A Laboratory manual

For

REFRIGERATION AND AIR CONDITIONING

LAB –(PR- 1)

In accordance to syllabus (2020-21)

By S.C.T.E & V.T, Odisha

Semester – 5^{TH}

DEPARTMENT OF MECHANICAL ENGINEERING

PREPARED BY: GITANJALI SETHI

SR. LECTURER MECHANICAL

GOVERNMENT POLYTECHNIC, JAJPUR

EXPERIMENT NO : 01

AIM OF THE EXPERIMENT:

To study the constriction features of domestic refrigerator.

APPARATUS REQUIRED:

SL NO	EQUIPMENT	SPECIFICATION	QUANTITY
01	Domestic Refrigerator		1

THEORY:

A vapor compression refrigeration system is now days used for all purpose of refrigeration. It uses a refrigerant sealed in air tight and leak proof mechanism. The refrigerant is circulated through the system and undergoes a number of changes in its state while passing through various parts of the system. The refrigerant (R-12) absorbs heat from one place and releases it to other place.

MECHANISM OF DOMESTIC REFRIGERATOR:

A domestic refrigerator consists of 5 essential parts.

1. COMPRESSOR:

The low pressure and temp. Vapor refrigerant from evaporator is drawn into the compressor through the inlet or suction valve, where it is compressed to a high pressure and temp. This high pressure and temp. vapour refrigerant is discharged into the condenser through the delivery valve.

2. CONDENSOR:

The condenser or cooler consists of coils or pipes in which the high pressure and temp. vapour refrigerant is cooled and condensed. The refrigerant while passing through the condenser, gives up its latent heat to the surrounding condensing medium which is normally air or water.

3. RECEIVER:

The condensed liquid refrigerant from the condenser is stored in a vessel is known as receiver from where it is supplied to the evaporator through the expansion valve.

4. EXPANSION VALVE:

It is also called throttle valve or refrigerant control valve. The function of the expansion valve is to allow the liquid refrigerant under high pressure and low temp. to pass at a controlled rate after reducing its pressure and temp.

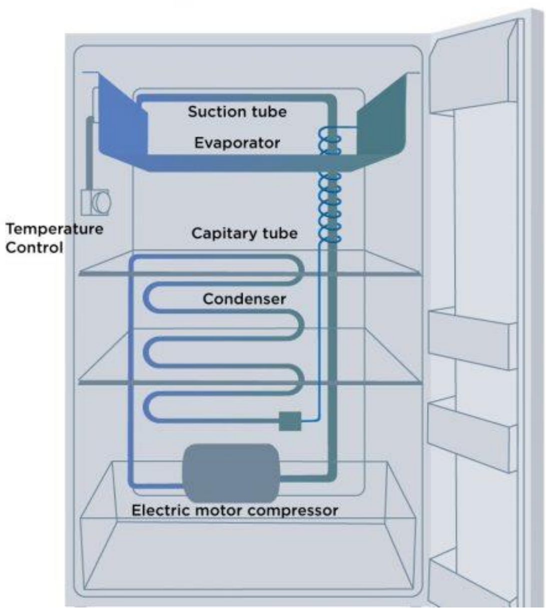
5. EVAPORTAOR:

An evaporator consists of coils of pipe in which the liquid vapour refrigerant at low pressure and temp. is evaporated and changed into vapor refrigerant at low pressure and temp. During evaporating the liquid vapor refrigerant absorbs its latent heat of vaporization from the medium which is used to be cooled.

WORKING PRINCIPLE :

The low pressure vapor in dry state drawn from the evaporator during the suction stroke of the compressor. During compression, the pressure and temp.is increased. When the high pressure refrigerant vapor enters the condenser, heat flows from condenser to cooling medium, thus allowing the vaporized refrigerant to return to the liquid state.

After condensation, the liquid refrigerant is stored in the liquid receiver. Then it is passed through the expansion valve, where the pressure is reduced sufficiently to allow the vaporization of the liquid at a low temp. The low pressure refrigerant vapor after expansion enters the evaporator where heat is absorbed by it and the cycle is completed.



CONCLUSION :

We successfully studied about the construction features of domestic refrigerator.

Practical related questions:

1. Which refrigerator is used in domestic refrigerator?
2. What is household refrigerator?
3. Which type of compressor is used in domestic refrigerator?
4. What is the cop of domestic refrigerator?
5. What are the different parts of refrigerator?
6. Why ammonia is not used in domestic refrigerator?

Space for answer

EXPERIMENT NO : 02

AIM OF THE EXPERIEMENT :

To study the construction features of water cooler.

APPARATUS REQUIRED :

Sl no	Equipment	Specification	Quantity
01	**Model of water cooler**		**1**

THEORY :

The purpose of water cooler is to make water available at a constant temp. Irrespective of ambient temp. .

They are meant to produce cold water at about 7^0 C to 13 ^{0}C (280K to 286K) for quenching the thirst of the people working in hot environment.

The temp.of the cold water is controlled with the help of a thermostatic switch set with in 7^0 C to 13 ^{0}C range.

There are two types of water cooler.

1. Storage type water cooler
2. Instantaneous type water cooler

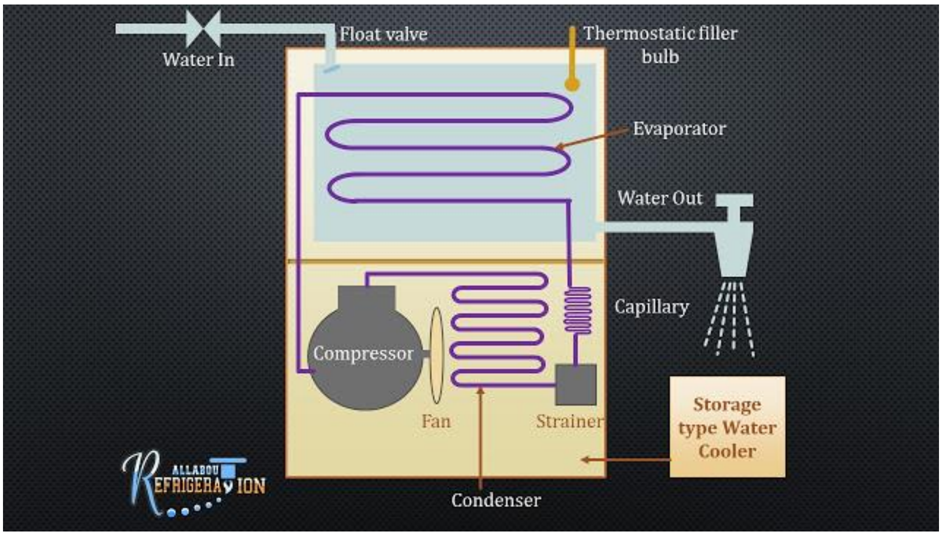
STORAGE TYPE WATER COOLER :

- The evaporator coil is soldered onto the wall of the storage tank of the cooler.
- The tank may be galvanized steel or stainless steel sheets. The water level in the tank is maintained by float valve.
- In this type of water cooler, the machine will run for a long period to bring down the temp. of the mass of the water in storage tank.
- When the water is drawn from the cooler and an equal amount of fresh water is allowed in the tank, the temp. will rise up slowly and the machine starts again.

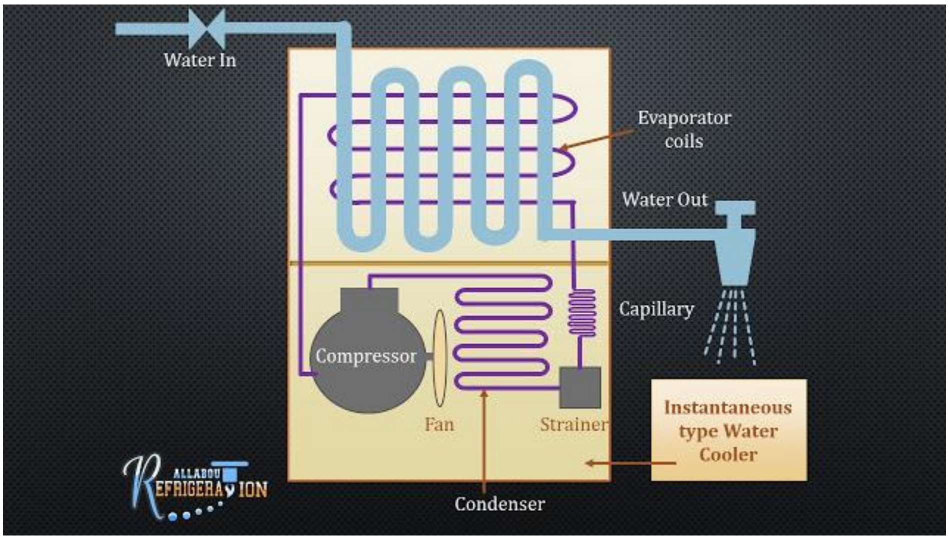
INSTANTANEOUS TYPE WATER COOLER:

- In this type of water cooler the evaporator consists of two separate cylindrical wound coil made up of copper or stainless steel tube.
- The evaporating refrigerant is in one of the coil and the water to be cooled is in the other coil.
- The water cooled by the refrigerant in evaporator by conduction.
- These water cooler are further classified as (a) Bottle type (b) Pressure type (c) Self contained remote type .

CONCLUSION: We have successfully studied about water cooler.



Storage Type Water Cooler



Instantaneous Type Water Cooler

Resources used (with major specifications)

Sl no.	Name of the apparatus	Specification	Quantity
01			
02			
03			
04			
05			
06			
07			

Actual procedure followed:

Precautions followed:

Observations:

Calculation:

Results:

Interpretation of results:

Conclusions and recommendations if any:

Practical related questions:

1. What is a water cooler?
2. How many types of water coolers are there?
3. Are water coolers bad for the environment?
4. What is the Difference between Storage and Instantaneous type water cooler?
5. How long do water coolers last?

