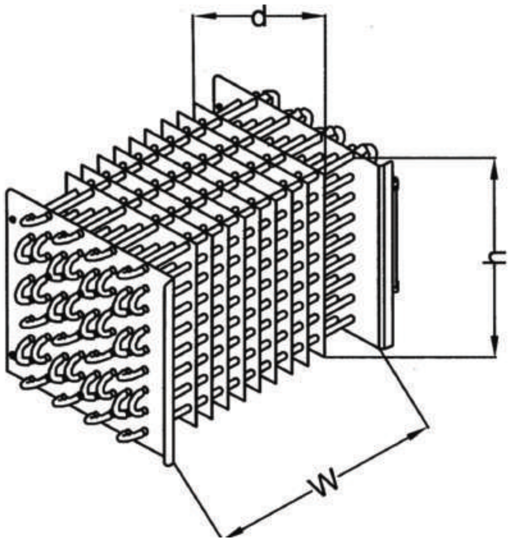
Now, let us see IS 11329:2018 in detail

2.1.1 Scope: This standard specifies the general requirement and method of tests for finned type heat exchangers used for the manufacturing of room air conditioners up to and including the capacity of 18 000 W.

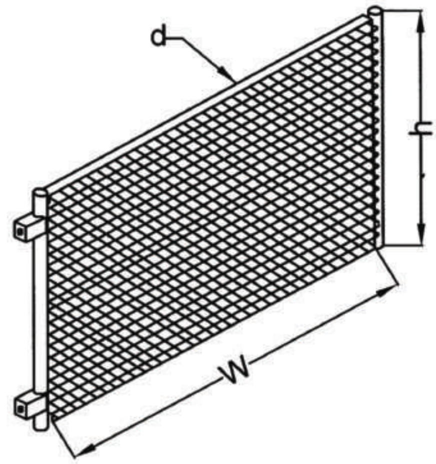
2.1.2 Classification of Finned type Heat Exchanger as per IS 11329

Heat exchanger can be classified based on the method of construction as follows:

a) Fin pack with collar and tube type, and
b) Micro channel tube with continuous fin type



Fin Pack with collar and Tube Type Heat Exchanger



Micro Channel Type Heat Exchanger

Fig. 1- Classification of Heat exchangers based on construction

a) **Fin pack with collar and tube type Heat exchanger**- These types of heat exchangers are made of plate fin packs with collar and tubes. These heat exchangers are manufactured by expansion of collar fin packs and tubes assembly. These can be further classified based on fin / tube material, tube type (Plain tube and inner grove tube) and by types of enhanced fin surfaces.

b) **Micro Channel Aluminium Tube and Aluminium Fin Heat Exchanger (MCHX)***:* Micro Channel Aluminium Tube and Aluminium Fin Heat Exchanger shall be made with flat micro channel tube, fins and two refrigerant manifolds / headers as shown in Fig. 4

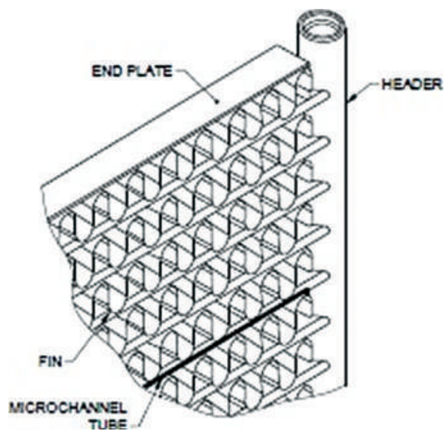


Fig. 2- Micro Channel Aluminium Tube and Aluminium Fin Heat Exchanger

2.1.3 Requirements of Finned type heat exchangers as per IS 11329:2018

The requirements specified in IS 11329 can be categorized into following requirements:

a) Material requirements
b) Constructional requirements
c) Performance requirements
d) Marking requirements

a) Material requirements-

Tube Material

The material for the tube shall be of copper or aluminium and shall conform to the relevant standard or Annex as described below:

i) Copper tube — Copper tube shall conform to IS 10773 or as per the requirements listed below:

Chemical composition: Copper- 99.9 % minimum; Phosphorous- 0.015 to 0.040 %

Physical properties: Tensile strength minimum- 205 MPa for soft and light annealed and 245-325 MPa ; % Elongation – 40 % , minimum; Additionally, Flattening test, Expansion test, Pneumatic and grain structure requirements, as applicable, are also required to be complied with.

ii) Aluminium tube — Aluminium tube material shall conform to following requirements:

Tensile Strength (Mpa)	*Percent Elongation*
Min 55 MPa	*Min* 1 percent

Fin Material

The material for the fin shall be of aluminium and shall conform to following requirements:

Tensile Strength (Mpa)	*Percent Elongation*
Min 55 MPa	*Min* 1 percent

Tube Sheet /End Plate: The material for the tube sheet and end plate shall conform to the relevant standards as described below:

Zinc coated galvanized iron (GI) sheet — Tube sheet/end plate material shall conform to IS 277.

Aluminium sheet — Aluminium sheet material shall conform to IS 737.

Brazing material: Brazing material shall confirm to IS 2927 or International Standard

b) Constructional requirements:

The ends will be covered with caps, plugs or polythene wrapping to prevent any contamination entering in heat exchangers, if stored for more than one day.

For Fin Pack with Collar and Tube Type Heat Exchanger (Expanded Tubes), Overall length of hairpin, which is the average of both legs shall be within of the nominal hairpin length (include shrinkages) indicated on the hairpin drawing. There shall be no sharp edges and the hairpins shall be properly deburred and free from chips and sawdust. Tube sheet / end plate holes shall be effectively free from interior burrs or sharp edges. Tube sheet / end plate holes sizes shall be defined by the manufacturers in their drawing.

For Micro Channel Aluminium Tube and Aluminium Fin Heat Exchanger, All the components and the material used in the heat exchanger assembly, namely, tube, header, side plate, fins and core assembly in the heat exchanger assembly shall be free from burrs.

c) Performance requirements and tests :

i) Permissible Assembly Contamination Specification

*Internal Contamination:*Total residue contamination is maximum 100 mg/m^2 of total internal surface area of which, 40 mg/m^2 *max* may be soluble and 60 mg/ m^2 *max* may be insoluble

ii) Leak Test

Each coil shall undergo leak test to conform tightness specification. Leak test method is either water leak test, Helium leak test or vacuum test as described in **IS 11329.**

iii) Corrosion Resistance

The material for the heat exchanger shall be corrosion resistant and shall be treated appropriately with anti- corrosive protection material to prevent damage or leakage due to oxidation effect due to presence of any pollutant in the surroundings. Any protective coating shall be agreed between purchaser and the manufacturer like lacquers, powder coat, cathode electric deposition, etC.

The corrosion resistance test to be carried out for to ensure the heat exchanger performs effectively under various atmospheric conditions. The test should be carried out for a minimum 72 h as per the procedure of IS 9844. After completion of test, heat exchanger shall confirm to assembly tightness specification.

d) Marking requirements for Finned type Heat exchangers as per IS 11329

Each finned type heat exchanger for room air conditioners shall be marked with the following:

a) Name of manufacturer;

b) Country of manufacture

c) Part number; and

d) Date of manufacture

Indian standards on both Unitary as well as Split type Room Air Conditioners specify that the heat exchanger used in these ACs shall conform to IS 11329.

CHAPTER VI

REQUIREMENTS OF AIR CONDITIONERS

(*Path shown by Standards*)

CHAPTER VI

REQUIREMENTS OF AIR CONDITIONERS

Requirements of Various types of Air Conditioners as specified in respective Indian Standards

Now, We will see the requirements of following types of Air Conditioners which are specified in respective Indian standards:

Sl. No.	**Indian Standard**	**Product of which requirements are covered in the Standard**
1	IS 1391 (Part 1): 2023	Room Air Conditioners- Part 1- Unitary Air Conditioners
2	IS 1391 (Part 2): 2023	Room Air Conditioners- Part 2- Split Air Conditioners
3	IS 8148: 2018	Ducted and Packaged Air Conditioners

1. Requirements of Unitary (Window) Room Air Conditioners as per IS 1391 (Part 1): 2023, Split Room Air Conditioners as per IS 1391 (Part 2): 2023 and Ducted and Package Air Conditioners as per IS 8148: 2018

Broadly, the requirements of Room AC specified in IS 1391 (Part 1) and IS 1391 (Part 2) and Ducted and Packaged AC as per IS 8158 can be categorized as following:

a) **Material requirements**

b) **Constructional requirements**

c) **Performance requirements**

d) **Safety requirements, and**

e) **Energy Consumption requirements**

f) **Marking requirements**

Let us go through these requirements one by one:

a) **Material requirements:** The material shall be free from defects which are liable to cause undue deterioration of failure. Under normal conditions of use and maintenance, the materials used shall not shrink, deteriorate, warp, or cause mould or odours and shall be resistant to attack of vermin and destructive pests.

Sealing and insulating materials shall not lose their essential properties such as adhesion, moisture, and heat resistance. Apart from the above general material requirements, requirements of material for individual components have also been specified in their respective Standards.

For example, the material of Tubes and Fins of Finned Type Heat Exchangers are specified in Indian Standard IS 11329: 2018. Following properties of material are specified in these Standards: Chemical Composition, Tensile properties (Yield Strength, % Elongation, Ultimate tensile strength), Hardness, Bend and reverse Bend test compliance etc.

Please refer to IS 11329, IS 694, IS 9968 Part 1 for details on material requirements for different components of Room Air Conditioners.

b) Constructional requirements:

i) General

The air conditioner and its parts shall be constructed with the strength and rigidity adequate for normal conditions of handling, transport, and usage. There shall be no sharp edges or corners liable to cause injury under normal conditions of use and all moving parts which constitute accident hazards shall be effectively guarded. Parts which require periodic servicing shall be readily accessible. Internal and external finishes shall be of being cleaned effectively without undue deterioration and shall be such as to afford protection against climatic action in all seasons under normal use. All metal parts which are exposed to moisture or ambient conditions shall be corrosion resistant or adequately protected against corrosion.

ii) Electrically Charged Parts:

The electrically live parts shall be protected from accidental contact of the user. Electric conductors shall be of electrically, thermally, and mechanically stable and shall be made up of anti-corrosive materials such as copper and copper alloys. Switches and the like shall work smoothly and keep good electrical contact.

iii) Refrigerant Circuit:

The refrigerant pipes and fittings shall be of approved quality, shall withstand maximum working pressures in refrigeration circuits of air conditioner, and shall conform to IS 10773 or material specified in Annex B of IS 11329.

iv) Provision for Earthing:

The earthing terminal and earthing lead wire shall be installed on a readily accessible place of the main body. Indication of earthing shall be marked on it or on the near spot as given in IS 302 (Part 1). The earthing terminal shall be so constructed that earthing wire can be easily and firmly fastened

v) Air Filter:

The filter used on the evaporator coil of the unit shall have a maximum 70 percent open area when measured in an area of 1 cm2. The measurement shall be made by measuring the wire diameter.

The pre-filter if used shall be as per IS 17570 (Part 1)/ISO 16890-1. The high efficiency particulate air (HEPA) filters if used shall be as per IS 16753 (Part 1)/ ISO 29463-1.

vi) Temperature Sensing Controls:

The temperature sensing controls shall conform to 8 to 28 of IS/IEC 60730-2-9 as applicable.

vii) Hermetic Compressors:

The hermetically sealed compressors shall conform to IS 10617.

viii) Heat Exchanger:

The heat exchanger used shall conform to IS 11329. For Ducted and Packaged AC, conformity of evaporator and Condenser to a specific Standard has not been prescribed in IS 8148, however, the performance and energy consumption requirements of the complete AC has been specified.

ix) Motors:

The motor used for driving the fan/blower motor shall be either capacitor type induction motors or brushless d.c. (BLDC) motor. The capacitor type induction motor shall comply with the requirements given in IS 996 as applicable for fan duty motors.

x) Drain Plug:

The air conditioner shall have a drain hole having the provision of drain plug attachment which can be detachable or welded and preferably provided at the rear or bottom side of the unit. However, exact location of the drain hole shall be as per the manufacturers design requirement. The material of the drain plug may be of rubber, plastic, or metal. The drain plug shall be so designed that it allows the unit to drain excess water while operating the air conditioners. The drain plug may also be attached with a pipe made of rubber or plastic so that drain water does not soil the walls of the building.

c) Performance requirements: Following performance requirements and tests to evaluate whether those requirements have been met or not, have been specified in IS 1391 (Part 1),IS 1391 (Part 2) and IS 8148:

i) Cooling and Heating capacity: The appliance shall be able to deliver the rated cooling/heating capacity.

Procedure for Cooling capacity Testing of Room Air Conditioner: The capacity test can be conducted using one of the following methods:

a) *Calorimeter method* ‾ This procedure shall be applicable when the air conditioner is tested in calorimeter. The air conditioner shall be tested in calorimeter complying as specified in IS 1391 (Part 1), IS 1391 (Part 2) and IS 8148. Simultaneous methods for determining capacities shall be used. One method shall determine capacity on the room side and the other shall determine the capacity on the outdoor side. These two simultaneous determinations shall agree within 4 percent of the value obtained on the room side for the test to be valid; or

b) *Air enthalpy method/Psychometric method* ‾ This procedure shall be applicable when the air conditioner is tested in psychometric room. The capacities will be determined from measurements of entering and leaving dry bulb and wet-bulb temperatures and the associated airflow rate. Air leaving the equipment under the 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. The static pressure difference between the discharge chamber and intake opening of the equipment under test shall be zero. Airflow measurements shall be made in as given in the respective Standard . For the cooling capacity calculations described in the respective Standard, the indoor-side room discharge airflow rate shall be expressed in units of cubic metre per second (m3/s) of the air-water vapour mixture. For reporting purposes, the indoor-side air volume flow rate shall be expressed in units of cubic metre per sec (m3/s) of standard air. Test conditions shall be maintained until *equilibrium has been reached, and maintained for not less than 1 h before recording data for the capacity test. The test shall then be run for 1 h recording data every 10 min, giving 7 sets of reading.*

Acceptance criteria for cooling capacity Test:

For Window Room AC: *The capacity of the production unit as determined on the room side shall be not less than 95 percent of the nameplate rating.*

For Split Room AC:

a) Up to 10 500W — For each unit tested, the following tolerances shall be applicable:

 1) The measured standard cooling at full capacity shall not be less than 95 percent of the rated value; and

 2) The measured standard cooling at 50 percent of full capacity shall be ± 5 percent of full load capacity.

b) Above 10 500 W up to and including 18 000 W— For each unit tested, the following tolerances shall be applicable:

 1) The measured standard cooling at full capacity shall not be less than 90 percent of the rated value; and

 2) The measured standard cooling at 50 per cent of full capacity shall not vary by more than ± 5 percent of full capacity.

