DEPARTMENT OF MECHANICAL ENGINEERING

LAB MANUAL

SUBJECT: REFRIGERATION & AIR CONDITIONING

B.TECH- 7th Semester BRANCH: - ME

KCT COLLEGE OF ENGG & TECH, FATEHGARH

Punjab Technical University

SR. NO.	NAME OF EXPERIMENTS
1	Study & Performance of Domestic Refrigerator
2	Study & Performance of ElectroLUX Refrigerator
3	Study & Performance of Window Type Air Conditioner
4	Calculation/Estimation of Cooling Load for a Large Building
5	Visit to a Central Air Conditioning Plant for study of process for Winter & Summer Air Conditioning
6.	Study of Various Elements of Mechanical Refrigerator System through Cut Section Models/ Actual Apparatus

Experiment No 1

AIM: Study and performance of domestic refrigerator.

APPARATUS: Refrigerator test rig. (Vapour compression cycle)

THEORY:

The refrigerator cycle in vapours forms finds application in countless industrial and domestic situations through out the world. For examples, the storage and transport of perishable food stuffs and drugs would be extremely difficult if not impossible without refrigeration's. Similarly the efficient operations of offices and factories in many part s of the world would be impossible without the use of refrigeration plants in air conditioning.

It is for this reason that engineers of many disciplines must have a good working knowledge of the refrigeration's cycle .a refrigerator is defined as a machine whose prime function is to remove heat from a low temperature region. Since the energy extracted cannot be destroyed, if follows that this energy required to operate the machine, must be rejected to the surrounding at a higher temperature, if the temperature of the rejections is high enough to be useful and this is the prime object of the machine, then the machine is called a HEAT PUMP.

The clausius statement of the second law of the thermodynamics states that heat will not pass from a cold to a hotter region without an "external agency" being employed. This external agency may be applied in the form of high-grade energy input of either "work" or a high-grade heat input. The high-grade heat input may take the form of either high temperature combustion products, electrical energy (in the form of heat) or solar energy.

The most common type of refrigerator or heat pump operates on the compression cycle and requires a work input. The vapour compression refrigeration test rig has been designed to enables students to safety study in the cycle in details. The test rig requires 220v ac,50c/s supply and fresh water supply connections.

REFRIGERANT USED - R12

REFRIGERATION RATE - 1400w maximum, but varies with the evaporating.

CONDENSATING TEMP. - 50° MAXIMUM

EVAPORATING TEMP. - -20°C TO +10°C. Variable by adjustment of load and cooling water temp.

COMPRESSOR - hermetically sealed 314l kirloskar

CONDENSER - shell and coil type

EVAPORATOR - compact once through concentric tube with refrigeration load supplied by separate concentric heating elements

EXPANSION VALVE - automatic expansion valve with two bypass capillary circuits.

THERMODYNAMIC ASPECTS OF REFRIGERATIONS:

The second law of thermodynamic includes the statements," it is impossible to transfer heat from a region at a low temperature to another at a higher temperature without the aid of an external agency".

Refrigerator and heat pumps are examples of machines, which transfer heat from a low to a high temperature region, and the "external agency" employed, may be either work or high-grade heat.

The first law of thermodynamics states in a cycle the net heat transfer is equal to the network transfer. Thus for a refrigerator, heat transfer at low temperature + heat transfer at high temperature = work done.

In the case of the refrigerator (or heat pump) using a work input, it follows that heat transfer at low temperature + work input = heat transfer at high temperature .if the external agency is high grade heat, the heat transfer at low temperature + heat transfer at high temperatures = 0

- A machine whose prime function is to remove heat from a low temperature region is called the refrigerator.
- A machine whose prime function is to deliver heat from a high temperature region is called the heat pump. From the first law of thermodynamics, it is apparent that a refrigerator must reject heat at a higher temperature and the heat pump must take in heat at a lower temperature. Thus, there is very little difference between the two plants, and both useful affects can be obtained from the same unit.
- COP:

$$= \frac{\text{Refrigerating effect}}{\text{Work done}}$$

REFRIGERATION LOAD: This is determined by the input to the electric heating element in the evaporator and is controlled by the heat input control setting. The product of the voltmeter and ammeter reading gives the evaporator heat input rate.