Space for answer

EXPERIMENT NO : 03

AIM OF THE EXPERIMENT:

To study the construction features of Window Air Conditioner.

APPARATUS REQUIRED:

Sl No	Equipment	Specification	Quantity
01	Window A.C	1 Ton Cap.	1

THEORY :

The working of window air conditioner can be explained (refer the figures given below) by separately considering the two cycles of air: room air cycle and the hot air cycle. The compartments of the room and hot air are separated by an insulated partition inside the body of the air conditioner. The setting of thermostat and its working has also been explained in the discussions below.

Room Air Cycle

The air moving inside the room and in the front part of the air conditioner where the cooling coil is located is considered to be the room air. When the window AC is started the blower starts immediately and after a few seconds the compressor also starts. The evaporator coil or the cooling gets cooled as soon as the compressor is started.

The blower behind the cooling coil starts sucking the room air, which is at high temperature and also carries the dirt and dust particles. On its path towards the blower, the room air first passes through the filter where the dirt and dust particles from it get removed.

The air then passes over the cooling coil where two processes occur. Firstly, since the temperature of the cooling coil is much lesser than the room air, the refrigerant inside the cooling coil absorbs the heat from the air. Due to this the temperature of the room air becomes very low, that is the air becomes chilled.

Secondly, due to reduction in the temperature of the air, some dew is formed on the surface of the cooling coil. This is because the temperature of the cooling coil is lower than the dew point temperature of the air. Thus the moisture from the air is removed so the relative humidity of the air reduces. Thus when the room air passes over the cooling coil its temperature and relative humidity reduces.

This air at low temperature and low humidity is sucked by the blower and it blows it at high pressure. The chilled air then passes through small duct inside the air conditioner and it is then thrown outside the airconditioner through the opening in the front panel or the grill. Thischilled air then enters the room and chills the room maintaining low temperature and low humidity inside the room.

The cool air inside the room absorbs the heat and also the moisture and so its temperature and moisture content becomes high. This air is again sucked by the blower and the cycle repeats. Some outside air also gets mixed with this room air. Since this air is sent back to the blower, it is also called as the return room air. In this way the cycle of this return air or the room air keeps on repeating.

Hot Air Cycle

The hot air cycle includes the atmospheric air that is used for cooling the condenser. The condenser of the window air conditioner is exposed to the external atmosphere. The propeller fan located behind the condenser sucks the atmospheric at high temperature and it blows the air over the condenser.

The refrigerant inside the condenser is at very high temperature and it has to be cooled to produce the desired cooling effect. When the atmospheric air passes over the condenser, it absorbs the heat from the refrigerant and its temperature increases. The atmospheric air is already at high temperature and after absorbing the condenser heat, its temperature becomes even higher. The person standing behind the condenser of the window AC can clearly feel the heat of this hot air. Since the temperature of this air is very high, this is called as hot air cycle.

The refrigerant after getting cooled enters the expansion valve and then the evaporator. On the other hand, the hot mixes with the atmosphere and then the fresh atmospheric air is absorbed by the propeller fan and blown over the condenser. This cycle of the hot air continues.

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Setting the Room Temperature with Thermostat

The temperature inside the room can be set by using the thermostat knob or the remote control. If your window AC has knob, you would see some numbers or the round scale round the knob that will enable setting the temperature desired in the room. If your AC has come with the remote control, then you will see the room temperature on the digital indicator placed in the control panel of the window AC. You would probably also see the temperature on the small screen of the remote control. With the buttons provided on the remote control you can easily set the temperature inside the room.

When the desired temperature is attained inside the room, the thermostat stops the compressor of the AC. After some time when the temperature of the air becomes higher again, the thermostat restarts the compressor to produce the cooling effect. One should set the thermostat at the required temperature and not keep it at very low temperature to avoid high electricity bills.

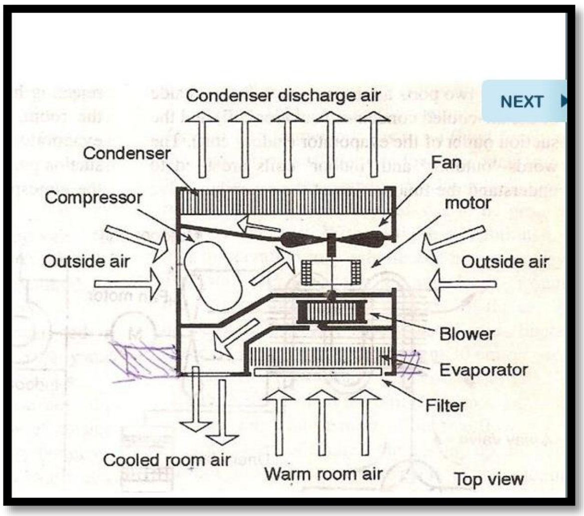
Setting the Speed of the Air

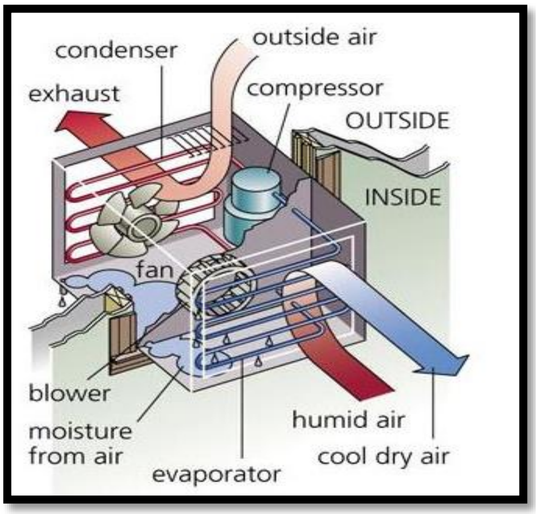
The Speed of the air can be set by the fan motor button provided on the control panel. If your AC has the remote control you can see the fan speed button on it. The motor of the blower is of multispeed that type that enable changing the speed or the flow of air inside the room.

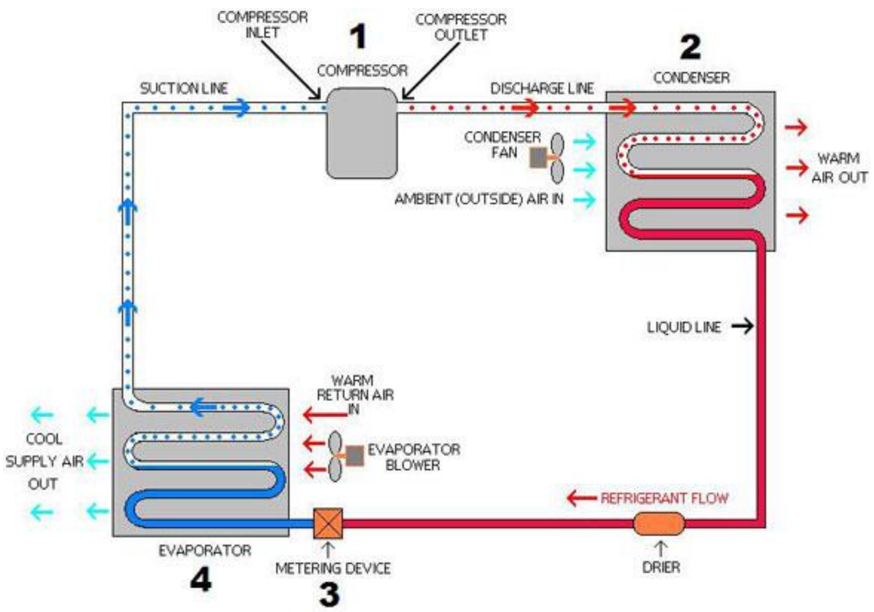
Important Part of the Window AC: Air Filter

The filter is a very important part of the AC since it cleans the air before it enters the room. For proper functioning of the filter it is very important to clean it every two weeks. If this is not done the filter will get choked and it won't be able to clean the air. Soon the dirt will also enter the evaporator coil and choke it. If this happens the AC will stop functioning and cleaning the evaporator becomes a very tedious process. Cleaning the filter hardly takes five minutes, do it regularly and enjoy the comforts of window AC on long-term basis.

Figure :







CONCLUSION :

We have successfully studied the windows air conditioner.

Resources used (with major specifications)

Sl no.	Name of the apparatus	Specification	Quantity
01			
02			
03			
04			
05			
06			
07			

Actual procedure followed:

Precautions followed:

Observations:

Calculation:

Results:

Interpretation of results:

Conclusions and recommendations if any:

Practical related questions:

1. What is a common problem with window air conditioning units?
2. How well do window AC units work?
3. What are common problems with air conditioners?
4. Can you run a window AC all day?
5. Do window AC units use a lot of electricity?

Space for answer

EXPERIMENT NO : 04

AIM OF THE EXPERIMENT:

To study the construction features of split Air Conditioner.

APPARATUS REQUIRED:

Sl No	Equipment	Specification	Quantity
01	Split A.C	1 Ton Cap.	1

THEORY:

COMPRESSOR:

The main function of compressor is to raise the pressure and temperature of tie refrigerant by the compression of the refrigerant vapor and then pump the condenser.

CONDENSER:

Condense the vapor refrigerant into the liquid by condenser fan passes it into the receiver tank for recirculation.

CAPILLARY TUBE:

It expends the liquid refrigerant at high pressure to the liquid refrigerant at low pressure so that a measured quantity of the liquid refrigerant is passed into the evaporator.