Procedure for Heating capacity Testing of Room Air Conditioner: Testing shall be conducted using the calorimeter test method or indoor air enthalpy test method. These test methods are detailed in IS 1391 (Part 1) and IS 1391 (Part 2). 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.

Acceptance criteria for Heating capacity Test : The measured heating capacity at full capacity obtained as test result shall not be less than 90 percent of the rated value in order to be declared as conforming to Indian standard.

For Ducted and Package AC as per IS 8148, The total cooling capacity/heating capacity of tested unit shall have a capacity not less than 90 percent of the rated capacity.

ii) Maximum Operating Condition requirement: The appliance shall be capable of operating satisfactorily under maximum operating conditions i.e. for extreme outside and inside air temperatures and under specified voltages which are different from the rated voltage.

Test Conditions: The maximum operating tests shall be conducted under the conditions specified below:

Under Cooling conditions:

- a) Room air temperature:
  - 1) Dry bulb temperature : 35 °C
  - 2) Wet bulb temperature : 24 °C
- b) Outside air temperature:
  - 1) Dry bulb temperature : 46 °C
  - 2) Wet bulb temperature : 27 °C
- c) Test voltage : 90 percent and 110 percent of rated voltage
- d) Test frequency : Rated frequency

Under Heating conditions:

The maximum operating tests shall be conducted under the conditions specified below:

- a) Room air temperature:
  - 1) Dry bulb temperature : 27 °C
  - 2) Wet bulb temperature : Not applicable
- b) Outside air temperature:
  - 1) Dry bulb temperature : 24 °C
  - 2) Wet bulb temperature : 18 °C
- c) Test voltage : 90 percent and 110 percent of rated voltage
- d) Test frequency : Rated frequency

Procedure of test: The air conditioner shall be operated continuously for 1 h after the specified air temperatures and equilibrium condensate level have been established. All power to the unitary air conditioner shall then be cut off for 3 min and then restored. During this test no water shall be sprinkled on to the condenser by external means other than what is condensed in the evaporator. The operation of the equipment may be restarted either automatically or through the use of a remote controller or similar device. The test shall continue for 60 min after the equipment restarts.

Acceptance criteria of the test :

During one entire test, the air conditioner shall operate without visible or audible indication of damage and without tripping. The motor of air conditioner shall operate continuously for the first 1 h of the test without tripping any protective devices. After the interruption of power, the equipment shall resume operation within 30 min and run continuously for 1 h. The motor overload protective device may trip only during the first 5 min after the shutdown period of 3 min. During the remainder of that 1 h test period, no motor overload protective device shall trip. For those models so designed that resumption of operation does not occur after initial trip within the first 5 min, the unit may remain out of operation for no longer than 30 min. It shall then operate continuously for 1 h.

iii) **Freeze-up requirements**- To determine freeze-up, the freeze-up air blockage and freeze-up drip performance tests are conducted. These tests are done to determine the ability of the air conditioners to operate satisfactorily under conditions with the maximum tendency to frost or ice the evaporator.

iv) **Air Blockage Test**:

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

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

Drip Test:

Procedure: The unit shall be operated for 4 h with the room side air inlet covered to completely block the passage of air so as to attempt to achieve complete blockage of the evaporator coil by frost. After the 4 h operating period, the unit shall be stopped and the air inlet covering removed until the accumulation of ice or frost has melted by itself. The unit shall then be turned ON again, with the fans operating at the highest speed, for 5 min.

Requirements: During the test no ice shall drop from the unit, and no water shall drip or blow off from the unit on the room side.

v) **Enclosure sweat performance**: Enclosure sweat test is to determine the resistance to sweating of the air conditioner when operating under conditions of high humidity.

Procedure: After establishment of the specified temperature conditions, the unit shall be operated continuously for a period of 4 h.

Requirements: During the test, no condensed water shall drip, run, or blow off from the unit.

vi) **Power factor requirement**: Power factor test is done to check that the air conditioner shall have an overall power factor not less than 0.9 when operating under full load capacity.

vii) **Maximum noise level requirements**: To check that the air conditioners do not produce noise beyond a specified levels, Sound pressure test is done.

The sound level measurement shall be made with the A-weighted sound pressure level or dBA scale. For sound test, the air conditioner shall be installed in a sound measuring room as specified in the Standard.

Sound Measuring Room:

The sound measuring room for indoor and outdoor side shall be of any of the following:

a) Anechoic room or hemi-anechoic room in accordance to **5** and Annex A of ISO 3745; or

b) Regular performance test laboratory, as installed for cooling capacity test (alternate room).

Test Equipment:

a) A sound level meter or dBA meter for sound pressure level. The sound level meter shall be of minimum class 2 as specified in IS 15575 (Part 1)/ IEC 61672-1. The equipment should be able to provide the A-rating or dBA sound pressure level; and

b) Measurement of the length shall be done with measuring scale or tape with an accuracy of ± 2 mm

Testing arrangement for Sound Pressure Test:

The test set up for measurement of Sound pressure shall be as specified below for Window and Split Room AC:

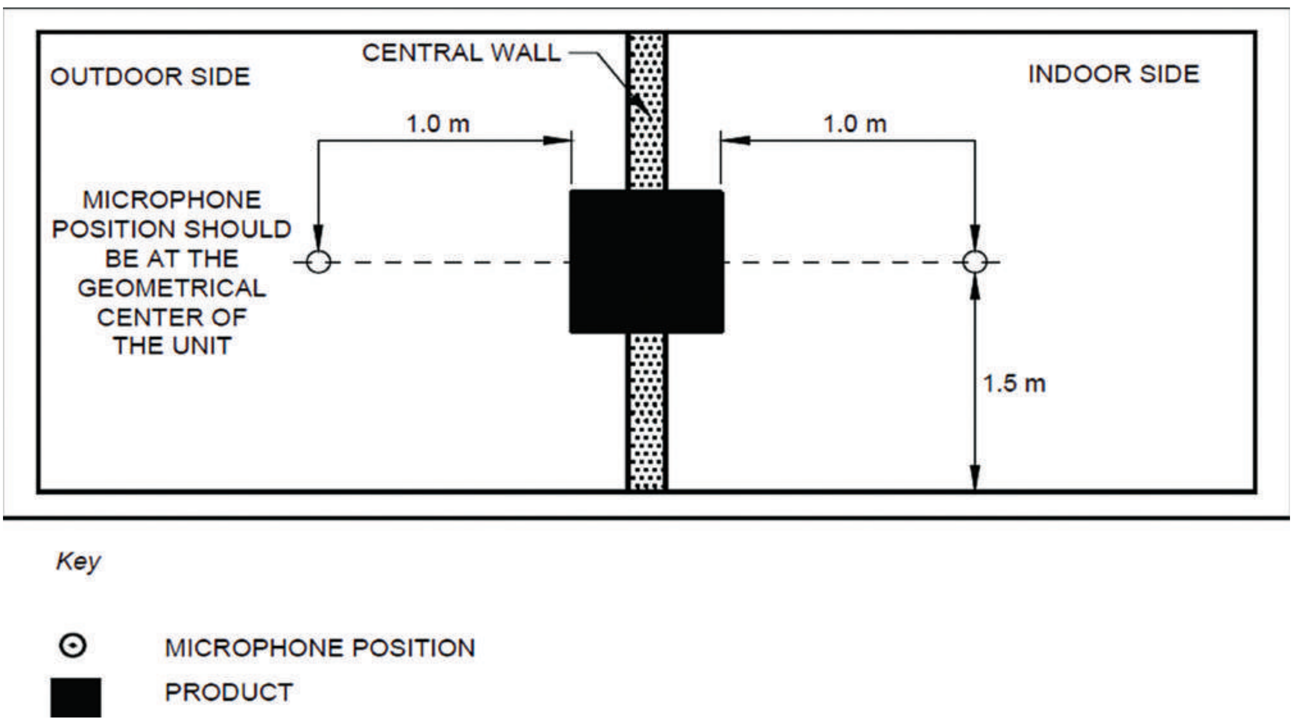


Fig.1 WINDOW TYPE ROOM AIR CONDITIONER INSTALLATION FOR SOUND MEASUREMENT

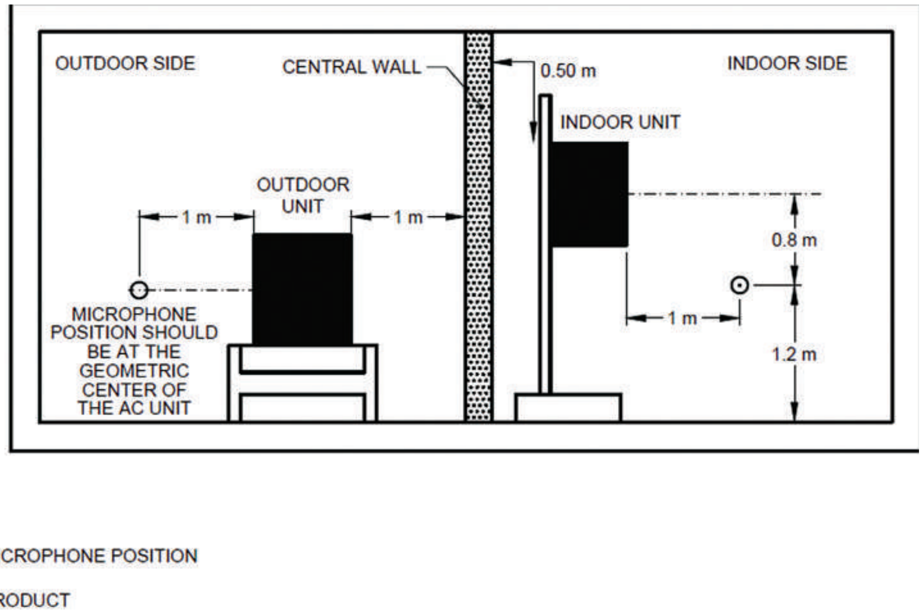


Fig. 2(a) WALL MOUNTED AIR CONDITIONER

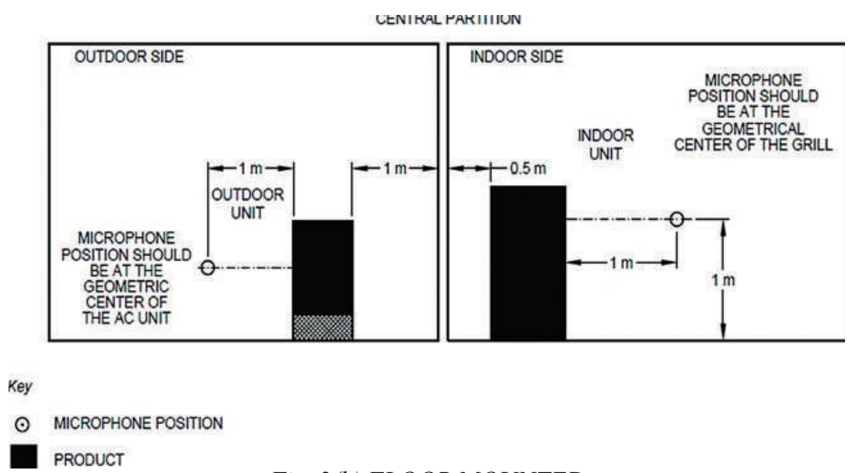


Fig. 2(b) FLOOR MOUNTED

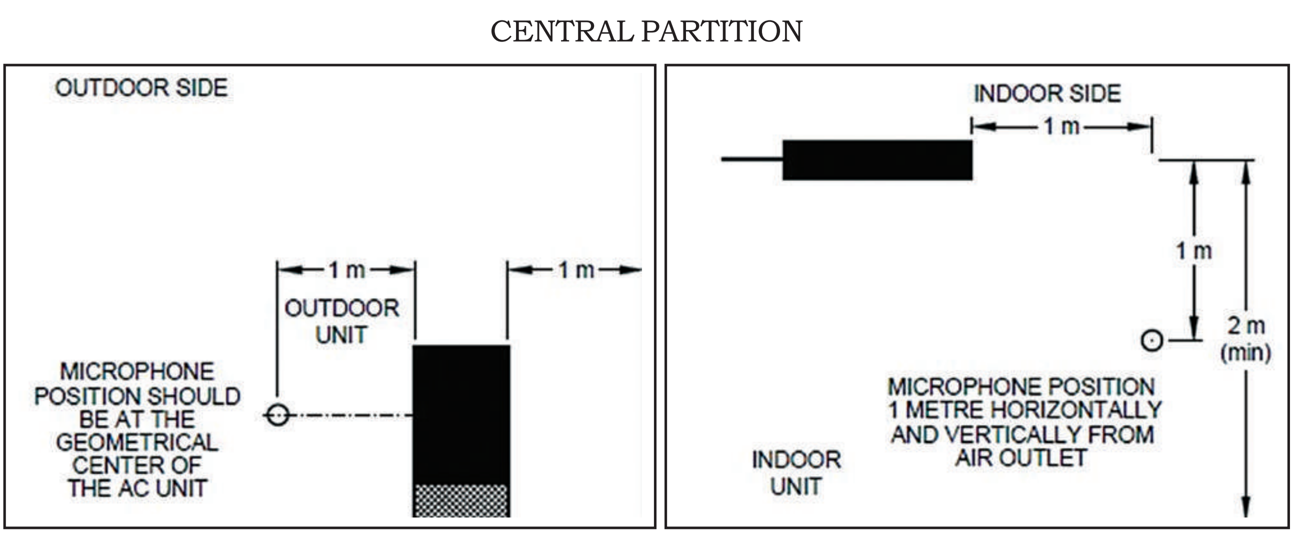


Fig. 2 (c) CEILING MOUNTED AIR CONDITIONER

Fig. 2 Split Type Room Air Conditioner Installation for Sound Measurement

The test method also prescribes provisions for background noise correction expected during testing.