CONDENSER PRESSURE: The cooling water flow rate and its inlet temperature controls condensor motor. Reduce the cooling water flow rate to increase the condenser pressure.

ELECTRIC INPUT: the voltmeter and ammeter indicates the input to the compressor motor. The electric power input is in the products of volts, amps, and the power factor applicable (0.8).

TEMPERATURE INDICATORS: the temperature may be measured at six points in the circuit by selecting station 1-6 and the appropriate temperature scale.

PROCEDURE:

1) Ensure that the operation of the plant is clearly understood.
2) Start the unit and adjust the evaporator heat input control and, to set the evaporating pressure adjust the condensor cooling water to give the required condensor pressure and hence saturation temperatures.
3) For performance curves start with a small duty, say 250w and increase this in increments of about 259w until the maximum duty is reached. The unit will respond quickly after the load change and stablise within 15 minutes, although it may take a little longer at light loads. Stability is reached when changes in pressure temperature, flow, etc have ceased.
4) Reduce the refrigerator load. Switch off mains switch and turnoff the cooling water.
5) The unit should be started and allowed to stabiles with a refrigeration load of about 250w.
6) In the evaporator, the pressure and temperature are high and the heat has been a heat input from the electric heating element.
7) In the condenser, the pressure and temperature are high and the heat has been given up to the cooling water, which has been given up to the cooling water, which has become warmer.
8) The compressor increases both the pressure and temperature and that the compressor requires a work input to-do this.
9) Both the pressure and temperature fall across the expansion valve and that no work transfer involved.

PRECAUTIONS:

1) Do not touch the compressor or the pipelines, which may be hot or cold.
2) Final readings be recorded after steady conditions have reached say after running for at least 30 minutes at a particular setting of water flow rate and heater evaporator load.
3) Ensures that water is continuously flowing through the condenser under all conditions of compressor working.
4) The flow of water should not be permitted to fall below 1lpm.

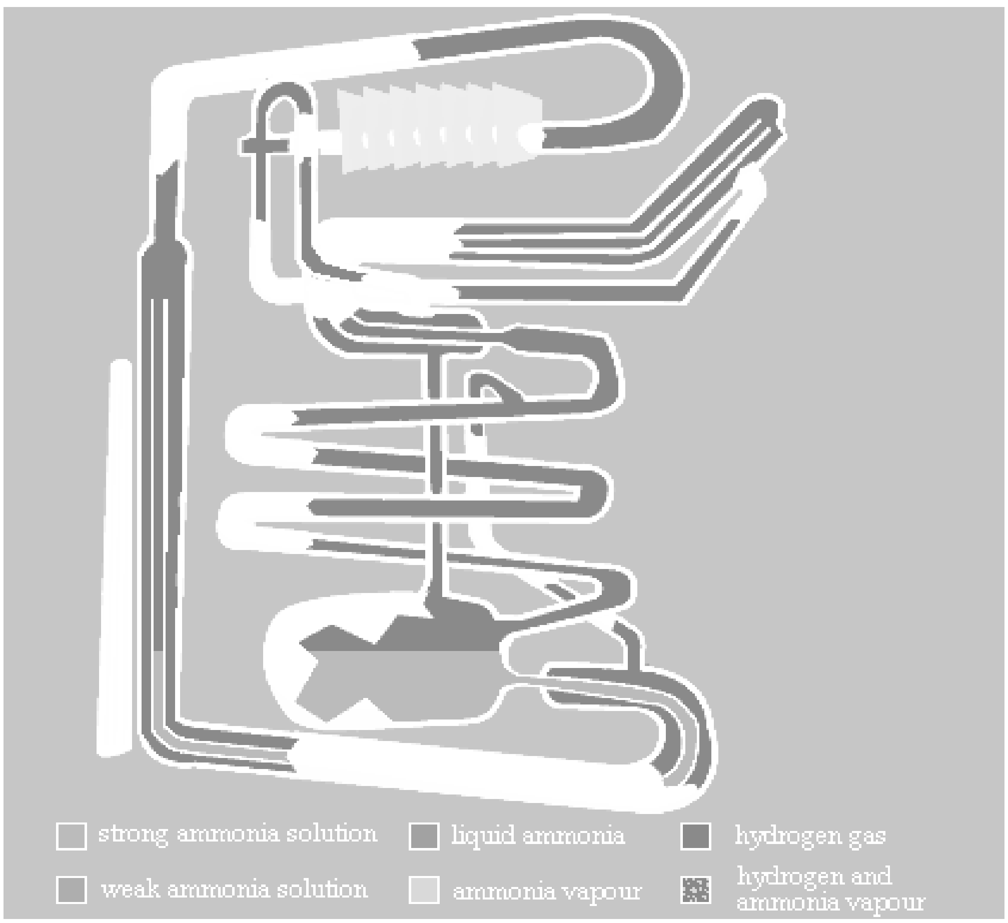
5) High pressure and low pressure cut out set to shut off all electrical supplies to motor and evaporator heaters if condenser pressure exceeds 1400 KN-M2.