EVAPORATOR:

Evaporator the liquid refrigerant by absorbing the heat into vapor refrigerant and sends back in to the compressor.

VAPOUR COMPRESSION REFRIGERATION CYCLE:

The refrigerant start at some initial state or condition passes through a series of processes in a definite sequence and return to the initial condition. This series of processes is called cycle.

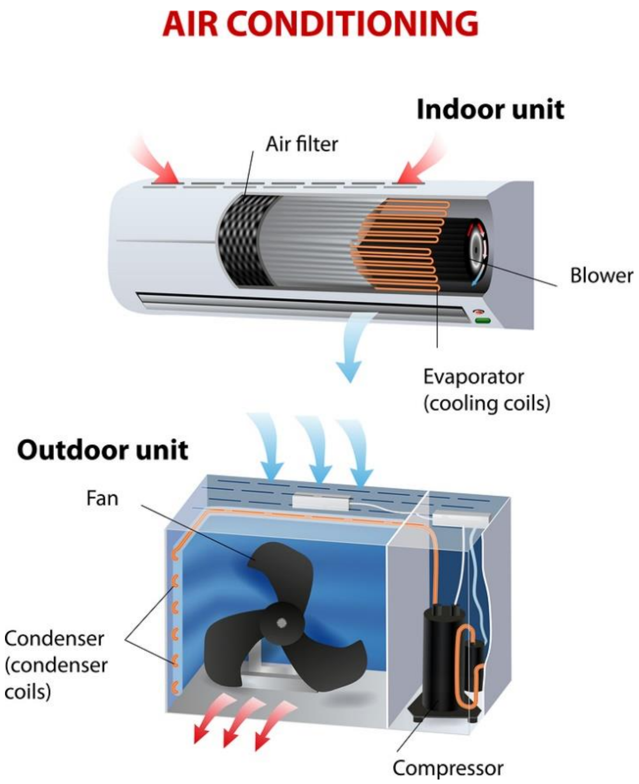
STANDARD VAPOUR COMPRESSION CYCLE (SVCC)

The standard vapor compression cycle (SVCC) consists of the following processes:

1. Reversible adiabatic compression from the saturation vapor to a super-heated condition.
2. Reversible heat rejection at constant pressure (sub cooling liquid and condensation of the refrigeration)

3. Irreversible is capillary tube expansion from saturated liquid to a low pressure vapor.

4. Reversible heat addition at constant pressure.



CONCLUSION :

We have successfully studied the Split air conditioner.

Resources used (with major specifications)

Sl no.	Name of the apparatus	Specification	Quantity
01			
02			
03			
04			
05			
06			
07			

Actual procedure followed:

Precautions followed:

Observations:

Calculation:

Results:

Interpretation of results:

Conclusions and recommendations if any:

Practical related questions:

1. What is a common problem with split air conditioning units?
2. How well do split AC units work?
3. What are common problems with split air conditioners?
4. Can you run a split AC all day?
5. Do split AC units use a lot of electricity?

Space for answer

EXPERIMENT NO : 05

AIM OF THE EXPERIMENT:

To determine the capacity and cop of vapour compression Refrigerator test rig.

APPARATUS REQUIRED:

SL NO	EQUIPMENT	SPECIFICATION	QUANTITY
01	Refrigerator		1

THEORY:

STANDARD VAPOUR - COMPRESSION CYCLE

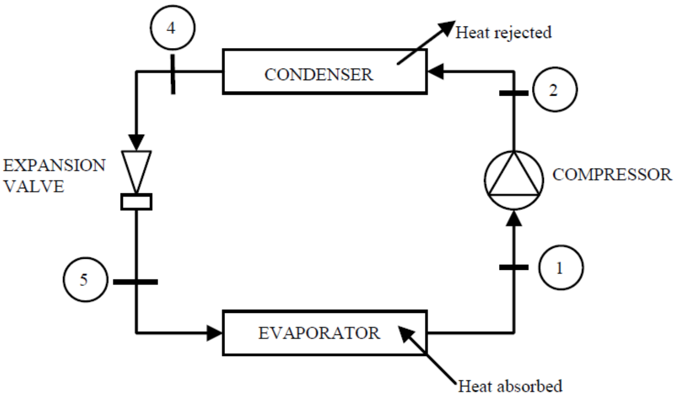
The standard Vapour Compress Cycle consists of the following processes.

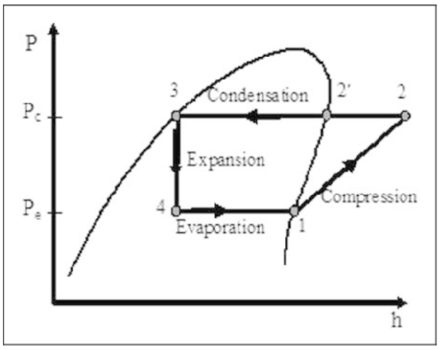
1-2 Reversible adiabatic compression from saturated vapour to the condenser pressure.

2-3 Reversible heat rejection at constant pressure de-superheating and condensation.

3-4 Irreversible constant enthalpy expansion from saturated liquid to the evaporator pressure.

4-1 Reversible heat addition at pressure (Evaporation to saturated vapour).





p- h DIAGRAM

Refrigerants such as 134a (CF3CH2F tetra fluoro-ethane) are used as the working medium because of their properties, which are required as refrigeration cycles.

Performance of standard vapour compression cycle :

Process 1-2 is the compression process wherein mechanical work is to be supplied (usually in the form of electrical energy to a compressor. This is the quantity to be spent. Process 4-1 represents the useful refrigeration effect.

The index of performance is defined as co-efficient of performance (not as efficiency, as for heat engines).

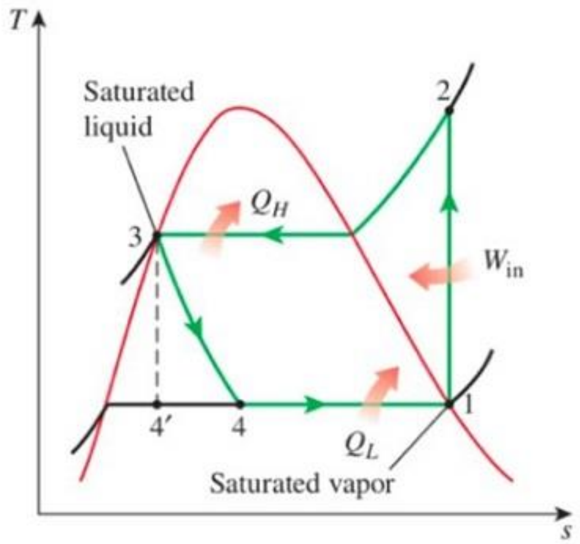
C.O.P. is defined as follows:

C.O.P. Useful refrigeration (output) /Network Compressor work (input)

A Carnot refrigeration cycle consists of all reversible process:

It will have the highest coefficient of performance when operating between any temperature limits.

C.O.P. of A Carnot refrigeration is defined as follows:



(T- S chart)

C.O.P.(CARNOT) =T1/(T2-T1)

NOTE: Carnot cycle C.O.P. depends only on condenser and evaporator temperature, Carnot is an ideal cycle. It cannot be constructed in practice. However, it is used as a for comparison.)

Difference between Carnot cycle and standard vapour compression cycle.

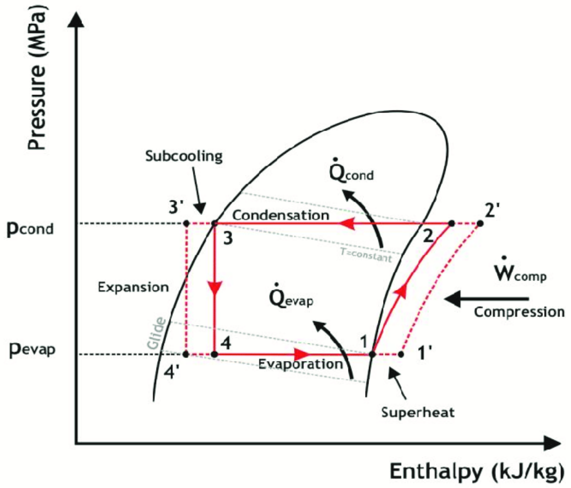
1. Process 1-2 is a wet compression process on carnot cycle whereas it is a dry compress process in SVCC.
2. Process 3-4 is a reversible process in carnot cycle whereas it is an irreversible process SVCC.

Actual Vapour Compression Cycle

The actual vapour compression cycle when practically constructed will differ from the stand: vapour compression cycle.

(Note: This could be because of using an intercooler which actually sub cools the condensate a slightly superheats the vapour before it enters the compressor).

Standard Vapour compression cycle (SVCC) and Actual Vapour compression Cycle (AVCC)are both drawn on the same p-h chart as shown below.