Requirements of Sound Test

For Window Room AC:

Sl No.	**Rating Cooling Capacity** (W)	**Maximum Sound Pressure Level** (dBA)	
		Indoor Side	Outdoor Side
(1)	(2)	(3)	(4)
i)	Up to 4 400	58	65
ii)	More than 4 400	65	68

For Split Room AC:

Sl No.	**Rating Cooling Capacity** (W)	**Maximum Sound Pressure Level** (dBA)	
		Indoor Side	Outdoor Side
(1)	(2)	(3)	(4)
i)	Up to 5 200	58	68
ii)	5 200 to 10 500	62	70
iii)	10 500 to 13 250	62	72
iv)	13 250 to 18 000	62	75

For Ducted and Package AC as per IS 8148, the acceptance value is declared by the manufacturer.

d) Safety requirements: Indian Standard specifies following safety tests for Air conditioners: Protection against access to live parts, Electric Strength test, Provision for earthing, Electric leakage current test.

i) *Protection against access to live parts :* The purpose of this test is to ensure that the room AC is so constructed and enclosed that there is adequate protection against accidental contact to electrically live parts of the appliance. Compliance is checked by inserting Standard Test Probe to all openings and for all positions of the appliance expected during normal use.

ii) *High Voltage Test:* The electrical insulation of all circuits shall be such as to withstand a test voltage of 1 000 V rms applied for not less than 1 s when tested as per Annex A of IS 302 (Part 1). For inverter unit's compressor drive, earthing wire from accessible metal part may be removed before testing.

iii) *Leakage Current Test:* The leakage current shall not exceed 3.5 mA at rated voltage when tested as per method given in **13.2** of IS 302 (Part 1).

iv) *Provisions for Earthing* (*Earth Resistance Test*): The earth resistance of the unit shall not exceed 0.1 Ù, when tested as per **27** of IS 302 (Part 1).

e) **Energy Consumption requirements:** Indian standards specify the maximum power consumption levels for different rated capacities of air conditioners. It is also specified that the power consumption under rated conditions shall not exceed by 10 % of the declared value. Power Consumption test is done to determine the energy consumed. Indian Standards also specify requirements and test methods for determination of Indian seasonal Energy Efficiency Ratio (ISEER) values of Acs, which is used for Star rating as per Bureau of Energy Efficiency (BEE) norms.

f) Marking requirements for Air Conditioners as specified in Indian standards:

For Unitary Air Conditioners:

As per IS 1391 (Part 1), the unitary air conditioner shall have the following information marked on a nameplate in a location where it is accessible and visible:

a) Manufacturers' name/brand/trademark/identification mark;
b) Country of manufacture/origin
c) Model number and serial number of the unit;
d) Name and quantity of the refrigerant charge;
e) Rated voltage, frequency, and phase;
f) Rated cooling capacity;
g) Heating capacity, if provided;
h) Total power consumption at the rated conditions;
j) Nominal current at rated conditions; and
i) ISEER at rated conditions

For Split Air Conditioners:

As per IS 1391 (Part 2), the split air conditioner shall have the following information marked on a nameplate in a permanent and legible manner in a location where it is accessible and visible. The details of marking on outdoor unit (ODU) and indoor unit (IDU) shall be as given below:

Marking on ODU

a) Manufacturers name /brand /trademark/identification mark;
b) Country of manufacture/origin;
c) Model number and serial number of the unit;
d) Name and quantity of the refrigerant charge;
e) Rated voltage or voltage range, frequency, and phase;
f) Rated cooling capacity;
g) Heating capacity, if provided;
h) Total power consumption at the rated conditions;

j) Nominal current at rated conditions; and

k) ISEER at rated conditions

Marking on IDU

a) Manufacturers name/brand/trademark/ identification mark;
b) Country of manufacture/origin.
c) Model number and serial number of the unit;
d) Rated voltage or voltage range; and
e) Rated frequency

For Ducted and Package Air Conditioners:

As per IS 8148, the packaged/ducted air conditioner shall have the following information marked in a nameplate in a permanent and legible manner in a location where it is accessible and visible:

a) Outdoor unit:

   1) Name and address of the manufacture;
   2) Type of model number and serial number of the unit;
   3) Power supply in V, phase and Hz;
   4) Full load amperage;
   5) Name and quantity of refrigerant charge;
   6) Nominal capacity, in W, under temperature conditions specified in the standard; and
   7) Power consumption, in W, at the normal operating conditions specified in the standard.

b) Indoor unit:

   1) Name and address of the manufacture;
   2) Type of model number and serial number of the unit;
   3) Power supply in V, phase and Hz; and
   4) Power consumption, in W, at the normal operating conditions specified in the standard

CHAPTER VII

TYPES AND CLASSIFICATIONS OF REFRIGERATING APPLIANCES

CHAPTER VII

TYPES AND CLASSIFICATIONS OF REFRIGERATING APPLIANCES

1. Types and classification of Refrigerating appliances:

We saw in the introduction of this handbook, the effort to produce low temperature than its surrounding was started from objective of preserving food items in cooler environment. Classification of refrigerating appliances on the basis of application (whether commercial or household)

1.1 Classification of Household Refrigerating Appliances based on climate class:

Household Refrigerating appliances are classified into one (or more) of four climate classes. The range of ambient temperatures in which the appliances are intended to be used, and for which the required storage temperatures are to be met , shall be as specified in Table 1.

Table 1- Classification based on Climate class

Sl No.	**Description**	**Class Temperature Range** °C	**Ambient**
(1)	(2)	(3)	(4)
i)	Extended temperate	SN	+ 10 to +32
ii)	Temperate	N	+ 16 to + 32
iii)	Subtropical	ST	+ 16 to + 38
iv)	Tropical	T	+ 16 to + 43

1.2 Common household refrigerators can also be classified as follows:

a) Based on refrigerating appliance technology:

- Frost free
- Direct Cool:
  - ✓ Mechanical
  - ✓ Absorption

b) Number of Door: Single/ Multiple

c) Frozen Compartment contained:

- ✓ One-star
- ✓ Two-star
- ✓ Three-star
- ✓ Four-star

1.3 Other types of refrigerating appliances are:

1.3.1 Deep Freezers- an appliance with colder temperatures and a faster freezing process than fridge freezers. They are used to preserve and store food products, medical equipment, blood samples, medicines and injections, etc. for a long period of time. Deep Freezers are used for industrial purposes as well as for household purposes.

1.3.2 Visi Cooler- Visi coolers provide uniform cooling, maintain a temperature between 1 to 10 degrees Celcius, and are ideal for storing and displaying items like milk products, chocolates, juice, beverages, etc. These coolers are vertical in height and have double-layered vacuum glass doors, ensuring that products are easily visible. while both refrigerators and Visi coolers are used for cooling purposes, they are designed for different applications. Refrigerators are more versatile and suitable for storing a variety of food items, while Visi coolers are specialized appliances designed specifically for displaying and storing beverages in commercial settings.

2. Glance of the subject through Standards' eye

2.1 Out of the above various types of refrigerating appliances, following Product Specific Standards are available :

- IS 17550 (Part 1): 2021- Household Refrigerating appliances- General requirements
- IS 17550 (Part 2): 2021- Household Refrigerating appliances- Performance requirements
- IS 17550 (Part 3): 2021- Household Refrigerating appliances- Energy Consumption requirements
- IS 7872: 2020- Deep Freezers

2.2 Scope of these Standards:

IS 17550 (Part 1): 2021- "Household Refrigerating appliances- General requirements" specifies the essential characteristics of household refrigerating appliances, cooled by internal natural convection or forced air circulation, their rated voltage not exceeding 250 V, 50 Hz a.c., and establishes test methods for checking the characteristics. This standard shall be read in conjunction with the requirements given in Part 2 and Part 3 of this standard.

IS 17550 (Part 2): 2021- "Household Refrigerating appliances- Performance requirements"

describes the methods for the determination of performance requirements such as Safety requirements, Cooling capacity, Freezing capacity, storage capacity, Pull down, Wine storage, temperature rise etc.

IS 17550 (Part 3): 2021- "Household Refrigerating appliances- Energy Consumption requirements" describes the methods for the determination of energy consumption characteristics and defines how these can be assembled to estimate energy consumption under different usage and climate conditions. This standard also defines the determination of volume.

IS 7872: 2020- "Deep Freezers" specifies the safety, constructional and performance requirements including methods of determining performance of deep freezers based on vapour compression working principle. This standard covers deep freezers of top access type, having a storage volume up to and including 1 000 litre, with both hard top, glass top (sliding, hinged and curved) and their rated voltage not exceeding 240 V a.c. 50 Hz for single phase and 415 V a.c. 50 Hz for three phase a.c. including units with fixed speed and variable speed compressors.

(Indian standard on Visi Cooler is under preparation)

CHAPTER VIII

REQUIREMENTS OF REFRIGERATING APPLIANCES

(Path shown by Standards)

CHAPTER 8

REQUIREMENTS OF REFRIGERATING APPLIANCES

(Path shown by Standards)

Requirements of Various Refrigerating appliances as specified in respective Indian Standards

Now, We will see the requirements of following Refrigerating appliances which are specified in respective Indian standards:

Sl. No.	Indian Standard	Product of which requirements are covered in the Standard
1	IS 17550 (Part 1): 2021	Household Refrigerating appliances
2	IS 7872: 2020	Deep Freezers

1. Requirements of Household Refrigerating appliances as per IS 17550 (Part 1): 2021

Requirements of Household Refrigerator have been specified in IS 17550 (Part 1), IS 17550 (Part 2), and IS 17550 (Part 3). Broadly, these requirements can be categorized as following:

a) Material, design and manufacture requirements
b) Constructional requirements
c) Performance requirements
d) Safety requirements, and
e) Energy Consumption requirements
f) Marking requirements

Let us go through these requirements one by one:

a) Materials, design and manufacture

i) **General**: Appliances shall be constructed in such a manner as to ensure adequate performance and durability in use. Their performance in use is checked by applying a series of relevant tests. This clause defines some characteristics which are not tested but to which the attention of the manufacturer is drawn.

ii) **Materials and Finishes**

Materials used inside the appliances shall not transmit odours or taste to food. When testing in accordance with **15 of IS 17550 (Part 1)**, the mean value of the individual results during each evaluation for odour and taste shall not exceed mark 1. Materials used inside appliances shall not contaminate food placed in contact with them nor transmit poisonous substances to food. They shall be resistant to the action of moisture and food acids.

All surface finishes shall, for the purpose intended, be resistant to impact, sufficiently hard, colourfast, smooth, easily washable, and resistant to damage by moisture and by food acids.

iii) **Thermal Insulation and Air Tightness**

The thermal insulation of the appliance should be efficient and permanently maintained. In particular, the insulating material shall not be subject to shrinkage and shall not allow, under normal working conditions, an excessive accumulation of moisture.

No running water shall appear externally when the appliance is subjected to the water vapour condensation test (*see* **13** and Annex D of part 2 of IS 17550 (Part 1)).

When the door or lid is closed, there shall be no abnormal ingress of air into the interior.

A strip of paper shall not slide freely when door or lid seals are subjected to the air tightness test specified in 9 of IS 17550 (Part 1).

iv) Doors, Lids and Fittings

Hinges and handles shall be strong and resistant to corrosion.

External doors and lids of fresh food storage compartments and chill compartments cellar compartments shall withstand 10 000 openings and closings without deterioration which may be prejudicial to the air tightness of the appliance when subjected to the durability test of **11 of IS 17550 (Part 1)**.

In the case of frozen food storage cabinets, food freezers and appliances with the food freezer compartment and the frozen food storage compartment, if any, having a separate access door or lid, the hinges and handles of the door or lid of that compartment (or cabinet) shall withstand 10 000 openings and closings.

The fastening system shall be such as to enable the door or lid to be easily closed and opened. It shall be efficient and capable of maintaining its proper function.

For appliances having any compartment or section with a volume equal to or greater than 60 l, it shall be possible to open the door or lid of that compartment from the inside with a force not exceeding 70 N when subjected to the test specified in **10 of IS 17550 (Part 1)**. The volume of any compartment or section shall be determined when all shelves, partitions, and other internal components removable without the aid of a tool have been removed.

ii) Shelves and Containers

Shelves, containers, and similar components shall have adequate mechanical strength. Those used for storing food shall withstand the loading test specified in **12 of IS 17550 (Part 1)** without showing such distortion that they could no longer fulfil their intended function. In particular, sliding or revolving components shall be capable of their full movement when loaded.

Shelves, containers, and similar components which are intended to be removable should be easily removable.

vi) Disposal of Defrost Water

A means shall be provided for completely collecting the defrost water in an external receptacle wherein the defrost water is evaporated.

The defrost water receptacle should have adequate volume and should have adequate evaporating means.

Any drainage system shall be designed to ensure its proper function. It shall be easily accessible for the clearing of any blockage, and shall be designed so as to prevent any undue ingress of air into the food storage compartment(s) (or cabinets).

vii) **Refrigerating System**: The mechanical operation of the appliance should not give rise to undue noise or vibration. The design of the condenser should be such as to reduce to a minimum the accumulation of dust. The evaporator shall be so designed or protected so that it will not suffer any damage during the normal use of the appliance. The heat exchange surfaces shall be made of corrosion-resistant material, or shall be finished with a corrosion-proof, non-poisonous coating, resistant to temperature changes and alternating frosting and defrosting. The means of adjustment of temperature control devices, if intended to be adjusted by the user, should be readily accessible, and their function shall be, such as to enable the appliance to meet the requirements of the performance tests. Pipes and connections to moving or resiliently mounted parts should be arranged so as not to generate noise, neither to touch nor to transmit vibrations to other parts, and should be so designed as to prevent failure due to fatigue. All other pipes and connections should be securely anchored, where necessary.

Suitable means should be provided to prevent water condensed on cold parts from affecting the operation of the unit or its controls, or from causing any other damage to the appliance and its surroundings.

viii) **Supply Cord**: The length of the supply cord shall be at least 1.5 m when measured from entry point of the refrigerator to the point of entry of the cord into the plug. It shall conform to IS 694.

ix) **Compressor:** The compressor shall comply with IS 10617.

x) **Temperature Sensing Controls (Thermostat)**:The temperature sensing controls shall comply with IS/IEC 60730-2-9.

xi**)** **Temperature Sensing Controls (Thermostat) Setting**: The temperature sensing controls (thermostat) setting should be such that when set at any one point, it should not cut-in before the system is balanced under any operating conditions.

b) Constructional requirements tests to evaluate the appliance for mechanical strength and rigidity:

i) Testing the air tightness of door or lid seal(s):

The purpose of this test is to ensure that the gasket(s) of the door(s) or lid(s) of the appliance adequately prevent(s) any abnormal ingress of the surrounding air.

Procedure: The ambient temperature shall be between + 16 °C and + 43 °C. The appliance shall be switched off and shall be in equilibrium with the ambient temperature before carrying out the test.