Reduce the refrigeration load (evaporator heat input control) switch off mains switch and turn off the cooling water.

Experiment No 2

Aim: Study the performance of Electro-Lux-Refrigrator.

Theory: This type of refrigerator is generally used for domestic purposes as it is more complicated in its instructions and work. This type of refrigerator was developed first in 1925 by Munters and Boltzervon when they were at Royal Institute of Technology. This type of refrigerator is known as three fluids absorptions system.



The elimination of aqua pump from the absorption machine would produce a system with a complete absence of moving parts and working input .the main purpose to eliminate the pump is to make the machine noiseless. It use a refrigerant , a solvent and an inert gas for working of system .

This inert gas is confined to low side of the system only by this absence. It is possible to maintain the uniform pressure throughout the system and at the same time permitting the refrigerant to evaporate at low temperature. Corresponding to its partial pressure. In high pressure side of the system, there exists only the refrigerant which is subjected to total pressure of the system so that it is condensed by using the normal cooling the water or air as it is done in other system.n low system side of system, the total pressure is the sum of partial pressure of ammonia vapor and the partial pressure of hydrogen which is used as inert gas. The liquid ammonia which comes into the evaporator evaporates at the partial pressure of ammonia.

WORKING: The strong aqua ammonia solution is heated in generator by the application of external heat source and NH_3 vapor is removed from the solution the water vapor caused with the NH_3 vapor is passed in the condenser and it is condensed by using the external cooling of source. The liquid NH_3 from under gravity to evaporator and it is evaporated in the presence of hydrogen atmosphere absorbing the heat from the evaporator and it maintain low temperature in the evaporator. This mixture of hydrogen and ammonia vapor is passed into the absorber and the work solution of the aqua ammonia solution comes in contact with the hydrogen and ammonia vapor and it absorb only ammonia, making the solution rich in ammonia and hydrogen is separated as shown in fig this strong solution is further passed to the generator and it completes the cycle.

There is pump to create the pressure differential between condenser and evaporator or not as expansion value. The evaporator side is changed with H_2 so that total pressure is same as that of condenser side.The cycle operates on the principle of Dalton's law where pr.(NH_3)+pr.(H_2)=Constant ,so that the total pressure is same throughout the system. Due to the presence of H_2 in the low side of the system, pressure of NH_3 will be below that of NH_3 on the condenser side. Thus the NH_3 can evaporate at low pressure while H_2 takes no parts in the process except to supply its partial pressure to maintain the balance.H_2 is prevented entering into the condenser side by strong solutions forming a trap absorber and liquid Nh3. U-trap at the condenser outlet. The H_2 returns to the evaporator having no affinity for the absorbent. The H_2 is held in this position by the U tube.

Due to the small pressure difference in this system, solution is circulated through absorber and generator by the thermal action. The parts are so arranged that the liquid refrigerant flow to the evaporator by the gravity action only. Core is taken to keep the hydrogen isolated in the proper parts of the system. Otherwise the pressure will be unbalanced and machine will stop.

The liquid NH_3 also evaporates in the presence of air or other inert gases, but lightest the gas, the faster .The evaporation takes place, since H_2 is the light gas and readily available and is also non-corrosive and in insoluble in water, it is generally used for this type of refrigeration system.