1-2-3-4 : Standard vapour compression cycle

1'-2'-3'-4': Actual vapour compression cycle

Energy meter readings time for 'n'rev= t secs	Suction pressure **P_1** in Psi.	Suction pressure **P_2** in Psi.	Refrigerant at inlet to compressor **T_1**	Refrigerant at outlet from compressor **T_2**	Refrigerant temp. at outlet from condenser **T_3**	Refrigerant temp. at inlet to Evaporator **T_4**	Water temp. in Chiller **T_5**

1.01325 bar = 14.7 psi

1.01325/14.7 = 0.068 bar

Pressure = 0.068 + pressure gauge reading + 1 atmospheric pressure = bar

Energy meter constant (Em)'C' = 750 rev/Kw.hr

Efficiency of motor ' η_m' = 0.9

Mechanical efficiency of compressor ' η_c' = 0.85

Model Calculations for reference

$$\text{Work done by compressor} = W = \frac{\text{No of energy meter revolution x 3600 X } \eta_m \text{ X } \eta_c}{\text{Time taken for no. of Em rev x C (Em constant)}}$$

Incase of mass of water in chiller

Refrigeration effect (N) = (Mw x cp X ΔT)/Time taken for drop in initial to final temperature = kw

Mw = Mass of Water in Chiller

Cp = Specific Heat of Water (4.1868 KJ/kg° C)

ΔT = Drop in water temperature (Ts initial and final temperature and time taken to drop)

C.O.P. actual = Refrigeration effect (N)/ Work done by the compressor (W)

Locate 1, 2, 3, 4 on P-h chart for R 134a using (P, T,), (P2 T2) T3 and 14 read specific enthalpy values at 1,2,3 and 4.

h_1 = kj/kg

h_2 = kj/kg

$h_3 = h_{4=}$ kj/kg

Theoretical C.O.P = $\mathbf{(h_1 - h_4) / (h_2 - h_1)}$

Operational Instructions:

Before starting the unit please observes and notes the following points.

a. All the hand shut of valves should be opened except charging line valve which should not

be touched.

b. Fill measured quantity of water or measure the flow rate of water using inlet and outlet arrangement to achieve mass of water

c. P_1/ P_2 indicate suction and discharge pressure in the gauges

d. Provide a single-phase 15 amps 3-pin socket power supply close to the unit.

e. Keep main switches in off position.

f. Now put the main switch on.

g. Decide which system you are going to use first. For (a) hand shut off valve with thermostat expansion valve and close any one capillary operated valve.

h. For (b) hand shut off valve with capillary expansion and close thermostatic expansion valve operated valve.

CONCLUSION :

From the experiment, we found the result of the capacity and cop of vapour compression Refrigerator test rig.

Resources used (with major specifications)

Sl no.	Name of the apparatus	Specification	Quantity
01			
02			
03			

04			
05			
06			
07			

Actual procedure followed:

Precautions followed:

Observations:

Calculation:

Results:

Interpretation of results:

Conclusions and recommendations if any:

Practical related questions:

1. Which are the main parts of a mechanical refrigeration system?
2. What do you mean by a condensing unit?
3. Why is pressure difference necessary in a refrigeration system?
4. What is wet compression?
5. What is refrigerating effect or cooling effect?
6. What is COP (Coefficient of Performance)?

Space for answer

EXPERIMENT NO : 06

AIM OF THE EXPERIEMENT :

To determine the capacity and cop of water cooler.

APPARATUS REQUIRED :

Sl no	Equipment	Specification	Quantity
01	Model of water cooler		1

THEORY :

The purpose of water cooler is to make water available at a constant temp. Irrespective of ambient temp.

They are meant to produce cold water at about 7^0 C to 13 ^{0}C (280K to 286K) for quenching the thirst of the people working in hot environment.

The temp.of the cold water is controlled with the help of a thermostatic switch set with in 7^0 C to 13 ^{0}C range.

There are two types of water cooler.

3. Storage type water cooler
4. Instantaneous type water cooler

STORAGE TYPE WATER COOLER :

- The evaporator coil is soldered onto the wall of the storage tank of the cooler.
- The tank may be galvanized steel or stainless steel sheets. The water level in the tank is maintained by float valve.
- In this type of water cooler, the machine will run for a long period to bring down the temp. of the mass of the water in storage tank.
- When the water is drawn from the cooler and an equal amount of fresh water is allowed in the tank, the temp. will rise up slowly and the machine starts again.

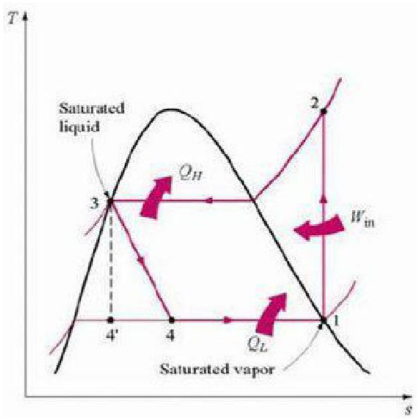
INSTANTANEOUS TYPE WATER COOLER:

- In this type of water cooler the evaporator consists of two separate cylindrical wound coil made up of copper or stainless steel tube.
- The evaporating refrigerant is in one of the coil and the water to be cooled is in the other coil.
- The water cooled by the refrigerant in evaporator by conduction.
- These water cooler are further classified as (a) Bottle type (b) Pressure type (c) Self contained remote type .

Temperature–entropy diagram

That results in a mixture of liquid and vapour at a lower temperature and pressure as shown at point 4. The cold liquid-vapour mixture then travels through the evaporator coil or tubes and is completely vaporized by cooling the warm air (from the space being refrigerated) being blown by a fan across the evaporator coil or tubes. The resulting refrigerant vapour returns to the compressor inlet at point 1 to complete the thermodynamic cycle.

The above discussion is based on the ideal vapour-compression refrigeration cycle, and does not take into account real-world effects like frictional pressure drop in the system, slight thermodynamic irreversibility during the compression of the refrigerant vapour, or non-ideal gas behavior (if any).



ure 1. T-S Diagram for the Ideal Vapor Compression Refrigeration Cycle

Where

P1=suction pressure

P2=discharge pressure

T1= temperature before entering to compressor

T2=temperature after exit from compressor

T3=temperature after condenser

T4=temperature after expansion valve

MR =rotameter reading (kg/min.)

S.NO	P1	P2	T1	T2	T3	T4	MR
1.							
2.							
3.							
4.							
5.							

Coefficient of performance: - The coefficient of performance is defined as the ratio of heat extracted in the evaporator to the work done on the refrigerant

C.O.P. = Q/W

Using points (P1,T1) ; (P2,T2) ;T3 and T4 locate points 1,2,3,4 on the p-h chart for R-22 and obtain the enthalpy values H1, H2, H3, H4

THEORETICAL C.O.P.= (**H1-H4)/(H2-H1)**

CONCLUSION: The C.O.P. of the system is…………….

Resources used (with major specifications)

Sl no.	Name of the apparatus	Specification	Quantity
01			
02			
03			
04			
05			
06			
07			

Actual procedure followed:

Precautions followed:

Observations:

Calculation:

Results:

Interpretation of results:

Conclusions and recommendations if any:

Practical related questions:

1. Are water coolers good for health?
2. Which gas is used in cooler?
3. What is COP formula?
4. Is a high COP good or bad?
5. How much water do cooler use?

Space for answer

EXPERIMENT NO : 07

AIM OF THE EXPERIMENT:

To determine the capacity and cop of Window Air Conditionier.

APPARATUS REQUIRED:

Sl No	Equipment	Specification	Quantity
01	Window A.C	1 Ton Cap.	1

THEORY :

COMPRESSOR:

The main function of compressor is to raise the pressure and temperature of tie refrigerant by the compression of the refrigerant vapor and then pump the condenser.

CONDENSER:

Condense the vapor refrigerant into the liquid by condenser fan passes it into the receiver tank for recirculation.

CAPILLARY TUBE:

It expends the liquid refrigerant at high pressure to the liquid refrigerant at low pressure so that a measured quantity of the liquid refrigerant is passed into the evaporator.

EVAPORATOR:

Evaporator the liquid refrigerant by absorbing the heat into vapor refrigerant and sends back in to the compressor.

VAPOUR COMPRESSION REFRIGERATION CYCLE:

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STANDARD VAPOUR COMPRESSION CYCLE (SVCC)

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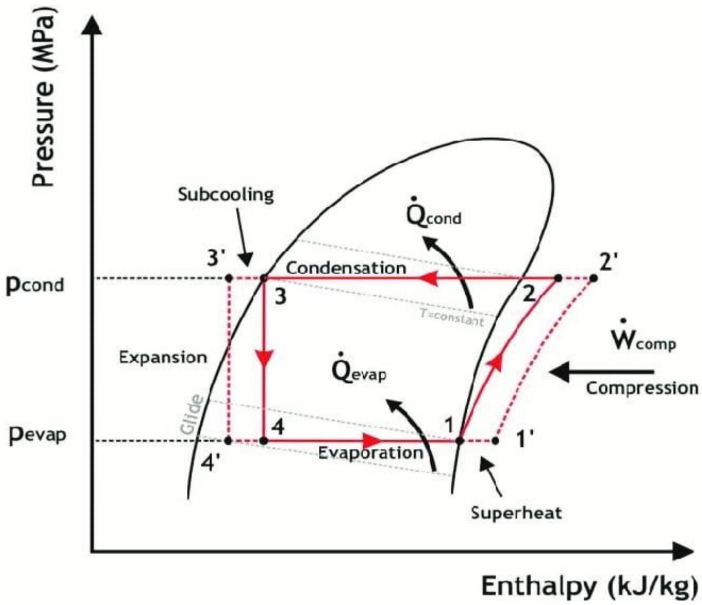
3. Reversible adiabatic compression from the saturation vapor to a super heated condition.

2. Reversible heat rejection at constant pressure (sub cooling liquid and condensation of

the refrigeration)

3. Irreversible is capillary tube expansion from saturated liquid to a low pressure vapor.

4. Reversible heat addition at constant pressure.



COEFFICENT OF PERFORMMENCE (C.O.P):

The coefficient of performance (C.0.P) of a refrigerating cycle is defined as the ratio between net refrigeration (output) and compressor work (input).