A strip of paper 50 mm wide and 0.08 mm thick and of suitable length shall be inserted at any point of the seal, and the door or lid shall be closed normally on it. The verification of the thickness of the paper used shall be in accordance with IS 1060 (Part 1).

The seal shall be assessed by checking that the strip of paper does not slide freely.

The most unfavourable points may be found by inspecting the area around the seal with the appliance closed and illuminated from the inside. This test shall be carried out both before and after the mechanical durability test.

ii) testing the opening force of door(s) or lid(s)

The purpose of this test is to check that the door(s) or lid(s) can be opened from the inside. Compliance shall be checked by inspection and by the following test Procedure: The ambient temperature shall be between + 16 °C and + 43 °C. The appliance shall be switched off and be in equilibrium with the ambient temperature. The door or lid shall be closed for a period of 1 h, after which an 'opening' test shall be carried out under the following conditions:

The opening force of 70 N shall be considered as being applied to the inside of the door or lid of the appliance at the midpoint of the edge furthest from the hinge axis in a direction perpendicular to the plane of the door or lid.

The method of measurement shall be one of the following:

a) By applying the force at a point on the outer surface of the door or lid corresponding to the internal measuring point (for example, with the aid of a suction pad); and

b) If the handle of the door or lid is at the midpoint of the edge farthest from the hinge axis, by applying a force to the handle, the value of the force required to open the door or lid from the inside being determined by proportional calculation from the distances of the handle and of the internal measuring point from the hinge axis.

This test shall be carried out both before and after the mechanical durability test.

iii) TESTING THE DURABILITY OF HINGES AND HANDLES OF DOOR(S) AND LID(S)- Mechanical Durability test

The purpose of this test is to check the durability of the hinges and handles of door(s) and lid(s).

For External Door(s)

Test Conditions/Preparation: The ambient temperature shall be between + 16 °C and + 43 °C.The appliance shall be switched off. The inner door(s) shall be loaded as specified in **12.1.2**. The door shall be opened at least 45° from the cabinet reference wall before it starts closing.

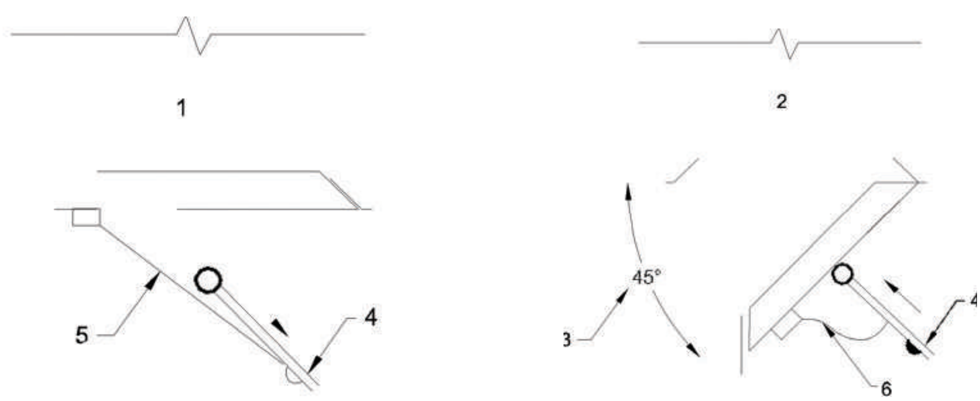
Opening sequence (*see Fig. below*): The movement of the door shall be controlled from an angle of 0° to an angle of opening between 5° and 15°, followed by a free movement of the door, the controlled movement being approximately sinusoidal. The opening of the door shall take place in the first quarter of the period of the cycle.

Closing sequence (*see Fig. below*): The movement of the door shall be controlled from the angle of opening of 45° to an angle between 40° and 35°, followed by the free movement of the door and its closing as in normal use.

The number of cycles per minute shall be 20 to 25.

a) For compartments with an internal temperature *T* > – 6 °C, external doors and lids shall withstand 100 000 opening and closing operations without deterioration which could be prejudicial to the air tightness of the door or lid.

b) For compartments with an internal temperature *T d”* – 6 °C, external doors and lids shall withstand 30 000 opening and closing operations without deterioration which could be prejudicial to the air tightness of the door or lid.



Key

1	Door Opening	4	Pusher
2	Door Closing	5	Taut Cable
3	Angle of Opening	6	Slack Cable

EXAMPLE OF OPENING AND CLOSING OF EXTERNAL DOORS

iv Testing the mechanical strength of shelves and similar components

The purpose of this test is to check the mechanical strength of the components used for storing food (shelves, containers).

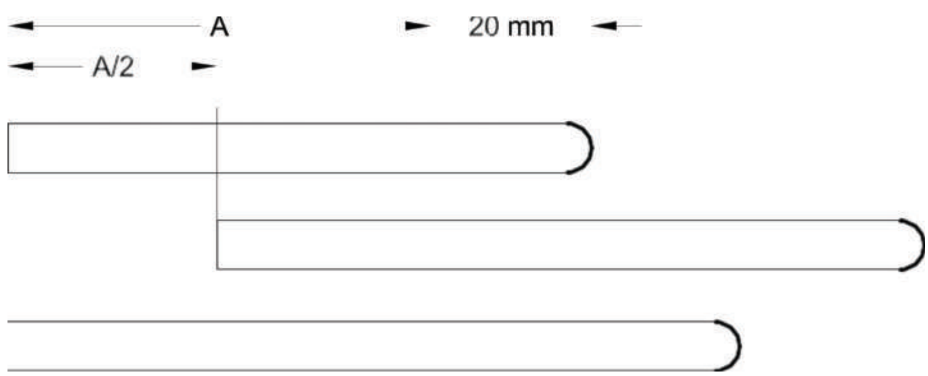
Procedure: The ambient temperature shall be between + 16 °C and + 43 °C.

Food Freezer Compartment (or Cabinet), Frozen Food Storage Cabinet and Low Temperature Compartments (if Applicable)

After the storage test (*see* **6** of IS 17550 (Part 2) of this standard), and with the appliance switched off, the behaviour of all loaded shelves, baskets, and containers and their supports shall be examined.

All sliding or revolving shelves and containers shall be moved, without modification of their load, to the halfway position, A/2, of their permissible course (*see* Fig. 7), except that if stops are provided which limit the movement to less than the half-way position the components shall be moved to their stop. They shall be left in this position for 1 h then returned to their initial position.

If the manufacturer has stated in the instructions for use that some shelves or containers slide out for maintenance or transportation, but must remain in a definite position in normal use, they shall be considered as fixed and the checking shall be carried out in the position as for the storage test.



A = PERMISSIBLE COURSE

FIG. 7 TEST POSITION FOR SLIDING COMPONENTS wHICH HAVE NO LIMITING STOP

Fresh Food Storage, Chill and Cellar Compartments (if Applicable)

The appliance shall be switched off, with the door(s) open.

The components to be tested shall be loaded in turn with 80 mm diameter cylindrical weights of 1 000 g, but of only 500 g in the case of components above which the clear height in normal service cannot exceed 150 mm. Components that are specially designed to hold eggs shall not be loaded.

The weights shall be placed with their axes vertical and in such a way that the maximum possible number is accommodated without one weight being placed over another and without overlapping the edge of the component under test.

In the case of door shelves, the diameter of the weights may be changed, if necessary, to adapt them to the shape of the shelves, provided the load per unit area is the same.

The applied loads shall remain in position for 1 h.

c) Performance requirements:

i) Test for absence of odour and taste:

The purpose of this test is to check that materials used for the internal components of the fresh food storage compartments and cellar and chill compartments, if any, will not impart either taste or odour to food.

Test conditions and Procedure:

Ambient Temperature

The ambient temperature shall be between + 16 °C and + 32 °C.

Cleaning

The appliance shall be cleaned prior to the test in accordance with the manufacturer's instructions and afterwards with pure water.

Samples:

The analytical samples and check samples respectively for each compartment shall be:

a) 100 ml potable water; and

b) A slice of fresh unsalted butter of dimensions 75 mm × 35 mm × 5 mm.

From each of (a) and (b), at least six samples are necessary to serve as analytical samples and at least six to serve as check samples.

The analytical samples shall be placed in petri dishes and the check samples in glass containers, the latter being hermetically sealed. Prior to the test, all petri dishes and containers which are used for the test shall be cleaned with timing nitric acid and subsequently washed with distilled water until the complete absence of odour is obtained.

The analytical samples of water and butter shall be placed uncovered in the fresh food storage, cellar and chill compartments.

The check samples in the hermetically sealed glass containers shall be placed close to the analytical samples.

Test Period

The analytical samples and the check samples shall be left in the operating appliance with the door(s) closed and at the specified temperature conditions for 48 h.

After 48 h, the analytical samples shall be covered. Then the analytical samples and check samples shall be removed and warmed up to approximately 20 °C by leaving them in the test room.

Examination of Samples

Conditions

Examination shall be made about 2 h after removal of the samples from the appliance and shall be carried out by at least three expert assessors familiar with the test method. Each expert assessor shall receive:

a) two analytical samples of water;
b) two check samples of water;
c) two analytical samples of butter; and
d) two check samples of butter.

The identity of the samples shall not be made known to the expert assessors. Examination for odour shall be carried out before examination for taste.

The samples of water shall be examined prior to the samples of butter unless a separate examination by different expert assessors takes place.

The examiners shall record their remarks, independently of each other, in writing.

Evaluation

The evaluation of the analytical samples shall be carried out with reference to the following scale:

a) Mark 0: No foreign odour or foreign taste;
b) Mark 1: Slight foreign odour or foreign taste;
c) Mark 2: Definitely perceptible foreign odour or foreign taste; and
d) Mark 3: Distinct foreign odour or foreign taste.

If the requirement in accordance with above is not clearly met, the test shall be repeated. The following provisions shall be made for the second test:

a) Cleaning of the compartments;
b) Operation of the empty appliance for one week;

and

c) Temperature adjustment in the fresh food storage, cellar and chill compartment for the second test for absence of odour and taste.

ii) Storage Test

The storage test is used to establish whether the refrigerating appliance is capable of maintaining suitable internal storage temperatures in a range of ambient conditions defined under the climate classes for which it is rated (*see* **6**).

iii) Cooling Capacity Test

The cooling capacity test is used to measure the load processing capability of fresh food compartments by determining the time to pull-down a specified test load from ambient to a specified temperature (*see* **7**).

iv) Freezing Capacity Test

The freezing capacity test is used to measure the load processing capability of frozen compartments by determining the time to pull-down a specified test load from ambient to a specified temperature. This test is required to establish whether a frozen compartment also qualifies for a four-star performance rating (*see* **8**).

v) Automatic Ice-Making Capacity Test

The ice-making capacity test is used to determine the quantity of new ice cubes that can be produced over a specified period of time.

Pull down Test- This test is done to measure the reserve refrigerating capacity of a refrigerating appliance. The time required to pull-down the appliance to the temperatures specified in IS 17550 (Part 2) shall not be more than the value stated by the manufacturer by more than 10 percent of the latter;

i. Wine storage test — This test is performed to check compliance with the requirements of Part 2 at appropriate ambient temperatures for the various climate classes;

ii. Temperature rise test — This test is performed to determine the time taken for the temperature to rise in the warmest test package from – 18 °C to – 9 °C after the power is disconnected. It is applicable to refrigerating appliances with one or more three-star or four-star compartments; and

iii. Water vapour condensation test (Annex D) — This test is performed to determine the extent of water condensation on the external surface of the refrigerating appliance under specified ambient conditions.

d) Safety requirements: Indian Standard specifies following safety tests for Air conditioners: Protection against access to live parts, Electric Strength test, Provision for earthing, Electric leakage current test.

i) *Protection against access to live parts :* The purpose of this test is to ensure that the room AC is so constructed and enclosed that there is adequate protection against accidental contact to electrically live parts of the appliance. Compliance is checked by inserting Standard Test Probe to all openings and for all positions of the appliance expected during normal use.

ii) High Voltage Test: The electrical insulation of all circuits shall be such as to withstand a test voltage of 1 000 V rms applied for not less than 1 s when tested as per Annex A of IS 302 (Part 1). For inverter unit's compressor drive, earthing wire from accessible metal part may be removed before testing.

iii) Leakage Current Test: The leakage current shall not exceed 3.5 mA at rated voltage when tested as per method given in **13.2** of IS 302 (Part 1).

iv) Provisions for Earthing (*Earth Resistance Test*):The earth resistance of the unit shall not exceed 0.1 Ù, when tested as per **27** of IS 302 (Part 1).

e) Energy Consumption requirements: DETERMINATION OF ENERGY CONSUMPTION

i) General

The key energy consumption components as specified in **6 of the Standard** shall be determined for each refrigerating appliance tested in accordance with this standard. This shall be based on data measured in accordance with Annex B to H, as applicable.

Clause **6** also specifies the method to be used to determine the components of energy consumption for a refrigerating appliance when tested in accordance with this standard.

The main components of energy consumption determined in accordance with this standard are:

a) Steady state power consumption — This is determined at ambient temperatures of 32 °C ;

b) Defrost and recovery energy and temperature change — For products with one or more defrost systems (each with its own defrost control cycle), the defrost and recovery energy for a representative number of defrost and recovery periods for each system shall be determined;

c) Defrost frequency — For products with one or more defrost systems (each with its own defrost control cycle), the defrost interval shall be determined for each system under a range of conditions;

d) Specified auxiliaries — Where a refrigerating appliance contains a specified auxiliary, the energy impact of this auxiliary shall be determined; and

e) Load processing efficiency — Where a load processing efficiency is measured or claimed, the specified method shall be used.

The lowest conceivable value of energy consumption for a refrigerating appliance under this standard (that is, the theoretical optimum), is the value where the temperature of every compartment is exactly equal to its target temperature for energy consumption (*see* **5**). Not every appliance is capable of operating at this condition, nor is it practicable for a laboratory to continue testing in an attempt to precisely obtain this condition during a specific set of tests. Under this standard there is the option of undertaking several tests with different temperature control settings (where available). This is to facilitate interpolation to estimate the energy consumption for a point where all compartments are at or below their relevant target for energy consumption (*see* **6.3**)

ii) Objective

In order to determine the characteristics of a household refrigerating appliance in accordance with this standard, it is necessary to measure the temperature and energy consumption for a representative period of steady state operation that complies with the relevant requirements (that is, compartment temperatures at or below their target for energy consumption). Several test points at different temperature control settings may be required to obtain the most favourable (optimal) result for energy consumption.