Experiment no 3

AIM: Study and performance of Window Air-Conditioner

Theory:

Air condition is defined as simultaneous control over the air, regarding its temperature, humidity, motion and purity. Window type room air conditioner is used to condition the air of a particular space. Such as office room, bedroom of a house, drawing office, room etc. it cools the air and sometimes dehumidifies it. It operates automatically once it is put into operation.

Charge the refrigerant in Air-conditioner through the charging pipe of compressor with Suction Pressure 70 to 75psi and discharge pressure 250 to 270 psi. The compressor compresses the refrigerant with high pressure and high temperature to send it through discharge pipe to condenser, which the temperature of refrigerant to convert into liquid form.

High pressure liquid flow through filter and capillary to evaporator when liquid enters after capillary the refrigerant expands and change liquid to vapor by air of room, when room air through heat transfer to its evaporator becomes cool and flows in room by the grille. The vapor goes back to compressor and is again compressed. The refrigerant cycle continues the fan motor fitted in the centre of air conditioner with one side fitted with propeller type fan blade (condenser side) and one side blower of evaporator 9 room side). The air through fan condenses the refrigerant. The room air passes over evaporator and become cool and flow the cool air through grille louvers.

Specifications

a)	Fan Capacity	:	177lps
b)	Compressor	:	1.0 Ton (3.52 kW), Kirloskar make
c)	Refrigerant	:	R-22
d)	Heater1, 2, 3 & 4	:	each of 500 W
e)	Kettle Load	:	500 W
f)	Moisture Content	:	2257kj/kg of water evaporated in kettle
g)	Electric tube Load	:	18 W
h)	Power Factor cos ø	:	0.8
i)	Pressure Gauge	:	psin
j)	Compound Gauge	:	psin
k)	Temperature Sensor	:	Copper Constantan

Experimental Procedure

Step1: Fill water in the DBT/WBT Thermometer cassette.
Step2: Fill 500ml of water in the electric kettle.

Step3: Set the thermostat knob of the A/C at particular temperature. And run the A/C for nearly10 minutes.
Step4: Load the chamber by switching ON a heater(of predetermined load).
Step5: Add moisture from electric kettle by feeding regulated power to match the desired latent heat load.

Measurements

1. Note down the chamber load from the heater.
2. Note down the DBT & WBT from thermometer mounted near window gives room /chamber temperature.
3. Note down the input Amp &Volts of refrigeration units.
4. Note down the suction and discharge pressures (average during operation)
5. Note down the thermocouple temperatures in C at
   (a) Ambient Air.
   (b) Outgoing air from condenser.
   (c) Evaporator air at inlet and
   (d) Air leaving the evaporator at grille.

Observations

Name of Experiment	:	Window A/c test rig.
Refrigerant	:	R-22
Heater 1,2,3 & 4	:	Each of 500W
Kettle load	:	500W
Moisture Content	:	2257 kJ/kg of water evaporated in kettle
Electric Tube Load	:	18W
Power factor cos	:	0.8
Conversion factor 1 kPa	:	psig x 6.89s

Run no	Latent Heat (W)	Heater Load (W)	Thermometer		Compressor		Suction pr. (psi)	Discharge pr.(psi)	Temp. ˚C			
			Wbt (˚C)	Dbt (˚C)	V Volt	I Amp			1	2	3	4

Calculations

1. Room sensible heat load (SHL) can be found out by the summation of Heater load andTube light load
   Room Sensible Heat Load= Heater Load+Tube Light load in kJ/s or J/s or in watt.
2. Room latent heat load (LHL) can be found out from the moisture/steam generating capacity by the electrical kettle.
3. Room total heat load (THL) can be found out by the summation of room sensible heat load and room latent heat load.

   THL=SHL+LHL

4. Sensible heat factor (SHF) can be found out by the ratio of room sensible heat load and room total heat load.

   SHF= SHL/ THL

5. Apparatus dew point (ADP) can be obtained from the Psychometric chart supplied in the manual.
6. Dehumidified air is the amount of air being cooled and dried circulated by evaporator.

   Dehumidification rise= Temperature of Evaporator air into it – Temperature of Evaporator air at grill.
   Dehumidification air= SHL/ 1.23x Dehumidifier rise in lps

7. Coefficient of Performance of a Refrigerator (C.O.P) or EER
   = Refrigerator rate or Duty/ Power Input to the compressor

Precautions:

1. Run the apparatus for about 5 minutes without any load.
2. Fill the kettle with 500ml of water and estimate the moisture load.
3. operate the apparatus for 25-30 minutes only. Or add more water for generation of latent heat.
4. Do not touch the heater or the pipeline, which may be hot/cold.