C.O.P = RE /CW

R.E = $H_1 - H_4$

CW = $H_2 - H_1$

COP = $H_1 - H_4 / H_2 - H_1$

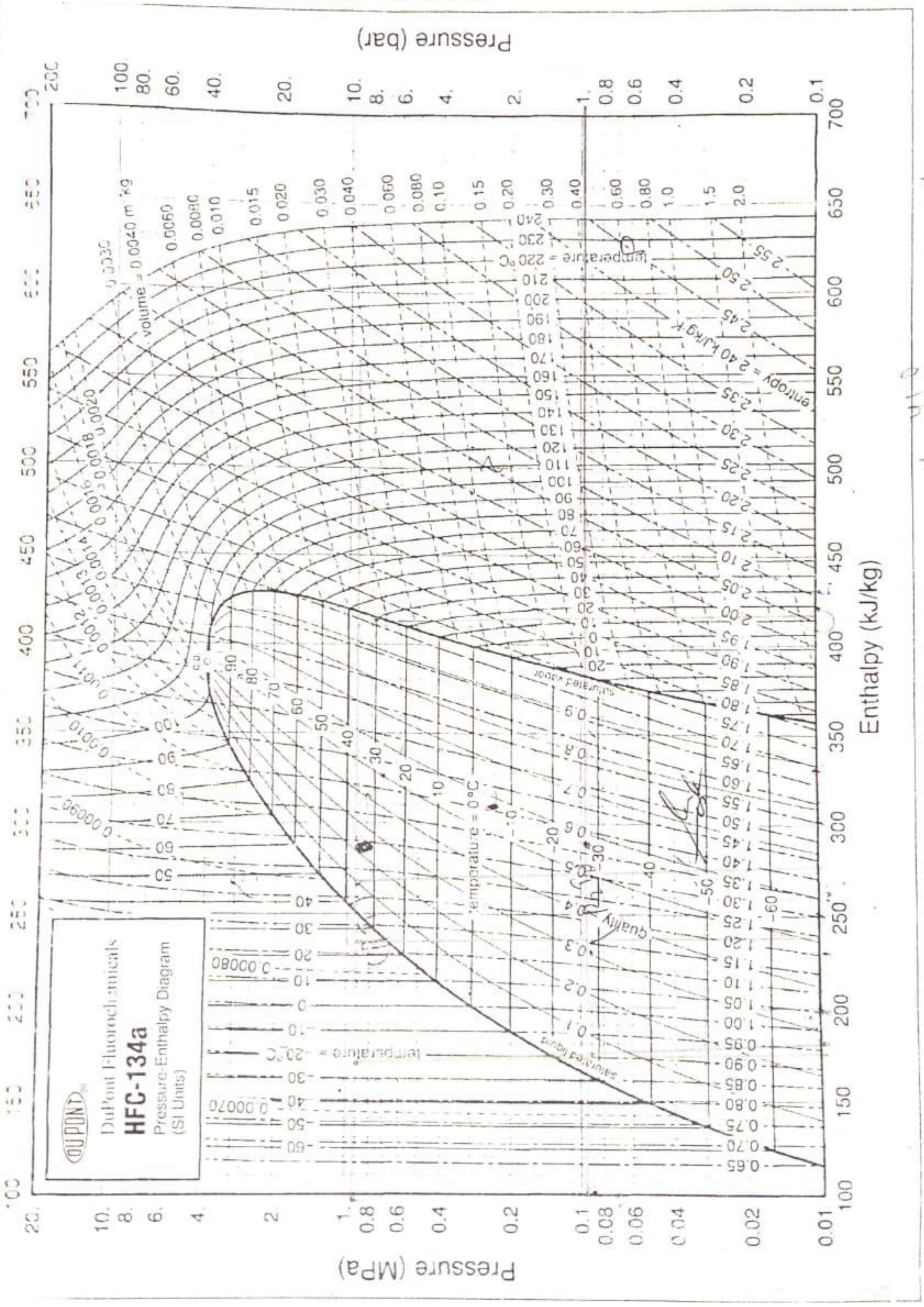
DESCRIPTION:

The air conditioning test rig unit is required to conduct experiments and demonstrate the process cooling of atmospheric air. The unit consists of a compressor. The compressor working fluid is R-134a. Both evaporator and the air cooled condenser are mounted on board with separate fans Air is sucked from the room and is supplied to the room after cooling. The system is provided with energy meter, voltmeter, ammeter. Rotameter and a digital temperature indicator. The unit will be fitted with alt instruments facilities so temperature and pressure can be measured.

UTILITIES REQUIRED:

1. Electricity Supply: Single Phase: 200 VAC, 50Hz. 5-15 Amp socket with earth connection.

Figure 7. Pressure-Enthalpy Diagram for HFC-134a (SI Units)



EXPERIMENTAL PROCEDURE:

1. Clean the apparatus and make it free from dust .

2. Ensure that all ON OFF switches given on the panel are at OFF position

3. Now switch ON the main compressor.

4. After the gap 10 or 15 minutes take the reading of pressure gauge, voltmeter, Ampere meter and T1, T2. T3, T4 , T5 and T6 by digital temperature indicator.

5. Calculate COP

OBSERVATION TABLE –

SL. NO.	P1(Kg/cm^2)	P2(Kg/cm^2)	T1(℃)	T2(℃)	T3(℃)	T4(℃)	T5(℃)

CALCULATIONS:

Mark points 1,2,3 using (P_1,T_1) ,(P_2,T_2), (P_3,T_3) respectively on P-h diagram for (R-22) read H_1,H_2 and H_3 (Where $H_3 = H_4$) to calculate theoretical COP

(COP) = $H_1 – H_4 / H_2 – H_1$

NOMENCLATURE:

H_1= Enthalpy at (P1,T1) kj/kg

H_2= Enthalpy at (P2,T2) kj/kg

H_3= Enthalpy at (P2,T3) kj/kg

H_4= Enthalpy at (P2,T4) kj/kg

P_1= Pressure at compressor suction,kg/cm^2

P_2= Pressure at compressor discharge,kg/cm^2

T_1= Compressor inlet temperature , °C

T_2= Compressor outlet temperature , °C , Condenser inlet temperature , °C ,

T_3= Condenser outlet temperature , °C ,

T_4= Evaporator inlet temperature , °C ,

T_5= Outlet temperature of air , °C ,

PRECAUTIONS AND MAINTENANCE INSTRUCTIONS:

1. Never run the apparatus if power supply is less than 180 volts and above 230 volts.

CONCLUSION :

The C.O.P of Window Air Conditioner is…………

Resources used (with major specifications)

Sl no.	Name of the apparatus	Specification	Quantity
01			
02			
03			
04			
05			
06			
07			

Actual procedure followed:

Precautions followed:

Observations:

Calculation:

Results:

Interpretation of results:

Conclusions and recommendations if any:

Practical related questions:

1. What is a common problem with window air conditioning units?
2. How does a window air conditioner work?
3. What is the life of a window AC?
4. Can you run a window AC all day?
5. Do window AC units use a lot of electricity?

Space for answer

EXPERIMENT NO : 08

AIM OF THE EXPERIMENT:

To determine the capacity and cop of split air conditioner

INTRODUCTION:

Air conditioning is the simultaneous control of the temperature, humidity, motion and purity of the atmosphere in a confined space. Air conditioning applies in the heating season as well as in the cooling season. The air conditioning has wide applications in submarine ships, aircrafts and rockets. Air conditioning is associated with the human comfort and controlling humidity ratio.

THEORY:

COMPRESSOR:

The main function of compressor is to raise the pressure and temperature of tie refrigerant by the compression of the refrigerant vapor and then pump the condenser.

CONDENSER:

Condense the vapor refrigerant into the liquid by condenser fan passes it into the receiver tank for recirculation.

CAPILLARY TUBE:

It expends the liquid refrigerant at high pressure to the liquid refrigerant at low pressure so that a measured quantity of the liquid refrigerant is passed into the evaporator.

EVAPORATOR:

Evaporator the liquid refrigerant by absorbing the heat into vapor refrigerant and sends back in to the compressor.

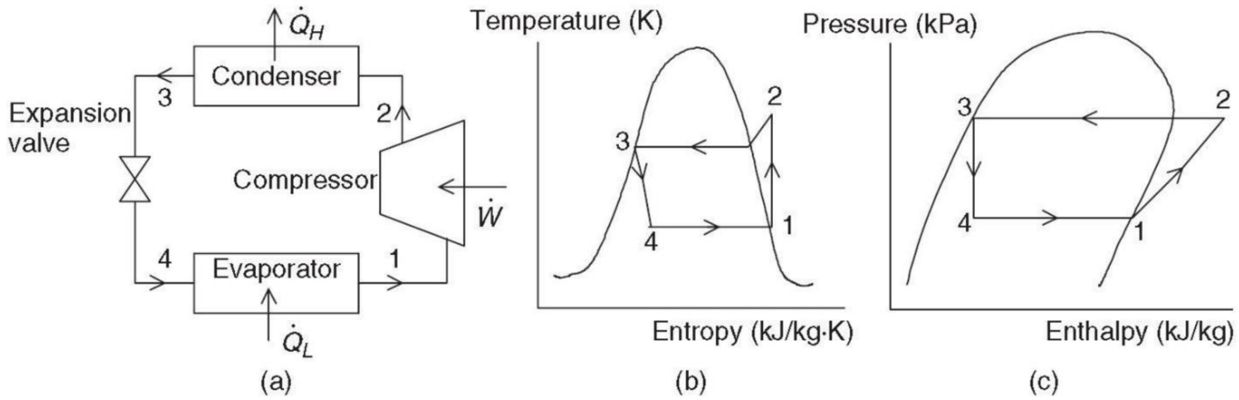
VAPOUR COMPRESSION REFRIGERATION CYCLE:

The refrigerant start at some initial state or condition passes through a series of processes in a definite sequence and return to the initial condition. This series of processes is called cycle.