In the case of products with automatic defrost functions that affect the power consumption of the product (that is, has a defrost control cycle), the incremental energy during defrost and recovery (that is, the additional energy *“E*df over and above the underlying

These values are measured at specified ambient temperature (32 °C) for energy determination.

To assess whether a proposed period of test data is acceptable for the determination of energy consumption, the data are analysed and examined to assess whether changes in internal temperatures and power consumption are within acceptable limits. In terms of energy assessments, there are two alternative approaches to the determination of steady state power consumption:

a) SS1: Steady state power and internal temperature determination where there is no defrost control cycle or where steady state conditions according to Annex B can be established between defrost and recovery periods (generally where defrost events are widely spaced); and

b) SS2: Steady state power and internal temperature determination where steady state conditions according to Annex B cannot be established between defrosts and recovery periods (generally where defrost events are more closely spaced).

The incremental energy consumption and temperature change during a defrost and recovery period also needs to be assessed (relative to the steady state power and internal temperatures before and after the defrost and recovery period).

In each case, criteria are established to determine whether the periods are representative of the operation of the appliance.

f) Marking requirements for Household Refrigerators as per IS 17550 (Part 1):

Following marking requirements for household refrigerating appliances have been specified in IS 17550 (Part 1):

Rating Information

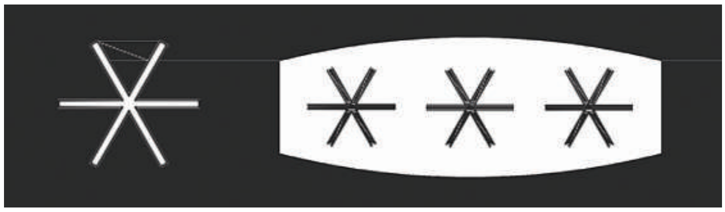
The following information shall be marked in a permanent and legible manner on the appliance:

a) Manufacturer's name, trademark, or identification mark;
b) Type of refrigerating appliance (for example, "refrigerator", with the designation being prefixed by the term "frost-free" if applicable);
c) Serial number and/or date of manufacture, which may be coded;
d) Total volume (alternatively, the volume for each compartment type may be listed);
e) Country of manufacture/origin
f) Designation and mass, in gram, of the refrigerant (see IS 16656/ISO 817);
g) Information relating to the energy source; and
h) Letters indicating the climatic class or classes (SN, N, ST, T);

Identification of Frozen Compartments

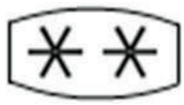
When identified, four-star compartments shall be identified by a symbol readily visible from the front, externally or internally, in accordance with that as given below.

Additionally, in the case of a One, Two or Three -star section in an identified freezer compartment, the standard two-star symbol (*as given below*) shall be placed to clearly indicate this section

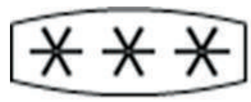


IDENTIFICATION SYMBOL FOR A FOUR-STAR COMPARTMENT

1-star compartment



2-star compartment



3-star compartment

Identification symbols for 1,2,3,4-star compartment

Additionally, IS 17550 (Part 1) also specifies that every refrigerating appliance shall be accompanied on delivery by instructions for its installation, use, user maintenance, and safe disposal.

Instructions should include the following where applicable:

a) The installation requirements (best location, levelling, connections to energy source, connection – if required – for water supply or for defrost water);

b) The space required in use and the overall space required in use with sketches showing the refrigerating appliance dimensions and minimum clearances required with the means of access (open and closed);

c) For a refrigerating appliance which is intended to be built-in, the recess dimensions together with any additional ventilation requirements;

d) The limit values of the range of ambient temperature for the rated climate classes and a warning that if the refrigerator operates outside the climate class (ambient temperature range) for which it is rated then it may not be able to maintain satisfactory internal temperatures

e) Operating instructions (starting and stopping procedures, use of the various controls — temperature-control devices, fast-freeze switch, indicator lights, air circulation and defrosting control, water and ice dispensers etc.);

f) The care required for best performance, such as:

    1) loading the refrigerating appliance, especially when there are sections with different star ratings within the same compartment and when no load-limit lines exist;

    2) the arrangement of food for storage, in particular the need to avoid cross-contamination;

3) the arrangement of food for storage and for freezing, where applicable, particularly including advice that food to be frozen is not to be placed in direct contact with food in storage and, if appropriate, that it could be necessary to reduce the quantity to be frozen if freezing every day is anticipated;

4) in the case of refrigerating appliances with chill compartment, a statement to the effect that some types of fresh vegetables and fruits are sensitive to cold, and that therefore they are not suitable for storage in this kind of compartment; and

5) the placing of ice-cube tray(s) in order to achieve optimal ice-freezing

g) The user maintenance and cleaning of the refrigerating appliance;

h) For manual defrost products, any precautions with respect to defrosting and damage to stored food during this process;

j) The action to be taken when the refrigerating appliance is switched off and taken out of service temporarily or for an extended period (e.g. emptied, cleaned and dried, and the door(s) or lid(s) propped ajar);

k) The necessity that, for doors or lids fitted with locks and keys, the keys be kept out of the reach of children and not in the vicinity of the refrigerating appliance, in order to prevent children from being locked inside;

m) Removal of doors and lids on disposal to prevent entrapment; and

n) Recovery of refrigerant and recycling of components on disposal of the refrigerating appliance

CRITERIA FOR ECO-LABEL FOR HOUSEHOLD REFRIGERATORS as per IS 17550 (Part 1)

a) The refrigerators shall conform to the requirements for quality, safety, and performance prescribed in the standard.

b) The manufacturer shall produce the consent clearance as per the provisions of *Water* (*Prevention and Control of Pollution*) *Act*, 1974, *Water* (*Prevention and Control of Pollution*) *Cess Act*, 1977, and Air (Prevention and Control of Pollution) Act, 1981 along with the authorization, if required under the Environment (Protection) Act, 1986 to BIS while applying for ECO Mark.

c) NOISE LEVEL

For ECO Mark the refrigerators shall conform to the noise levels as notified under the Environment (Protection) Act, 1986 from time to time.

d) INSTRUCTIONS

The refrigerators shall be sold along with instructions for proper use so as to maximize product performance, minimize wastage, and method of safe disposal of used product.

e) ENERGY CONSUMPTION

The power consumption shall be at least 5 percent less than those specified in the standard.

f) ENERGY EFFICIENCY

The product shall have at least 96 percent energy efficiency.

g) PACKING

The refrigerators shall be packed in such packages, which are made of recyclable or biodegradable materials.

h) REFRIGERANTS

The refrigerants and foam blowing agents shall not contain any Ozone-Depleting Substances (ODS) relevant to the refrigeration industry as identified under Montreal Protocol.

2. Requirements of Deep Freezers as per IS 7872: 2020

Broadly, the requirements of Deep Freezer specified in IS 7872 can be categorized as following:

a) Constructional and material requirements

b) Performance requirements

c) Safety requirements, and

d) Energy Consumption requirements

e) Marking requirements

Let us go through these requirements one by one:

a) Construction and material requirements:

i) General Design

The freezers shall have adequate mechanical strength and be constructed to withstand handling and transportation that may be expected in normal use. Where an internal light is fitted, the lamp shall be suitably protected from mechanical damage but shall be accessible easily without any undue force or pressure. There shall be no sharp edges or corners liable to cause injury to the user in the normal conditions of use.

ii) Materials

Materials used in the construction of the outer body shall comply with relevant Indian Standards wherever applicable, except where such requirements are modified by this standard. They shall be free from defects which are liable to cause undue deterioration or failure. Under normal conditions of use, the materials used shall not shrink, warp or cause odour and shall be resistant to attack by local vermin’s and destructive pests.

Where liable to be exposed to moisture, chemically active substances and food or food products, they shall be suitably resistant and shall not contaminate stored products placed in contact with them. Sealing materials used shall not loose in service, any of their essential properties, such as adhesiveness, plasticity and moisture resistance, due to ageing, temperature and humidity variations.

iii) Finish

The interior and exterior finish shall be durable and capable of being cleaned effectively and hygienically without undue deterioration. All metal parts used inside or outside the freezer which are exposed to moisture or ambient conditions shall be corrosion resistant or adequately protected against corrosion. It shall be tested for 72 h as per IS 9000 (Part 11).

iv) Thermal Insulation

The quality, thickness and application of the insulating material shall be such that insulation of the cabinet is effective and efficient to maintain the required temperature inside the cabinet. There shall be proper seals against moisture penetration by diffusion or condensation. Detachable plates and covers in the cabinet shall be provided with suitable seals to prevent ingress of moisture into the insulation. Highly conductive external or internal surfaces shall be separated by insulating breaker strips or their equivalent. As far as possible, no member of the frame shall penetrate the full thickness of the insulation.

NOTE — Insulation material used should comply with Indian regulatory norm listed by Ministry of Environment, Forest and Climate Change for Ozone depleting substance.

v) Fittings

Linings and facing shall have sufficient mechanical strength to resist distortion and give reasonable protection to the insulation. When the doors of the refrigerated space are closed, there shall be no leakage of external air into the cabinet either past the door gaskets or by any other means .

vi) Hardware

Door fasteners and hinges shall be smooth and positive in action and designed to maintain their proper function without undue wear under normal conditions of service. Screws and all other hardware shall be adequately protected from corrosion so that they can be easily serviceable.

The rails, shelves and baskets shall be sufficiently strong for the duty specified in **11.5**. The shelves shall be of welded metallic construction galvanized, chromium plated or of non-corrosive finished casting, plastic or any other protective coating not reacting with food in any way. The shelf supports shall be strong enough to take the load. The interior lining shall be of suitable metallic sheets or polystyrene materials and shall be non-corrosive. The surfaces which are coming in contact food stuff shall be made of food grade material so that during storage it shall not impact/ deteriorate the food quality.

vii) Door and Fittings

Hinges and handles shall be strong and resistant to corrosion. They shall be able to withstand the normal usage without adversely affecting the air tightness of the freezer. The opening of the door shall be sufficient to enable removable shelves or baskets to be easily withdrawn. In case of horizontal freezers, the door hinges shall be spring loaded for easy closing and opening and for self-opening when the door latch is released. Door/ lid shall withstand 100 000 opening and closing without deterioration for hard top and curved glass door/lid and 50 000 opening and closing for each of the sliding doors, which in particular, may adversely affect air tightness of the freezer, when subjected to the durability test as described below:

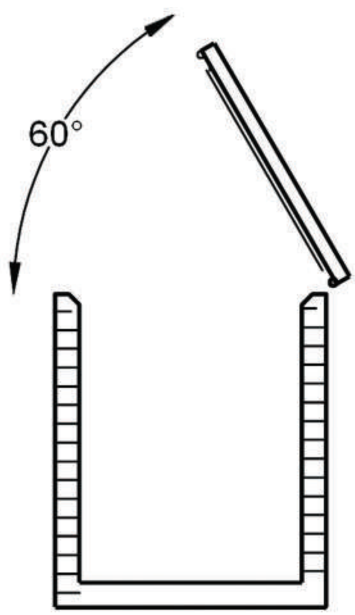
viii) External Doors

a) *Procedure* — The ambient temperature during the test shall be at normal ambient and the appliance shall be switched off. The door opening and closing sequence is shown in Fig. 3.

b) *Opening sequence* — The movement of the door shall be controlled from an angle of 0° to an opening angle of 60° followed by free movement of the door.

c) *Closing sequence* — The movement of the door shall be controlled from the angle of opening of 60° to an angle between 60° and 50°, followed by the free movement of the door and its closing as in normal use. The number of cycles per minute shall be 10 to 15 as shown in Fig. below.

DOOR OPENING SEQUENCE FOR HARD TOP AND HINGE GLASS TOP



ix) Disposal of Defrost / Condensate Water

A means shall be provided for draining the defrost/ condensate water or while cleaning with an external receptacle. Any drainage system shall be designed to ensure its proper function. It shall be easily accessible for the clearing of any blockage, and shall be designed so as to prevent any undue ingress of air into the food storage compartment(s).

x) Strength-Pressure Test for Components

General

Components of refrigerating systems shall be designed with a sufficient mechanical strength. Compliance is checked by carrying out the tests specified in **5.4.2** to **5.4.4**.

Individual Strength-Pressure Test

Each component shall be strength-pressure-tested individually at minimum 1.43 × PS for a period of minimum 1 min. The individual strength-pressure test shall be carried out as a hydrostatic pressure test by means of water or some other liquid, except where a component cannot be pressure-tested with liquid for technical reasons. In that case, it shall be tested by means of air or some other non-hazardous gas. Adequate precautions shall be taken to prevent danger to people and to minimize risk to property.

As an alternative to the above Strength-Pressure test on individual components, Strength Pressure test at higher pressure or fatigue test for specified number of cycles (250 000 cycles) can be conducted as design approval test.

b) Performance requirements: Following performance tests are done on Deep Freezers:

i) Sound pressure level

The refrigerating system shall not have sound pressure level more than 65 dBA for commercial places (Ambient Air Quality Standards in respect of noise as per *Noise Pollution (Regulation and Control) Rules,* 2000 issued by Ministry of Environment, Forest and Climate Change) the normal running operation at no load at prevailing room temperature and should not transmit vibration to adjoining portions of the surroundings. A random machine should be picked from manufacturing line for conducting the sound test. Freezer should be placed centrally in the test chamber with background noise less than 45 dBA.

With the help of calibrated sound meter/analyser or recorder, noise level of freezer is to be measured at a distance of 1.1 m from each side (except back side) of freezer and 1.2 m above the floor.

ii) STORAGE CAPACITY

Gross Volume

The gross volume of the freezer shall be the product of inside depth, inside width and inside height.