Experiment no 4

AIM: Calculation/estimation of cooling load for large building.

PROCEDURE FOR COOLING LOAD ESTIMATION

There are a no of factors which effects the cooling load calculation for a large building. To estimate the total cooling load we have to take many factors into consideration which are enumerated below:

5.1 Space Heat Gain and Space Cooling Load

Space heat gain is the rate at which heat enters a space, or heat generated within a space during a time interval.
Space cooling load is the rate at which heat is removed from the conditioned space to maintain a constant space air temperature.
Figure 3 shows the difference between the space heat gain and the space cooling load. The difference between the space heat gain and the space cooling load is due to the storage of a portion of radiant heat in the structure. The convective component is converted to space cooling load instantaneously.

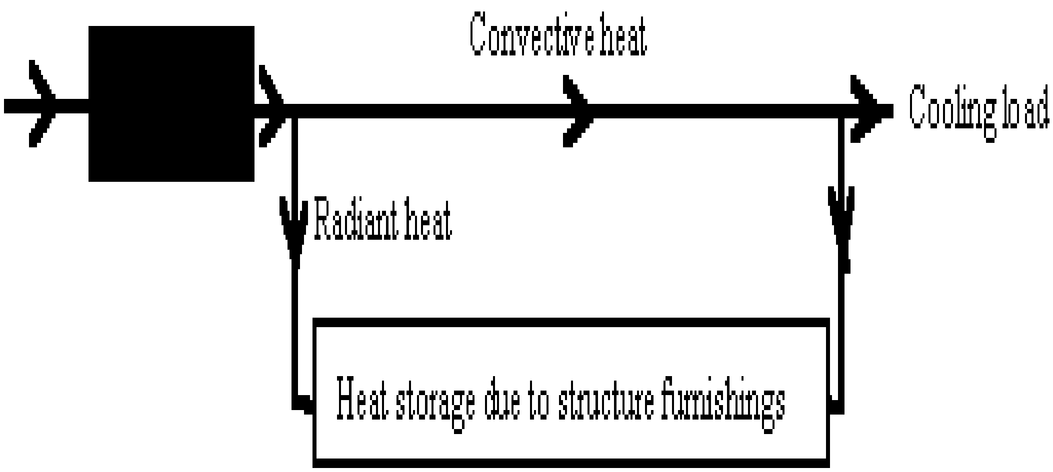


Figure 5.1
Differences between Space Heat Gain and Space Cooling Load

5.2 Cooling Load Temperature Difference (CLTD) and Cooling Load Factor (CLF)
Cooling load temperature difference and cooling load factor are used to convert the space sensible heat gain to space sensible cooling load.
5.2.1 Cooling Load Temperature Difference

The space sensible cooling load Qrs is calculated as:
$$Q_{rs} = A \cdot U \cdot CLTD \quad (1)$$
where A = area of external wall or roof

U = overall heat transfer coefficient of the external wall or roof.
CLTD values are found from tables, as shown in Tables 1 and 2, which are designed for fixed conditions of outdoor/indoor temperatures, latitudes, etc. Corrections and adjustments are made if the conditions are different.

5.2.2 Cooling Load Factor

The cooling load factor is defined as:

$$CLF = \frac{\text{sensible cooling load}}{\text{sensible heat gain}} = \frac{Q_{rs}}{Q_{es}} \quad (2)$$

CLF is used to determine solar loads or internal loads. Some CLF values are shown in Table 3.

Table 1
Cooling Load Temperature Difference for Conduction through Window Gla

Solar time, hour	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
CLTD,oC	1	0	-1	-1	-1	-1	-1	0	1	2	4	5	7	7	8	8	7	7	6	4	3	2	2	1

The values are calculated for an inside temperature (Ti) of 25.5oC and outdoor daily mean temperature (Tom) of 29.4^{o}C.