STANDARD VAPOUR COMPRESSION CYCLE (SVCC)

The standard vapor compression cycle (SVCC) consists of the following processes:

4. Reversible adiabatic compression from the saturation vapor to a super heated condition.
2. Reversible heat rejection at constant pressure (sub cooling liquid and condensation of the refrigeration)
3. Irreversible is capillary tube expansion from saturated liquid to a low pressure vapor.
4. Reversible heat addition at constant pressure.



COEFFICENT OF PERFORMMENCE (C.O.P):

The coefficient of performance (C.0.P) of a refrigerating cycle is defined as the ratio between net refrigeration (output) and compressor work (input).

C.O.P = RE /CW

R.E = $H_1 - H_4$

CW = $H_2 - H_1$

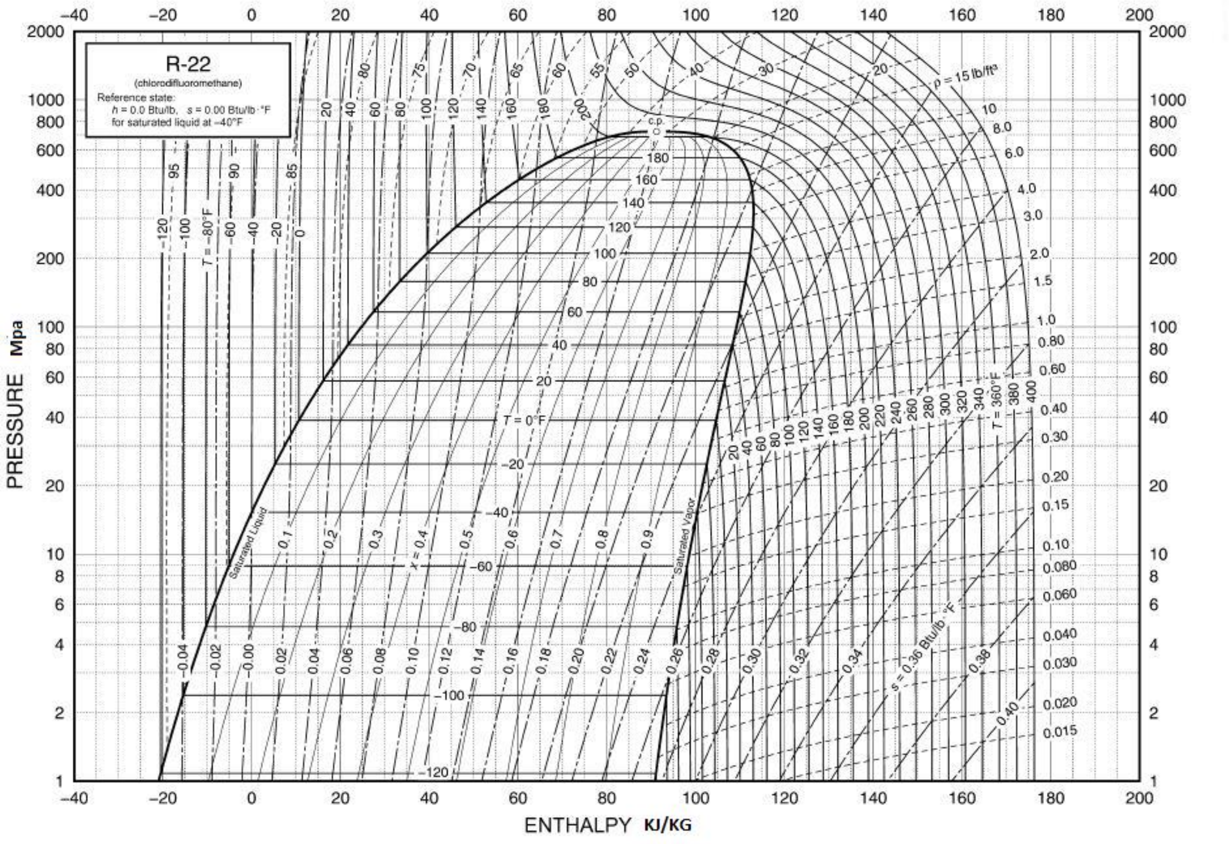
COP = $H_1 - H_4$ / $H_2 - H_1$

DESCRIPTION:

The air conditioning test rig unit is required to conduct experiments and demonstrate the process cooling of atmospheric air. The unit consists of a compressor. The compressor working fluid is R-22. Both evaporator and the air cooled condenser are mounted on board with separate fans Air is sucked from the room and is supplied to the room after cooling. The system is provided with energy meter, voltmeter, ammeter. Rotameter and a digital temperature indicator. The unit will be fitted with alt instruments facilities so temperature and pressure can be measured.

UTILITIES REQURIED:

1.Electricity Supply: Single Phase: 200 VAC, 50Hz. 5-15 Amp socket with earth connection.



Pressure-Enthalpy Diagram for Refrigerant 22

EXPERIMENTAL PROCEDURE:

1. Clean the apparatus and make it free from dust .

2. Ensure that all ON OFF switches given on the panel are at OFF position

3. Now switch ON the main compressor.

4. After the gap 10 or 15 minutes take the reading of pressure gauge, voltmeter, Ampere meter and T1, T2. T3, T4 , T5 and T6 by digital temperature indicator.

5. Calculate COP

OBSERVATION TABLE –

SL. NO.	P1(Kg/cm^2)	P2(Kg/cm^2)	T1(℃)	T2(℃)	T3(℃)	T4(℃)	T5(℃)

CALCULATIONS:

Mark points 1,2,3 using (P_1,T_1) ,(P_2,T_2), (P_3,T_3) respectively on P-h diagram for (R-22) read H_1,H_2 and H_3 (Where $H_3 = H_4$) to calculate theoretical COP

(COP) = $H_1 – H_4 / H_2 – H_1$

NOMENCLATURE:

H_1= Enthalpy at (P1,T1) kj/kg

H_2= Enthalpy at (P2,T2) kj/kg

H_3= Enthalpy at (P2,T3) kj/kg

H_4= Enthalpy at (P2,T4) kj/kg

P_1= Pressure at compressor suction,kg/cm^2

P_2= Pressure at compressor discharge,kg/cm^2

T_1= Compressor inlet temperature , °C

T_2= Compressor outlet temperature , °C , Condenser inlet temperature , °C ,

T_3= Condenser outlet temperature , °C ,

T_4= Evaporator inlet temperature , °C ,

T_5= Outlet temperature of air , °C ,

PRECAUTIONS AND MAINTENANCE INSTRUCTIONS:

1. Never run the apparatus if power supply is less than 180 volts and above 230 volts.

CONCLUSION :

The C.O.P of Split Air Conditioner is…………

Resources used (with major specifications)

Sl no.	Name of the apparatus	Specification	Quantity
01			
02			
03			
04			
05			
06			
07			

Actual procedure followed:

Precautions followed:

Observations:

Calculation:

Results:

Interpretation of results:

Conclusions and recommendations if any:

Practical related questions:

1. Which gas is used in split AC?
2. What is a split air conditioning system?
3. How long does split AC gas last?
4. What are the parts of a split system air conditioner?
5. Which split AC consumes less electricity?

Space for answer

EXPERIMENT NO : 09

AIM OF THE EXPERIMENT:

To study and performance experiment on vapour absorption system.

THEORY:

The vapour absorption refrigeration system is one of the oldest method of producing refrigerating effect. The principle of vapour absorption was first discovered by Michael Faraday in 1824 while performing a set of experiments to liquefy certain gases. A french scientist Ferdinand carre developed the first vapour absorption refrigeration machine in 1860. This system may be used in both the domestic and large industrial refrigerating plants. The refrigerant, commonly used in a vapour absorption system, is ammonia.

The vapour absorption system uses heat energy, instead of mechanical energy as in vapour compression systems, in order to change the conditions of the refrigerant required for the operation of the refrigeration cycle.

In the vapour absorption system, an absorber, a pump, a generator and a pressure-reducing valve replace the compressor. These components in vapour absorption system perform the same function as that of a compressor in vapour compression system. In this system, the vapour refrigerant from the evaporator is drawn into an absorber where it is absorbed by the week solution of the refrigerant forming a strong solution. This strong solution is pumped to the generator where it is heated by some external source. During the heating process, the vapour refrigerant is driven off by the solution and enters into the condenser where it is liquefied. The liquid refrigerant then flows into the evaporator and thus the cycle is completed.

WORKING:

- The Ammonia is used as a refrigerant because it possesses most of the desirable properties.It is toxic, but due to absence of moving parts, three are very little changer for the leakage for the total amount of refrigeration used is small.
- The Hydrogen being the lightest gas is used to increase the rate of evaporation of the liquid Ammonia passing through the evaporator. The Hydrogen is also non-corrosive and insoluble in water. This is used in the low-pressure side of the system.
- The water is used as a solvent because it has the ability to absorb ammonia readily.