Storage Volume (Net Volume)

The storage volume shall be the gross volume or sum of the gross volumes of individual compartments less the volumes of internal fittings fixed in the cabinet and the volumes of the shelves, partitions and baskets essential which are assembled with tools for the proper operation of the cabinet. This volume will be obtained after deducting from the gross and also deducting the volume of any other space which is identified as unusable for storage of food, provided that its individual volume is greater than 0.25 litre or its thickness or width is greater than 13 mm:

a) Volume occupied by parts necessary for proper functioning of the freezer, such as evaporator material, evaporator doors, cooling coils, evaporator ribs and suction header;

b) Volume between the deductible door projections and adjacent liner walls;

c) Volume occupied by fixed partitions or projections, such as control knobs, shelf hangers, shelf and tray rails or basket supports which individually occupy a volume of more than 0.25 litre and have a width or thickness of more than 13 mm; and

Requirement: The measured storage (net) volume as described above shall not be less than the rated storage volume by more than 3 percent

iii) No Load Pull Down Test

The freezer shall be operated under no load, at 43°C ambient as per climate class T**.** The time required to pull down the average freezer air temperature from maximum temperature of 43°C to an average temperature of -18°C and maximum temperature shall not be warmer than -15°C and pull down time shall be not more than 200 min. The position of the thermocouple shall be as given in Fig. 9. The temperature shall be stabilized before the test within 43 ± 1°C.

iv) Temperature Rise test: The purpose of this test is to check the time for the temperature rise of test packages, after the operation of refrigeration system is interrupted.

The refrigerating appliance shall be prepared in ambient temperature as per climate class mentioned by manufacturer and shall be stabilized and loaded as per **12 of IS 7872**.

The setting of temperature control device or other control shall be set to maintain to achieve warmest package temperature of -18°C.

The power supply to the refrigerating appliance shall be cut off immediately after the end of a refrigeration cycle.

For automatic defrosting refrigerating appliances, the power supply shall be cut off after the power disconnection point to be a ‘compressor off’ during the stable part of the refrigeration cycle. If there are temperature variations, the test shall be commenced at a low temperature point.

The period of time shall be noted from the moment when the temperature of the warmest 'M-package' reaches –18°C to the moment when any one of the 'M-packages' in any of these compartments (or cabinets) first reaches –9°C.

v) Door Seal Test

The purpose of this test is to ensure that the gasket of the door of the deep freezer adequately prevents any ingress of the surrounding air. With the freezer at rest, a strip of paper 50 mm wide 0.08 mm thick and of suitable length shall be inserted at any point of the seal and the door closed normally on it shall not slide freely.

vi) Mechanical Strength of the Shelves and Similar Components

The purpose of this test shall be to check the mechanical strength of the components used for storing food, means shelves, containers, baskets, etc., with the freezer at rest and the door open. The test shall be conducted as follows:

i. Place the shelves in the proper location parallel to a flat surface;

ii. Use a height measure, caliper, or ruler to measure the existing deflection (if any) of the shelf at its maximum point on the underside of the shelf;

iii. For shelves uniformly load shelf with load of 195.3kg/m^2. Load can be either dead weight or actual products which are uniformly disturbed across the shelf area;

iv. After 72 h have elapsed, use the same measuring device used in b) to measure the total deflection of the shelf at its maximum point on the underside of the shelf;

v. Subtract the second measurement from the first measurement to get the total deflection. Divide the total deflection measurement obtained by the width of the shelf to obtain the deflection in cm/m; and

vi. Remove the load and measure the total deflection of the empty shelf.

Deflection has to be 1.04 cm/m when loaded with 195.3 kg/m^2. There should be no permanent shelf deformation/deflection which impacts the functionality of component.

However, in the case of baskets, maximum loading shall be checked based on the declaration of instruction manual/product provided by manufacturers.

vii) Thermal Insulation Test (External Condensation Test)

The purpose of this test is to determine the effectiveness of the insulation, on the external surface of the freezer. The test shall be carried at no load condition.

The freezer shall be held with an average internal temperature of -18°C in a surrounding ambient temperature between 31°C and 33°C and relative humidity between 70 and 75 percent. It shall be considered satisfactory, if condensed moisture is not visible on the outer surface, and no running droplets are visible on the external surface of the freezer during a period of time lasting for 12 h after the test conditions have become stable.

viii) Pressure Test

All parts of the refrigerating system subject to internal pressure shall be tested. No part of the assembly under test shall show signs of leakage or permanent deterioration after subjecting to the appropriate pressure .

c) Safety requirements:

The deep freezers shall comply with the safety requirements given in *clause* **8** to **32** of IS/IEC 60335- 2-89. The equipment shall be capable of working within ± 10 percent of rated voltage.

d) Energy Consumption requirements:

Energy Consumption Test

The freezer shall be operated at no load in an ambient temperature of 38°C for at least for 4 h prior to commencement of the testing.

After stable operating conditions (no load) have been attained the test period shall start. It shall be operated for 6 hrs and calculated for 24 h duration. During this period the average temperature should be below -18^{o}C.

The energy consumption shall be determined either by one test at the target temperatures or by interpolation from the results of two tests when target temperature is not achieved by one test. When interpolation is used, the temperature obtained from one of the two tests shall be warmer than the target temperature, and the temperature obtained from the other of the two tests shall be colder than the target temperature. The difference between the two temperatures used for the interpolating test shall not exceed 4°C.

The value measured in the energy consumption test on the first appliance tested shall not be greater than the energy consumption by more than 10 percent of the rated energy consumption. If the result of the test carried out on the first appliance is greater than the declared value (on marking label) plus 10 percent, the test shall be carried out on a further three appliances. Average energy consumption of three units recorded shall not be more than 10 percent of the value declared by the manufacturer on marking label.

e) Marking requirements for Deep Freezers as per IS 7872: 2020:

As per IS 7872, each deep freezer shall have the following information marked in a permanent and legible manner on one or several locations where it is readily accessible.

a) Manufacturer’s name and the trade-mark;
b) Model (or commercial designation) of freezer and Sl No.;
c) Rated gross volume, in litres;
d) Rated storage volume;
e) Name of the refrigerant used in system and its quantity;
f) Full load current or rated current or rated power input;
g) Type of Freezer
h) Rated Voltage
i) Rated frequency
j) Country of manufacture

CHAPTER IX

FEW MORE APPLIANCES WORKING ON VAPOUR COMPRESSION REFRIGERATION CYCLE

CHPATER IX

FEW MORE APPLIANCES WORKING ON VAPOUR COMPRESSION REFRIGERATION CYCLE

In addition to Refrigerator and Air Conditioners, there are few more appliances which work on the principle of vapour compression cycle and on which Indian standards are available. In this chapter, we will see two such appliances which are commonly used in household as well as commercial places. They are: Water Cooler, and Bottled Water Dispenser

1. Water Cooler:

Drinking water coolers facilitates easy supply of cool drinking water. It plays a vital role in places like educational institutions, offices, railway stations, industrial canteens, factories, restaurants, fast food outlets, etc. With advancements in technology, water coolers today come with environment-friendly and energy saving options. It is also commercially known as self-contained drinking water cooler.

Fig. 1: A typical commercial Drinking Water Cooler with Taps for Cold and Plain water

1.1 Types of Drinking Water Cooler:

1.1.1 Pressure/Instantaneous Type Drinking Water Cooler — A type of water cooler which employs a refrigeration system (cooling coil) having connections for inlet water under pressure and outlet for cold water without the need of storing water. It may employ faucet/spout for dispensing water.

1.1.2 Storage Type Drinking Water Cooler — A type of water cooler which stores and cools the water in the same container and/or separate containers. Such water coolers may or may not be fitted with plumbing connections for water inlet, drain, overflow, etc.

2. Bottled Water dispenser:

A bottled water dispenser is an appliance which cools and/or heats up and dispenses water with an optional refrigeration unit. The appliance requires Bottled Water to fed into it. It is very common in office spaces, where the drinking water is supplied in big jars/bottles.

Fig. 2: Bottled Water Dispenser with Hot, Cold and plain water dispensing taps

2.1 **Types of Bottled Water Dispenser**:

a) Bottom load water dispenser

b) Table Top Dispenser

c) Free standing Water DispenserFig. 3 (a) Bottom load water dispenser Fig. 3 (b) Table top water dispenser

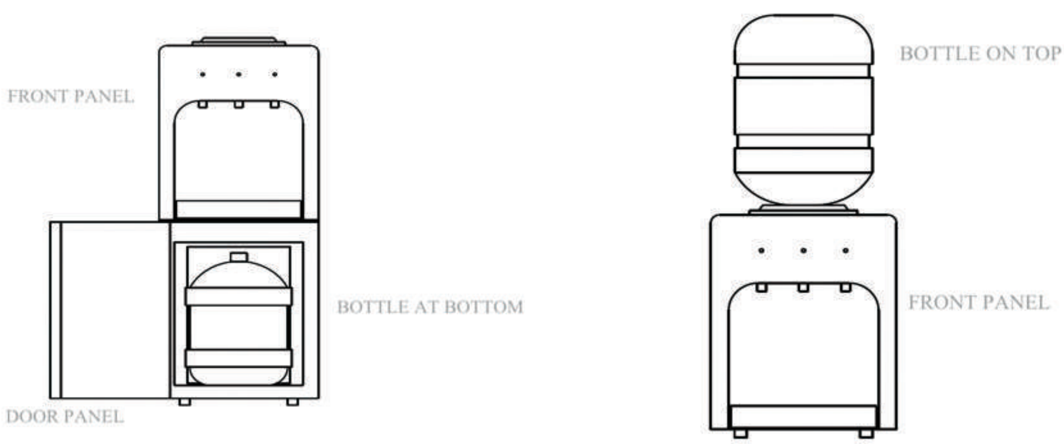


Fig. 3 (c) Free standing Water dispenser

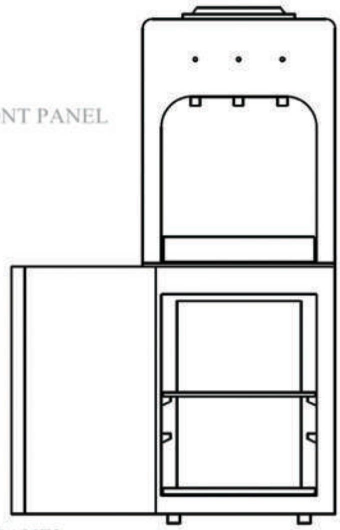


Fig. 3 Types of Botlled water Dispensers

1. Indian standards on Drinking Water Cooler and Bottled water Dispenser

Following product specific Indian Standards are available on Water Cooler and Bottled water Dispenser:

IS 1475: 2024- Drinking Water Cooler

IS 17681: 2021- Bottled water Dispenser

Let us see how are these Standards covering the products and what requirements are specified in these Standards

3.1 Scope of the Standard:

IS 1475: 2024- This standard specifies the general construction, performance, safety, and methods of testing of pressure and storage type drinking water coolers up to and including 225 l/h cooling capacity and up to and including 550 litre storage capacity. This standard covers the water coolers with rated voltage not exceeding 240 V, 50 Hz a.c. for single phase and 415 V, 50 Hz a.c. for three phase including units with fixed speed and variable speed compressors.

IS 17681: 2021- This standard specifies the safety and performance requirements of bottled water dispensers based on a vapor compression refrigeration system for dispensing cold and hot water including water at room temperature. It covers a bottled water dispenser with a rated voltage not exceeding 240 V a.c., 50 Hz for a single-phase and the rated cooling capacity up to and including 8 l/h and heating capacity up to and including 5 l/h.

3.2 Requirements of water Cooler and Bottled water Dispensers as specified in Indian standards:

3.2.1 Requirements of Drinking Water Cooler specified in IS 1475: 2024

- **a) Material and Constructional requirements**
- **b) Performance requirements**
- **c) Safety requirements**

d) **Energy Consumption requirements**

e) **Marking requirements**

Let us see these requirements in bit more detail

a) **Material and Constructional requirements**- The water coolers shall have adequate mechanical strength and be constructed to withstand handling and transportation. There shall be no sharp edges or corners liable to cause injury to the user in the normal conditions of use.

Chassis shall be of rigid construction, made of steel or alloy steel members, and coated with anti-rust plating or paint.

Cooling unit for storage type water cooler shall consist of storage tank with its surfaces acting as heat exchanger on the exterior. If the heat exchanger consists of cooling coil it shall be bonded to the tank on the exterior and held in good thermal contact. The coil, if prone to rust, shall be given a good coating of suitable rust preventing material.

Cooling unit for pressure or instantaneous type water cooler shall comprise a suitable heat exchanger designed to promote effective heat transfer. In case of double coil heat exchanger, both coils shall be held in good thermal contact. The portion of the heat exchanger in contact with the cooled water shall be of suitable corrosion resistant alloy so as to keep the water safe for human consumption.

The material used for the storage tank shall be either of stainless-steel conforming to IS 5522 or IS 6911 or of plastic conforming to IS 10146 or IS 10151 or IS 10910 or equivalent FDA grade material.

The drain tray shall be made of sufficiently strong corrosion-resistant material which shall not warp or get deteriorated due to constant use with cooled water under varying weather conditions. The drain tray shall be of suitable size to prevent any splash outside its periphery. The drain wherever provided, shall have a suitable strainer so as to prevent this from being clogged.

The outlet device and its valve for fitting the container or for direct feed shall be drip proof and made of a material which is corrosion resistant or where the material is not corrosion resistant it shall be suitably protected against corrosion so as to keep the water safe for human consumption.

The thermal insulation for the cooling unit, connections therefrom to the outlets, and for suction pipe of the condensing unit shall be of vapour-proof materials or covered with external vapour-proof barrier. The insulation shall have no interior air gap and shall be of sufficient thickness to prevent condensation on the exterior cold surfaces.

The enclosure of the unit shall be of suitable materials (steel sheets, galvanized iron, aluminium or plastics or decorative laminates) having proper thickness and suitably protected against the corrosion and coated to give decorative finish and long life under condition of use.

Three-core cable conforming to IS 9968 (Part 1 or IS 694 of at least 1.5 m length when measured from entry point of the water cooler to the point of entry of the cord into the plug shall be provided with each unit. A three-pin plug conforming to IS 1293 and starter, if required, shall be provided at the time of installation.

Where the static head is in excess of 12 m, a suitable pressure reducing device shall be provided at the time of installation.

The capacitor type single phase motor shall comply with IS 996. For brushless direct current (BLDC) motor, compliance shall be checked by the tests specified in 5.9 of IS 1391 (Part 1).

The compressor shall conform to IS 10617.

The water cooler with remote type dispensing means has the primary function of cooling potable water for delivery to remotely installed dispensers. Such remotely installed dispensing means are not considered part of the water cooler. Water coolers with remote type dispensing means can be either of pressure type or storage type.

The water coolers may also employ means of pre-cooling. In another arrangement suction line of refrigeration system may be used to pre-cool incoming water before it enters storage tank.

b) **Performance requirements**: Following performance requirements and tests have been specified in IS 1475: 2024 for Drinking Water Cooler: Cooling capacity requirement, Maximum Operating Condition requirements, Pull Down test, and Storage capacity test

i) **Cooling capacity requirement**:

Test Conditions:

The water coolers of all type shall be rated under the following conditions:

Ambient temperature 35 °C;

Inlet water temperature 30 °C; and

Maximum outlet water temperature 16 °C.