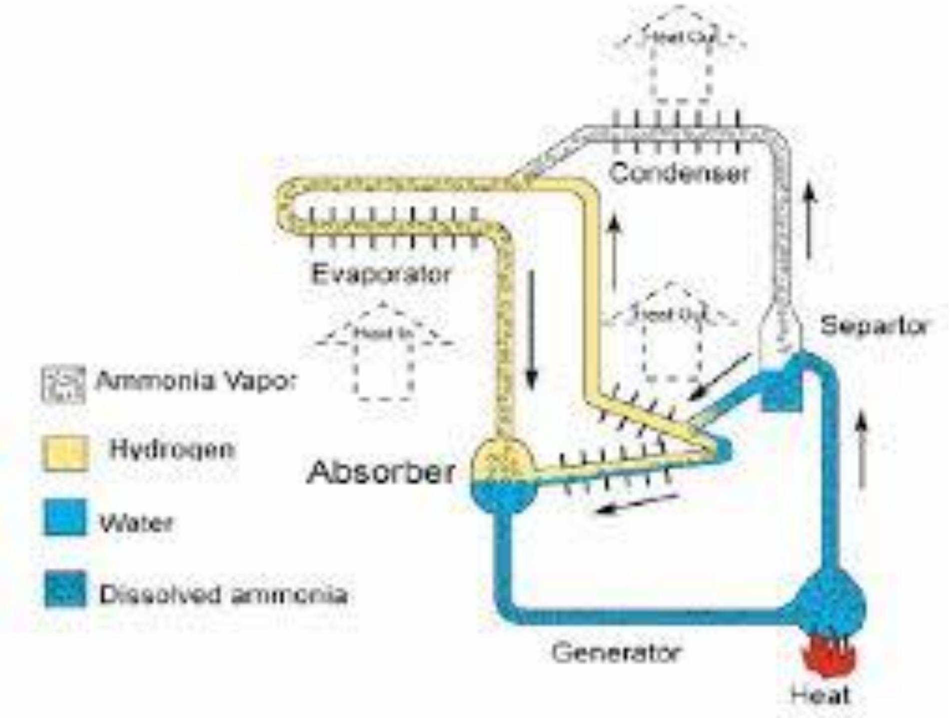
The strong ammonia solution from the absorber through heat exchanger is heated in the generator by applying heat. During this heating process, ammonia vapour are removed from the solution and passed to the condenser. A rectifier or a water separator fitted before the condenser removed water vapour carried with the ammonia vapour, so that dry ammonia vapour are supplied to the condenser. These water vapour, if not removed, they will enter into the evaporator causing freezing and choking of the machine. The hot weak solution while passing through the exchanger is cooled. The heat removed by the weak solution is utilized in raising the temperature of strong solution passing through the heat exchanger, in this way, the absorption is accelerated and the improvement in the performance of a plant is achieved.

The ammonia vapour in the condenser is condensed by using external cooling source. The liquid refrigerant leaving the condenser flows under gravity to the evaporator where it meets the Hydrogen gas. The Hydro gas which is being fed to the evaporator permits the liquid ammonia evaporate at a low pressure and temperature according to DALTON'S Principal. During the process of evaporation, the ammonia absorbs latent heat from the refrigerated space and thus produces cooling effect

The mixture of Ammonia vapour and Hydrogen is passed to the absorber where ammonia is absorbed in water while the hydrogen rises the top and flows back to the evaporator,

THE MAIN DISADVANTAGE OF ELECTROLUX REFRIGERATOR IS:

- It cannot be used for Industrial purpose as the COP of the system is very low.



SCHEMATIC DIAGRAM OF VAPOUR ABSORPTION REFRIGERATION SYSTEM

PROCEDURE:

1. Switch on the main supply.
2. Take the initial reading of energy meter.
3. Take readings in Temperature Indicators (i.e. T1, T2 andT3).
4. When steady state is reached, take this reading for calculation and find the COP.

OBSERVATION TABLE:

Sl. No.	T1	T2	T3

CALCULATION:

COP =T3(T1-T2) / T1(T2-T3)

TECHNICAL SPECIFICATION: -

- Refrigerator : 40 Litters
- Temp. Range : 0°C -8°C
- Cooling Medium : Ammonia, Helium (Hydrogen), Water
- Heating : Eternally Heated by Electric Resistance
- Evaporator : Coil Type Evaporator
- Voltage Input : 65 watts
- Power Supply : Single Phase 220-240V AC/50 Hz.
- Control Panel : Consists of:
  a) Digital Voltmeter
  b) Digital Ammeter
  c) Energy meter
  d) Digital Temp. Indicator with Selector Switch
  e) Temperature Sensor -- 4 No.(PT-100 type)

SPECIAL FEATURES: -

- Super Silent Operation
- Auto Defrost
- Interior Lamp
- Fully Adjustable Shelves
- CFC Free Ammonia Refrigerant

TEMPERATURE SENSOR DETAILS: -

- T_1 = Temperature of generator
- T_2 = Temperature of condenser
- T_3 = Temperature of evaporator

PRECAUTION & MAINTENANCE INSTRUCTIONS:

1. Always keep apparatus free from dust.
2. Wipe the inner and outer surface of the refrigerator and its accessories with wet cloth. Wipe off with dry, clean cloth.
3. For cleaning, do not use hot water, petrol, alcohol, kerosene etc.
4. Never directly spray the fridge with water.
5. The sealing rubber bars of the doors should always be cleaned, but due care should be taken so as no to damage the same.

TROUBLESHOOTING:

1. The Refrigerator does not work:-
    - Check if there is a power failure.
    - Check if the plug is placed correctly in the outlet.
2. The Refrigerator is cooling excessively:-
    - Check if the temperature control dial is set too high.
3. The Refrigerator is not cooling sufficiently:-
    - Something hot is placed in the refrigerator.
    - The door might not have been closed properly.
    - The door gasket might be damaged.
    - The refrigerator may not be properly ventilated.
    - The temperature control dial may not be set properly.
4. The back of refrigerator is getting very hot :-
    - This is normal when the fridge is cooling, especially if it is very hot where the fridge is placed

CONCLUSION :

The C.O.P of Vapour Absorption system is…………

Resources used (with major specifications)

Sl no.	Name of the apparatus	Specification	Quantity
01			
02			
03			
04			
05			
06			
07			

Actual procedure followed:

Precautions followed:

Observations:

Calculation:

Results:

Interpretation of results:

Conclusions and recommendations if any:

Practical related questions:

1. What is the function of water in this system ?
2. What is the function of the hydrogen in this system?
3. What is the function of the generator in this system?
4. What is the function of the rectifier/dehydrator in the system?
5. Is there is compressor is present in this type of system?

Space for answer

:

EXPERIMENT NO : 10

AIM OF THE EXPERIMENT:

Charging of a domestic refrigerator and its leak test.

THEORY:

Domestic refrigerators and freezers operate with very small refrigerant charges, and the charge must be administered accurately. This can be best achieved by using a visual charging cylinder, sometimes called a dial-a-charge (Figure 64).

This is basically a small refrigerant cylinder with a liquid-indicating sight glass or tube. In front of the sight glass and surrounding the cylinder and sight glass is a rotating screen upon which are graduated scales for the common refrigerants, RI2, R22 and R502. Above the refrigerant scales is a temperature range.

Fitted to the top of the cylinder assembly are a pressure gauge; a purging valve, which is normally a Schraeder type; and, if a heater is incorporated, a pressure relief valve for the cylinder protection. At the base of the cylinder is a charging valve and hose connection.

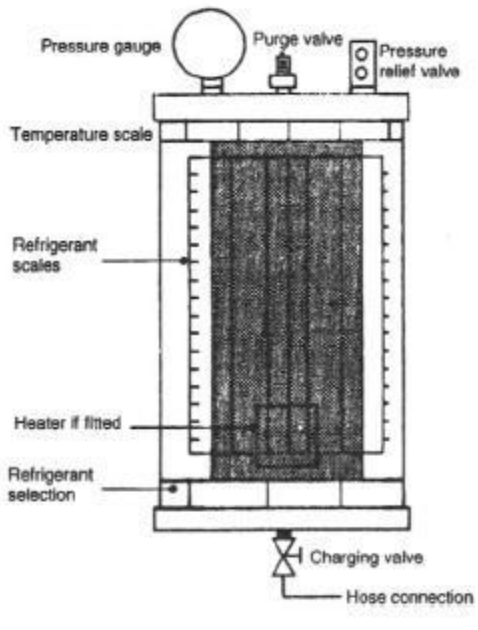


Figure 64 *Visual charging cylinder*

Visual charging cylinder

Filling the cylinder

1. Obtain a service cylinder of the correct refrigerant. Connect it to the visual charger with a suitable hose.
2. Open the valve on the service cylinder and invert the cylinder.
3. Slacken the hose connection at the charging valve to purge air from the hose. Tighten the hose connection.
4. Open the charging valve to allow refrigerant liquid to flow by gravity into the cylinder. Observe the sight glass: when liquid flow ceases, depress the purge valve and gently vent off a small amount of refrigerant vapour. When a pressure difference between the charging cylinder and the service cylinder is created, the liquid will begin to flow again. Repeat this operation until the required amount of refrigerant is in charging cylinder.
5. Close the valves on both the visual charger and the service cylinder.
6. Disconnect the service cylinder.

Charging the system

1. Assuming a line tap valve has been installed and the system evacuated, connect the hose to the charging valve and the line tap valve.
2. Open the charging valve and slacken off the hose connection to purge air from the hose. Close the valve.
3. Note the ambient temperature. Rotate the screen until the required refrigerant scale lines up with the ambient temperature on the temperature scale.
4. Note the level of the refrigerant in the sight glass.
5. Open the line tap valve fully and slowly meter the prescribed amount of refrigerant into the system. If the visual charger has a heater this can be energized before opening the line tap valve to create a pressure difference between the charging cylinder and the system.
6. When the charge has been administered as indicated by the sight glass, close the charging valve.
7. Allow a few minutes for the liquid in the hose to vaporize and the system pressure to equalize. Then close the line tap valve.
8. Disconnect the visual charger and leak test the system.