Test procedure: The procedure given below shall be followed for the cooling capacity test.

Start the water cooler unit and regulate the voltage at the service connection to within 1 percent of the rated voltage and rated frequency.

Adjust the temperature of the inlet water for all types of water coolers or the average temperature of the water coolers to within ± 0.5 °C of the rating conditions as specified in above. For non-plumbing type storage water coolers, a temporary inlet water connection with a flow regulator/valve shall be provided to facilitate maintenance of constant water level in the tank to rated storage capacity, as specified by the manufacturer.

The temperature control device shall be bridged so that continuous operation during the test is assured.

Operate the water cooler until steady temperatures and thermal equilibrium are established. For storage type water cooler, the water cooler shall be run for a time depending upon storage and cooling capacity so as to ensure that a stable outlet water temperature is established.

The temperature data shall be recorded at equal measuring intervals not greater than 15 min. All temperature measurements shall be recorded to the nearest 0.1 K or better.

Continue the test until eight successive readings of outlet water temperature are steady, with individual readings varying within ± 0.5 °C and average of such readings conforming to **6.2 of IS 1475**.

Ambient temperatures shall be maintained within ± 1 °C of the specified value and shall be measured at points located 30 cm from the sides other than the sides in which the condenser outlet is located, on the perpendicular passing through the geometrical centers of the surfaces of these sides.

Requirement of cooling capacity test- Performance of any unit shall have a capacity not less than 95 percent of the rated cooling capacity.

ii) **Maximum Operating Condition requirements**: The appliance shall be capable of operating satisfactorily under maximum operating conditions i.e. for extreme outside and inside air temperatures and under specified voltages which are different from the rated voltage.

Test Conditions

The water coolers of all types shall perform satisfactorily and meet the requirements when tested under the following conditions:

a) Ambient temperature 43 °C;

b) Inlet water temperature 35 °C;

c) Maximum outlet water temperature 21 °C;

d) Water flow rate maintained at 90 percent of the rated capacity as per the conditions specified in **6.2 of IS 1475**; and

e) Supply voltage at 90 percent and 110 percent of rated voltage

iii) **Pull Down test**: The pull down test shall be conducted without withdrawal of water from the water cooler outlet tap as per the conditions specified for Cooling capacity test above. The storage tank shall be filled with water till the float valve level. This test is applicable for storage type water coolers only. Measurement shall be made of the following:

a) Ambient temperature;

b) Initial water temperature;

c) Final water temperature;

d) Pull down time;

e) Voltage;

f) Current; and

g) Power consumption.

Once the initial temperature of water is measured is the unit is switched ON and the thermostat or temperature control shall be set for maximum cooling. The initial and final temperature of the water shall be measured in the top layer of the water surface in the tank after thoroughly mixing the water. Then, the measured pull down time shall be less than 110 percent of the value declared by the manufacturer.

Storage Capacity test: This test is applicable to storage type water cooler. The storage tank shall be filled up to its full capacity by flow meter or measuring jar. The storage capacity of coolers shall not be less than 95 percent of the values specified.

c) **Safety requirements**: **:** Indian Standard specifies following safety tests for Drinking Water Cooler: Protection against access to live parts, High Voltage (Electric Strength) test, Provision for earthing, leakage current test. These tests are required to be done in accordance with IS 302 (Part 1) which is a horizontal Standard and specifies safety tests to be done on various electric appliances.

i) Protection against access to live parts *:* The purpose of this test is to ensure that the WATER COOLER is so constructed and enclosed that there is adequate protection against accidental contact to electrically live parts of the appliance. Compliance is checked by inserting Standard Test Probe to all openings and for all positions of the appliance expected during normal use as specified in IS 302 (Part 1).

ii) *High Voltage Test:* The electrical insulation of all circuits shall be such as to withstand a test voltage of 1 000 V rms applied for not less than 1 s when tested as per Annex A of IS 302 (Part 1). For inverter unit's compressor drive, earthing wire from accessible metal part may be removed before testing.

iii) *Leakage Current Test:* The leakage current shall not exceed 3.5 mA at rated voltage when tested as per method given in **13.2** of IS 302 (Part 1).

iv) *Provisions for Earthing* (*Earth Resistance Test*):The earth resistance of the unit shall not exceed 0.1 Ù, when tested as per **27** of IS 302 (Part 1).

d) **Energy Consumption requirements**: Indian standard IS 1475: 2024 specifies the maximum power consumption levels for different rated capacities of Water Coolers. Power Consumption test is done to determine the energy consumed. Indian Standards also specify requirements and test methods for determination of Annual Energy Consumption. The annual energy consumption of the water cooler shall not exceed 10 percent of the declared annual energy consumption.

e) **Marking requirements for Drinking Water Cooler**: Each water cooler shall have the following information marked in a permanent and legible manner in a location where it is easily accessible and easily visible after installation:

a) Name-plate data of water cooler including make, model, and serial number of the unit;

b) The name and quantity of refrigerant;

c) Rated voltage and frequency;

d) Cooling capacity;
e) Wiring diagram;
f) Full load current;
g) Annual energy consumption, in kWh;
h) Type of water cooler;
j) Marking of earthing terminal; and
k) Manufacturers' name/trademark and country of manufacture

3.2.2 Requirements of Bottled Water Dispensers specified in IS 17681: 2021

a) Material and Constructional requirements
b) Performance requirements
c) Safety requirements
d) Energy Consumption requirements
e) Marking requirements

Let us see these requirements in bit more detail

a) **Material and Constructional requirements**:

General Design

The water dispensers shall have adequate mechanical strength and be constructed to withstand handling and transportation. There shall be no sharp edges or corners liable to cause injury to the user in the normal conditions of use.

Materials

Materials used in the construction of the cabinet shall comply with relevant Indian Standards wherever applicable, except where such requirements are modified by this standard. They shall be free from defects that are liable to cause undue deterioration or failure. Under normal conditions of use, the materials used shall not shrink, warp or cause odour and shall be resistant to attack by local vermin and destructive pests.

Where liable to be exposed to moisture, chemically active substances, and beverages, they shall be suitably resistant and shall not contaminate stored products placed in contact with them. Sealing materials used shall not lose in service, any of their essential properties, such as adhesiveness, plasticity, and moisture resistance, due to aging, temperature, and humidity variations.

The material used for the storage tank shall be either of stainless steel conforming to IS 5522 or IS 6911 or of plastic conforming to IS 10146 or IS 10151 or IS 10910.

Finish: The interior and exterior finish shall be durable and capable of being cleaned effectively and hygienically without undue physical deterioration.

Thermal Insulation

The quality, thickness, and application of the insulating material shall be such that insulation of the water storage tank or cabinet is effective and efficient to maintain the required temperature inside the water storage tank and cabinet. There shall be proper sealing against moisture penetration by diffusion or condensation. Detachable plates and covers in the tank shall be provided with suitable sealing to prevent the ingress and trapping of moisture into the insulation. Highly thermal conductive external or internal surfaces shall be separated by suitable insulating material. As far as possible, no part of the frame shall penetrate and cause damage to the insulation layers.

The thermal insulation for the cooling unit, connections therefrom to the outlets, and for suction pipe of the condensing unit shall be of vapour-proof materials or covered with an external vapour-proof barrier. The insulation shall have no interior air gap and shall be of sufficient thickness to prevent condensation on the exterior cold surfaces.

Hardware

The structure fitted with fasteners and hinges shall be smooth and positive in action and designed to maintain their proper function without undue wear under normal conditions of service. Screws and all other hardware shall be adequately protected from corrosion.

Disposal of Waste Water

The appliance shall be suitably designed at the water dispense area, such that the wastewater must be stored for a certain quantity without any spillage or have a provision of proper disposal through a drain.

Hot Water Tank

The thermostat is connected to the tank in such a way that it controls the required temperature and cuts off the heater power supply once the required temperature is achieved.

Hermetically Sealed Compressor

The compressor shall comply with the requirements of IS 10617.

Protective Guards

All moving parts shall be protected by suitable guards, shields, or screens of adequate strength and durability to avoid the possibility of making inadvertent contact therewith during normal service conditions

b) **Performance requirements**: Following performance requirements and tests have been specified in IS 17681: 2022 for Bottled Water Dispenser: Cooling capacity requirement, Heating Capacity requirement (For appliance with heating provisions), Maximum Operating Condition requirements, Pull Down test, Freeze up test, Endurance of Door (For Appliance with refrigerating cabinet) and Sound Pressure (noise) level requirements.

   i) **Cooling capacity requirement**: Cooling capacity requirement ensures that the appliance is meeting the cooling requirement as declared by the manufacturer under specified ambient and inlet conditions. Cooling capacity is declared in terms of litre/hour.

Test procedure:

The water dispenser shall be operated continuously at rated voltage for a minimum of 60 min or till the steady-state condition is achieved without withdrawing water ; and 3 min after the steady-state, at the interval of 10 min the cold water shall be withdrawn at the rated cooling capacity. The minimum and maximum temperature of withdrawn water shall be recorded. For example – if the rated capacity is 3 l/ h, withdraw 500 ml in each cycle. Repeat this cycle 6 times.

NOTE — During the water withdrawal if the compressor trips then wait for 3 min. The compressor off time shall not be considered in the test time.

After the test, the water dispenser shall comply with the following requirements:

Mean outlet water temperature shall be d" 16 °C in each cycle readings; and If outlet water temperature is less than 16 °C in all the measurements, the dispenser qualifies the cooling capacity. However, if any of the readings is more than 16 °C, the dispensers shall be deemed not conforming to the requirement of the cooling capacity test. For appliance with refrigerating cabinet, additionally, refrigeration cabinet air temperature shall be lower than ambient temperature by *Min* 5 °C.

ii) Heating Capacity Test:

The purpose of the test is to validate the water heating performance of the dispenser, as declared by the manufacturer. Heating capacity is declared in terms of litre/hour.

Test procedure for Heating capacity test: *Test Procedure*

The dispenser shall be installed at ambient temperature and inlet water temperature as per Table 1 and 2 given in IS 17681. After establishing the stabilised conditions as specified in IS 17681, it shall be operated continuously for heating at rated voltage until the thermostat trips without the withdrawal of water; and Immediately after tripping of the thermostat water shall be withdrawn at an interval of 5 min (417 ml for 5 l/h). The minimum and maximum temperature of withdrawn water shall be recorded. Repeat this cycle 12 times. In each cycle, the mean outlet water temperature shall be within 80 ± 5 °C.

iii) Maximum Operating Conditions Test: The purpose of this test to ensure that the appliance continues to perform its intended performance under Maximum environmental and electric supply operating Conditions.

iv) Pull down test: Purpose of this test is to ensure that the appliance shall be capable to Cool the inlet water to specified level (i.e. below 23 deg C) under specified ambient condition (43 deg C) within maximum time of 60 Minutes. Compliance is checked by following test procedure:

The product is installed as per the cooling capacity test. The cold-water storage tank shall be filled with Inlet water as per the specified ambient and input conditions. The dispenser shall be operated at rated voltage and frequency. The water temperature and time shall be recorded.

v) Door Seal test: This test is applied for the bottled water dispenser with refrigeration cabinet.

The purpose of this test is to ensure that the gasket of the door of the water dispenser adequately prevents any ingress of the surrounding air. This test shall be conducted with bottled water dispenser at rest or when not under operation.

A strip of paper 50 mm wide, 0.08 mm thick, and of suitable length shall be inserted at any point of the seal and the door shall be closed normally. The strip of paper shall not slide freely.

vi) **Door Opening and Closing test**: The bottled water dispenser with refrigeration cabinet shall be subjected to 3 000 cycles of the door opening and closing of a minimum 5 cycles per min. Each cycle shall comprise of 1 opening and 1 closing. After this test, the dispenser shall qualify the door seal test as above and there shall be no failure of the hinges.

vii) **Freeze Up test**: The dispenser shall be operated for 24 h at ambient temperature and inlet water temperature specified in IS 17681 without withdrawing any water.

After 24 h, 3 cups of 100 ml cold water is withdrawn, and then normal water is withdrawn. The normal water temperature shall not be less than 25 °C and there shall not be any frosting on the outside of the water tank.

c) **Safety requirements**: **:** Indian Standard specifies following safety tests for Bottled Water dispensers: Protection against access to live parts, High Voltage (Electric Strength) test, Provision for earthing, leakage current test. These tests are required to be done in accordance with IS 302 (Part 1) which is a horizontal Standard and specifies safety tests to be done on various electric appliances.

i) *Protection against access to live parts :* The purpose of this test is to ensure that the Dispenser is so constructed and enclosed that there is adequate protection against accidental contact to electrically live parts of the appliance. Compliance is checked by inserting Standard Test Probe to all openings and for all positions of the appliance expected during normal use as specified in IS 302 (Part 1).

ii) *High Voltage Test:* The electrical insulation of all circuits shall be such as to withstand a test voltage of 1 000 V rms applied for not less than 1 s when tested as per Annex A of IS 302 (Part 1). For inverter unit's compressor drive, earthing wire from accessible metal part may be removed before testing.

iii) *Leakage Current Test:* The leakage current shall not exceed 3.5 mA at rated voltage when tested as per method given in **13.2** of IS 302 (Part 1).

iv) *Provisions for Earthing* (*Earth Resistance Test*):The earth resistance of the unit shall not exceed 0.1 Ù, when tested as per **27** of IS 302 (Part 1).

d) **Energy Consumption requirements**: The purpose of this test to check that the power consumed by the appliance is not excessive.

Test procedure:

The dispenser shall be switched ON after the cooling capacity test and at same conditions without drawing water. It shall be ensured that the compressor and heater (if applicable) are switched ON. The measurement shall be taken under ON condition till 24 h.

Calculation for energy consumption:

$$Q_{24h} = \frac{Q_{No\ water\ draw} \times 1440}{T_{No\ draw}}$$

Where

Q_{24h} = normalized 24 h energy Consumption (Wh):

$Q_{No\ water\ draw}$ = energy consumption during the ON made with no water draw (Wh):

$T_{No\ draw}$ = duration of the On Mode With no Water Draw (In Min): and

1 440 = Number of Minutes in 24 h.

Annual Energy Consumption = $Q_{24h} \times 365$

e) Marking requirements for Bottled Water Dispenser as per IS 17681: 2022:

Each bottled water dispenser shall have the following information marked in a permanent and legible manner on one or several locations where it is readily accessible:

a) The manufacturer's name, address and/or the trade-mark;
b) The model (or commercial designation) and serial number;
c) The rated capacity (cooling and heating) in l/h;
d) The name of the refrigerant used in system and its quantity;
e) Rated power input for cooling and heating in watts;
f) Rated voltage and rated frequency; and
g) Country of manufacture

In addition, IS 17681: 2022 also specifies that each bottled water dispenser shall be accompanied with the instructions for its use and maintenance printed on strong paper/cardboard or similar material. These instructions shall at least provide information related to the following:

a) Installation requirements;
b) Conditions of operation (starting and stopping);
c) Use of various control devices (thermostat, defrosting, etc.); and
d) Maintenance and cleaning the bottled water dispenser.

CHAPTER X

ABOUT BIS MED 03 COMMITTEE AND LIST OF INDIAN STANDARDS AVAILABLE ON REFRIGERATION AND AIR CONDITIONING

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ABOUT BIS MED 03 COMMITTEE AND LIST OF INDIAN STANDARDS AVAILABLE ON REFRIGERATION AND AIR CONDITIONING

1. About the concerned technical committee of BIS:

MED 03, Refrigeration and Air Conditioning Sectional Committee under the Mechanical Engineering Department in BIS is responsible for formulation of Standards for refrigeration and air- conditioning equipment and appliances including terminology, definitions and symbols, designation of refrigerants, testing of refrigerating systems; and refrigerating units. Stakeholders from various fields like manufacturing industry and their associations, academic institution, Testing laboratory, Regulatory bodies constitute this committee and strive to formulate Standards, with consensus after extensive deliberations, which are at par with International standards.

2. Under this technical committee, following **Indian standards** on various components have been formulated, which are relevant here:

List of Indian standards on Air Conditioners and its related parts:

	Indian Standards under MED 3- Refrigeration and Air Conditioning	
Sl. No.	**IS No.**	**TITLE**
1.	IS 10594 : 2021	Specification for Thermostatic Expansion Valves
2.	IS 10617 : 2018	Hermetic compressors - Specification
3.	IS 11327 : 2022	Requirements for Refrigerants Condensing Units
4.	IS 11328 : 2022	Self-contained Automatic Ice Makers Specification
5.	IS 11329 : 2018	Finned type heat exchanger for room air conditioner
6.	IS 11561 : 2018	Code of practice for testing of water cooling towers
7.	IS/ISO 13261 : Part 1 : 1998	Sound power rating of air - Conditioning and air - Source heat pump equipment Part 1 non - Ducted outdoor equipment
8.	IS/ISO 13261 : Part 2 : 1998	Sound power rating of air Conditioning and air - Source heat pump equipment Part 2 non - Ducted indoor equipment
9.	IS 1391 : Part 1 : 2017	Room air conditioners - Specification Part 1 unitary air conditioners
10.	IS 1391 : Part 2 : 2018	Room air conditioners - Specification Part 2 split air conditioners
11.	IS 1475 : Part 1 : 2001	Self - Contained drinking water coolers - Specification Part 1 energy consumption and performance
12.	IS 16656 : 2017 ISO 817 : 2014	Refrigerants - Designation and safety classification

13.	IS 16678 : Part 1 : 2018 ISO 5149 Pt 1:2014	Refrigerating Systems and Heat Pumps Safety and Environmental Requirements Part 1 Definitions Classification and Selection Criteria
14.	IS 16678 : Part 2 : 2018 ISO 5149 Pt 2:2014	Refrigerating systems and heat pumps - Safety and environmental requirements Part 2 design construction testing marking and documentation
15.	IS 16678 : Part 3 : 2018 ISO 5149 Pt 3:2014	Refrigerating systems and heat pumps - Safety and environmental requirements Part 3 installation site
16.	IS 16678 : Part 4 : 2018 ISO 5149 Pt 4:2014	Refrigerating systems and heat pumps - Safety and environmental requirements Part 4 operation maintenance repair and recovery
17.	IS 16753 : Part 1 : 2022 ISO 28803 : 2012	High Efficiency Filters and Filter Media for removing Particles from Air Part 1 Classification Performance Testing and Marking
18.	IS 16753 : Part 2 : 2018 ISO 29463-2 :2011	High - Efficiency filters and filter media for removing particles in air Part 2 aerosol production measuring equipment and particle - Counting statistics
19.	IS 16753 : Part 3 : 2018 ISO 29463-3:2011	High - Efficiency filters and filter media for removing particles in air Part 3 testing flat sheet filter media
20.	IS 16753 : Part 4 : 2018 ISO 29463-4:2011	High - Efficiency filters and filter media for removing particles in air Part 4 testing method for determining leakage of filter elements - Scan method
21.	IS 16753 : Part 5 : 2018 ISO 29463-5:2011	High - Efficiency filters and filter media for removing particles in air Part 5 test method for filter elements
22.	IS 17550 : Part 1 : 2021 ISO 16620-4 : 2016	HOUSEHOLD REFRIGERATING APPLIANCES CHARACTERISTICS AND TEST METHODS Part 1 General Requirements
23.	IS 17550 : Part 2 : 2021 ISO 22526-1 : 2020	Household Refrigerating Appliance- Characteristics and test methods Part 2 Performance requirements
24.	IS 17550 : Part 3 : 2021 ISO 22526-2 : 2020	Household Refrigerating Appliance- Characteristics and test methods Part 3 Energy Consumption and volume
25.	IS 17570 : Part 1 : 2021 11520-2:2001	Air Filters for general ventilation Part 1 Technical specifications requirements and classification system based upon particulate matter efficiency ePM Adoption of ISO 16890-1 2016
26.	IS 17570 : Part 2 : 2021 ISO 18154:2017	Air Filters for general ventilation Part 2 Measurement of fractional efficiency and air flow resistance Modified adoption of ISO 16890-2 2016

27.	IS 17570 : Part 3 : 2021 ISO/ IEC 18745-1:2018	Air Filters for general ventilation Part 3 Determination of the gravimetric efficiency and the air flow resistance versus the mass of test dust captured adoption of ISO 16890-3 2016
28.	IS 17570 : Part 4 : 2021 ISO 18871:2015	Air Filters for general ventilation Part 4 Conditioning method to determine the minimum fractional test efficiency adoption of ISO 16890-4 2016
29.	IS/ISO 17584 : 2022	Refrigerant properties
30.	IS 17681 : 2022 ISO 13737:2004	Specification for Bottled water dispensers
31.	IS 17773 : 2022 IEC/ TR 60092-370:2016	Closed-Circuit Ammonia Refrigeration System Code of Practice for Design and Installation ANSI IIAR 2 2014 NEQ
32.	IS 2370 : 2014	Walk - In cold rooms - Specification
33.	IS 3615 : 2020	Glossary of Terms Used in Refrigeration and Air Conditioning
34.	IS 4831 : 2019	Recommendation on units and symbols for refrigeration
35.	IS 5111 : 1993 ISO 917 : 1999	Testing of refrigerant compressors
36.	IS 60335 : Part 2 : Sec 34 : 2021 IEC 60050-845: 2020	Household and similar electrical appliances Safety Part 2-34 Particular requirements for motor-compressors Adoption of IEC 60335-2-34 2021
37.	IS/IEC 60335 : Part 2 : Sec 40 : 2018 60603-1 : 1991	Household and similar electrical appliances safety Particular requirements for electrical heat pumps air-conditioners and dehumidifiers Adoption of IEC 60335-2-40
38.	IS/IEC 60335 : Part 2 : Sec 89 : 2010 IEC 60335-2-89:2010	Household and similar electrical appliances - Safety Part 2 - 89 particular requirements for commercial refrigerating appliances with an incorporated or remote refrigerant unit or compressor
39.	IS 655 : 2006 ISO 7807: 1983	Air ducts - Specification
40.	IS 7613 : 1975	Method of testing panel type air filters for air - Conditioning and ventilation purposes
41.	IS 7872 : 2020	Deep Freezers - Specification
42.	IS 7896 : 2023	Air Conditioning Outdoor Design Conditions Data for Indian Cities
43.	IS 8148 : 2018 ISO 13253 : 2017 ISO 16358 (Part 1) : 2013	Ducted and package air - Conditioners - Specification

While many of the above Standards have been discussed or referred in this handbook, users may like to go through the other Standards as well as per their interest.

CHAPTER XI

ENSURING QUALITY THROUGH REGULATIONS - QUALITY CONTROL ORDER (QCO)

CHAPTER XI

ENSURING QUALITY THROUGH REGULATIONS - QUALITY CONTROL ORDER (QCO)

What is a Quality Control Order(QCO)?

Quality Control Orders are technical regulations brought by the Government to ensure quality of goods. In our country, Central government through its ministries and departments notifies Quality Control Order under the Bureau of Indian Standards Act, 2016.

The Central Government notifies (through Quality Control Orders) goods, article, process, system or service and directs compulsory conformity of such goods/articles/services to Indian Standard and compulsory use of Standard Mark (ISI)under a licence or of certificate of conformity on the following grounds:

- Protection of human, animal or plant health
- Safety of the environment
- Prevention of unfair trade practices
- National security

The Central Government authorizes BIS or any other agency having necessary accreditation or recognition and valid approval to certify and enforce conformity to the relevant standard or prescribed essential requirements under BIS Act.

In this regard, Department of Promotion of Industry and Internal Trade, Ministry of Commerce and Industry, Government of India has notified Air Conditioners and its related parts, Hermetic Compressors and Temperature Sensing Controls (Quality Control) Order, 2019.

Air Conditioners and its related parts, Hermetic Compressors and Temperature Sensing Controls (Quality Control) Order, 2019 and BIS Certification of Air Conditioners:

Air conditioners have been brought under the compulsory BIS Certification under the "Air Conditioners and its related parts, Hermetic Compressors and Temperature Sensing Controls (Quality Control) Order, 2019" (QCO) issued by Department of Promotion of Industry and Internal Trade, Ministry of Commerce and Industry, Government of India. As per the QCO, Room Air Conditioners (both Unitary and Split type), Ducted and Package Air Conditioners, Finned type Heat exchangers and Hermetic Compressors are required to conform to respective Indian Standards and are required to be BIS Certified. The QCO has come into force from 01 October 2023.

As on date, more than 100 units in India have been granted BIS Certification for air conditioners and its related parts.

Refrigerating Appliances (Quality Control) Order, 2020

Refrigerating appliances have been brought under the compulsory BIS Certification under the "Refrigerating Appliances (Quality Control) Order, 2020" (QCO) issued by

Department of Promotion of Industry and Internal Trade, Ministry of Commerce and Industry, Government of India. As per the QCO, Household Refrigerating appliances are required to conform to respective Indian Standard i.e. IS 17550 (Part 1) and are required to bear BIS standard mark () under a valid licence from BIS. Also, "Deep Freezers" are required to conform to Indian standard IS 7872 and are required to bear BIS standard mark () under a valid licence from BIS. The QCO has come into force from 01 Jan 2024.

As on date, 15 units in India have been granted BIS Certification for Drinking Water Cooler

Water Dispensers (Quality Control) Order, 2024:

Bottled Water Dispenser has been brought under the compulsory BIS Certification under the "Water Dispensers (Quality Control) Order, 2024" (QCO) issued by Department of Promotion of Industry and Internal Trade, Ministry of Commerce and Industry, Government of India. As per the QCO, Bottled Water Dispensers are required to conform to respective Indian Standard i.e. IS 17681 and are required to bear BIS standard mark () under a valid licence from BIS. The QCO will be effective from 01 July 2024, or as notified further by Central Government.

Self-Contained Drinking Water Cooler (Quality Control) Order, 2024:

"Drinking Water Cooler" has been brought under the compulsory BIS Certification under the "Self-Contained Drinking Water Cooler (Quality Control) Order, 2024" (QCO) issued by Department of Promotion of Industry and Internal Trade, Ministry of Commerce and Industry, Government of India. As per the QCO, Drinking Water Coolers are required to conform to respective Indian Standard i.e. IS 1475 and are required to bear BIS standard mark () under a valid licence from BIS. The QCO will be effective from 01 October 2024, or as notified further by Central Government.

As on date, 10 units in India have been granted BIS Certification for Drinking Water Cooler.

BIS Certification procedure in brief- BIS Certification or licence is granted to a manufacturer who has applied for certification on the product manufactured in his premises. Manufacturers are granted BIS licence to use Standard Mark () at a manufacturing premise under Scheme-I of BIS (Conformity Assessment) Regulations, 2018. Grant and operation of licence is done through network of BIS Branch Offices which are spread across the country. The manufacturer is required to apply for BIS Certification to the concerned Branch Office under whose jurisdiction the manufacturing unit is located. Entire process of BIS Certification is online and is executed through the portal www.manakonline.in. BIS Certification for air conditioner is granted under simplified procedure which ensures that licence is granted within 30 days of submission of application. Under the simplified procedure, the applicant itself gets the product tested in BIS recognized laboratory and submits the test reports issued by these labs along with the application. Thus there is no need to wait for the test report of the sample which is drawn by BIS during the verification visit. Once the application is submitted, a desk scrutiny of the application documents and the test reports is done and any deficiency found in application/test report is communicated to the applicant. This is followed by a verification visit by BIS during which manufacturing and testing capability as per the Indian Standard is checked. Any deficiency/non-conformity observed during the visit is explained to the applicant with the advice to take corrective actions.

Checking authenticity of BIS Standard Mark ()

Anyone can check the authenticity of BIS Standard mark on BIS Website or at BIS Care app. In case of any complaint, the same may also be lodged through the BIS Care app.

Current information on BIS licences : Updated information on BIS licences (both domestic as well as foreign) for any product can be obtained from BIS Website at following link:

https://www.manakonline.in/MANAK/ApplicationLicenceRelatedrpt - Domestic

https://www.bis.gov.in/fmcs/licensee/ - Foreign

References:

While the majority of the content of this handbook has been developed from the Indian Standards available on BIS website, assistance has also been derived from following textbooks on the subject:

1. Textbook on Engineering Thermodynamics- *by Shri P.K. Nag*
2. Textbook on Refrigeration and Air Conditioning – *by Shri C.P.Arora*
3. Paper published on Refrigeration application by Landmark University, Nigeria

How to access and download Indian Standards:

Indian Standards are available free of cost and can be accessed and downloaded from BIS website from the following link: https://www.services.bis.gov.in/php/BIS_2.0/

One needs to register on the portal in order to access and download the Standards