Refrigerants Handling Safety Precautions

Although the common refrigerants (RI2, R22, R502 etc.) are not considered hazardous, it must be remembered that all refrigerants are heavier than air and will replace air in a confined space very quickly. This can be dangerous; if the air does not contain at least 19 per cent oxygen, loss of consciousness may result.

When testing for leaks, always ensure that the area is well ventilated if at all possible. Always stand to one side of the detector in case there is a sudden violent discharge from the suspected pipework.

The following precautions should be taken:
1. Wear goggles, gloves and overalls at all times to protect eyes and to prevent direct contact of refrigerant with the skin, which can cause burns. This applies especially when charging or discharging refrigerant.
2. Make sure that the service cylinder is not overfilled.
3. Do not expose cylinders to direct sunlight, radiated heat or connected heat from appliances.
4. Avoid discharge near naked flames or flame producing appliances.
5. Avoid direct contact with refrigerant/oil solutions from hermetic systems (motor burn-out), which can be very acidic.

6. Always vapour charge a system from the low side to avoid possible damage to compressor valves.
7. Always check that the refrigerant is correct for the system being charged.
8. Whenever possible ensure that the working area is well ventilated. If ammonia is being used, ensure that a respirator or some form of breathing apparatus is at hand.

Refrigerants Handling Safety Precautions

Although the common refrigerants (RI2, R22, R502 etc.) are not considered hazardous, it must be remembered that all refrigerants are heavier than air and will replace air in a confined space very quickly. This can be dangerous; if the air does not contain at least 19 per cent oxygen, loss of consciousness may result.

When testing for leaks, always ensure that the area is well ventilated if at all possible. Always stand to one side of the detector in case there is a sudden violent discharge from the suspected pipework.

The following precautions should be taken:
1. Wear goggles, gloves and overalls at all times to protect eyes and to prevent direct contact of refrigerant with the skin, which can cause burns. This applies especially when charging or discharging refrigerant.
2. Make sure that the service cylinder is not overfilled.
3. Do not expose cylinders to direct sunlight, radiated heat or convected heat from appliances.
4. Avoid discharge near naked flames or flame producing appliances.
5. Avoid direct contact with refrigerant/oil solutions from hermetic systems (motor burn-out), which can be very acidic.
6. Always vapour charge a system from the low side to avoid possible damage to compressor valves.
7. Always check that the refrigerant is correct for the system being charged.
8. Whenever possible ensure that the working area is well ventilated. If ammonia is being used, ensure that a respirator or some form of breathing apparatus is at hand.

Refrigerant Pressure Leak Testing

This is carried out on new system installations or when a plant has been discharged of refrigerant prior to repair. It involves the use of oxygen-free nitrogen (OFN) which is a high pressure gas. This is used to obtain a higher pressure than that of the refrigerant in normal ambient temperatures. This pressure should be controlled and in excess of that under which the system is expected to operate with a normal operating charge of refrigerant. This could be as high as 500 psig (33 bar) in some instances.

Sometimes it is the practice to test the system pipework only in this manner before connecting to the condensing unit. If the condensing unit is new it would have already undergone very stringent tests to pressure vessel standards by the manufacturer.

When an installation is completed and a pressure test is to be carried out it is most important to ensure that the compressor is isolated, irrespective of design, before pressurising the system. The suction service valve should be front seated to avoid any damage to the compressor valves. This will also prevent rupture of the crankshaft seals in open type and semi-hermetic motor compressors.

All pressure controls must be **disconnected or by-passed**. If the expansion valve is not capable of withstanding the test pressure then it too must be removed or by-passed. The bellows or diaphragm of an expansion valve has a maximum operating pressure which must not be exceeded.

The OFN cylinder must be fitted with an **approved regulator** to control the test pressure. For safety reasons a pressure relief valve preset to the test pressure is recommended.
When the system is pressurized, that pressure should be recorded and the plant left for a reasonable period. Just how long that period should be is debatable. It could take a considerable time for a noticeable drop in the nitrogen pressure to become evident when a system has a small leak. The time allocated by some installers and service outlets varies, and with large installations periods of days under pressure is not uncommon.

With the time element being an important factor a ‘bubble test’ may be permissible but this is not accepted by all suppliers of refrigerants.

British Standard 4434 1995 states that only an inert gas may be used for pressure testing. R22 or any other refrigerant is not to be used as a ‘trace’ pressure test. The ‘trace’ is no longer regarded as good practice. (For reference, the trace method of leak detection involved charging a system with a small amount of its operating refrigerant and boosting the pressure within the system with nitrogen. The leak could then be detected using a halide torch. Another method of leak detection is to draw a vacuum on the complete system but again the waiting period will be necessary to see if the vacuum is held. The disadvantage of drawing a vaccum would be the ingress of air which contains moisture if a slight leak were to break the vacuum.

Refrigerant Leak Detection Test Pressures Methods

During normal service operations a leak test does not entail a prior evacuation of the system unless the system is contaminated or the refrigerant has been completely discharged. It is essential however, that a minimum of 30 psig (pounds per square inch gauge) or 2 bar exists in the system when testing for leaks. If no leaks are found then the system should be tested again at operating pressures.

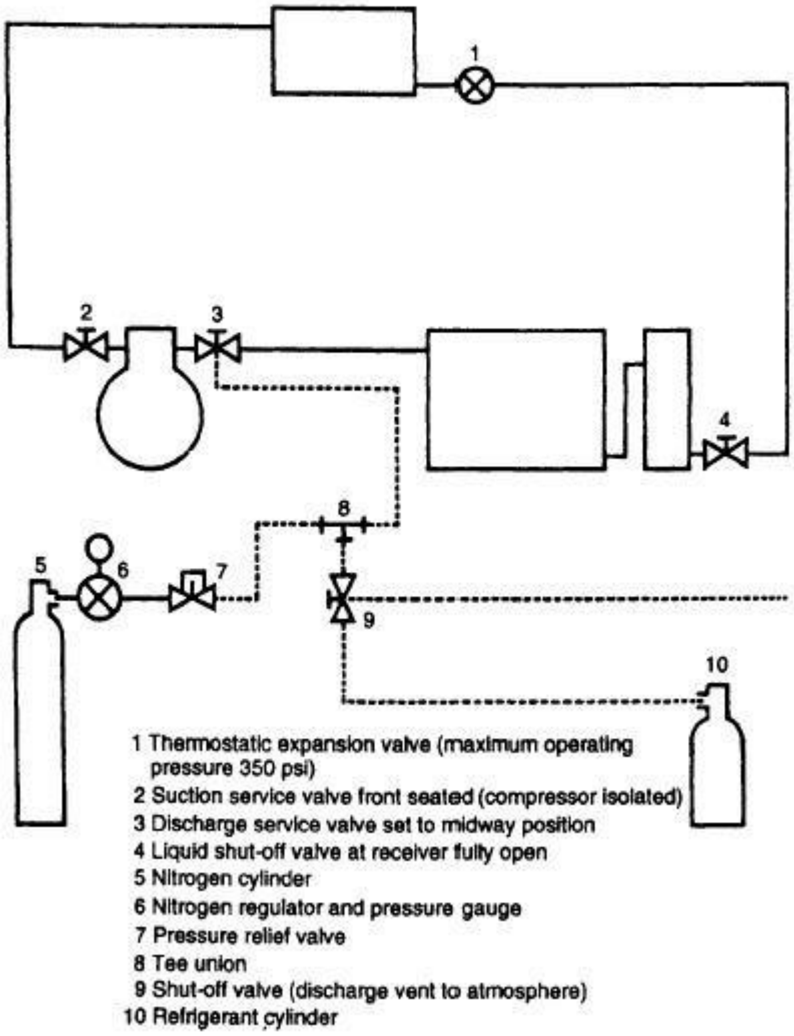
Methods of testing

Bubble test

The most common and inexpensive test is the bubble test. A water/soap solution is simply brushed around a joint or component which is suspected of leaking, or sprayed on with an aerosol. It is recommended that proprietary rather than made-up solutions are used, as they are more viscous and the bubbles are stronger and longer lasting. Ordinary soap bubbles are weaker and are normally short lived.
The disadvantage of this method is that a large leak can blow through the solution and then no bubbles will appear, although in most such cases the leak will be audible.

Halide torch

This consists of a small burner assembly mounted on top of a container of gas, for example propane. The burner comprises a hand valve and a venturi or mixing chamber with an attachment for the exploring tube. Above the orifice of the burner there is a copper ring, a strip or a tube through which the flame passes when the torch is ignited.
When the torch is lit the air will be drawn into the venturi via the exploring tube, and the flame will burn slightly blue or colourless. When a trace of halogen refrigerant (Rll, R12, R22, R500, R502 etc.) mixes with the air, the flame will immediately change colour as the refrigerant vapour contacts the hot copper ring or tube. The colour will range from green for a small leak to dark blue or purple for a large leak. When the refrigerant bums off, a toxic atmosphere will be created. To test for leaks the exploring tube is passed around the suspected area slowly, and for effectiveness the plant should be stopped.



Typical test arrangement for leak testing at 300 psi

CONCLUSION :

We successfully studied about charging of a domestic refrigerator and its leak test

Resources used (with major specifications)

Sl no.	Name of the apparatus	Specification	Quantity
01			
02			
03			
04			
05			
06			
07			

Actual procedure followed:

Precautions followed:

Observations:

Calculation:

Results:

Interpretation of results:

Conclusions and recommendations if any:

Practical related questions:

1. How do you charge a domestic refrigerator?
2. What controls the refrigerant flow in a domestic refrigerator?
3. When charging a refrigeration system it should be done?
4. Which fluid is used in leak test?
5. What are the two most common leak detections?
6. How do you perform a leakage test?

Space for answer