Correct CLTD = CLTD + (25.5 - Ti) + (Tom - 29.4)

Table 2
Cooling Load Temperature Difference (40 degree North Latitude in July) for Roofand External Walls (Dark)

Solar time, hour	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
Roof	14	12	10	8	7	5	4	4	6	8	11	15	18	22	25	28	29	30	29	27	24	21	19	16
External wall	8	7	7	6	5	4	3	3	3	3	4	4	5	6	6	7	8	9	10	11	11	10	10	9
North	9	8	7	6	5	5	4	4	6	8	10	11	12	13	13	13	14	14	14	13	13	12	11	10
North-east	11	10	8	7	6	5	5	5	7	10	13	15	17	18	18	18	18	18	17	17	16	15	13	12
East	11	10	9	7	6	5	5	5	5	7	10	12	14	16	17	18	18	18	17	17	16	15	14	12
South-east	11	10	8	7	6	5	4	4	3	3	4	5	7	9	11	13	15	16	16	16	15	14	13	12
South	15	14	12	10	9	8	6	5	5	4	4	5	5	7	9	12	15	18	20	21	21	20	19	17
South-west	17	15	13	12	10	9	7	6	5	5	5	5	6	6	8	10	12	17	10	11	12	11	11	19
West	14	12	11	9	8	7	6	5	4	4	4	4	5	6	7	8	10	12	15	17	18	17	16	15

North-west																							

The values are calculated for an inside temperature of 25.5oC and outdoor daily mean temperature of 29.4oC.Correction values for 22 degree north latitude in July are as follows:

Roof: +0.4^{o}C
Wall: N NE E SE S SW W NW
+1.8^{o}C +1.5^{o}C -0.4^{o}C -2.3^{o}C -3.6^{o}C -2.3^{o}C -0.4^{o}C +1.5^{o}C

Table 3
Cooling Load Factor for Window Glass with Indoor Shading Devices
(North Latitude and All Room Construction)

Solar time, hour	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	
Orientation:																				
North	0.08	0.07	0.06	0.06	0.07	0.73	0.66	0.65	0.73	0.80	0.86	0.89	0.89	0.86	0.82	0.75	0.78	0.91	0.24	0
North-east	0.03	0.02	0.02	0.02	0.02	0.56	0.76	0.74	0.58	0.37	0.29	0.27	0.26	0.24	0.22	0.20	0.16	0.12	0.06	0
East	0.03	0.02	0.02	0.02	0.02	0.47	0.72	0.80	0.76	0.62	0.41	0.27	0.24	0.22	0.20	0.17	0.14	0.11	0.06	0
South-east	0.03	0.03	0.02	0.02	0.02	0.30	0.57	0.74	0.81	0.79	0.68	0.49	0.33	0.28	0.25	0.22	0.18	0.13	0.08	0
South	0.04	0.04	0.03	0.03	0.03	0.09	0.16	0.23	0.38	0.58	0.75	0.83	0.80	0.68	0.50	0.35	0.27	0.19	0.11	0
South-west	0.05	0.05	0.04	0.04	0.03	0.07	0.11	0.14	0.16	0.19	0.22	0.38	0.59	0.75	0.81	0.81	0.69	0.45	0.16	0
West	0.05	0.05	0.04	0.04	0.03	0.06	0.09	0.11	0.13	0.15	0.16	0.17	0.31	0.53	0.72	0.82	0.81	0.61	0.16	0
North-west	0.05	0.04	0.04	0.03	0.03	0.07	0.11	0.14	0.17	0.19	0.20	0.21	0.22	0.30	0.52	0.73	0.82	0.69	0.16	0
Horizontal	0.06	0.05	0.04	0.04	0.03	0.12	0.27	0.44	0.59	0.72	0.81	0.85	0.85	0.81	0.71	0.58	0.42	0.25	0.14	0

5.3 Space Cooling Loads

Space cooling load is classified into three categories:

5.3.1 External Cooling Loads

External cooling loads have the following components:

5.3.1.1 Solar Heat Gain through Fenestration Areas, Qfes

$$Q_{fes} = (A_s \cdot \max.SHGF + A_{sh} \cdot \max.SHGF_{sh}) \cdot SC \quad (3)$$

Where As = unshaded area of window glass
Ash = shaded area of window glass
Max. SHGFsh = maximum solar heat gain factor for the shaded area on window glass (Table 4)
Max. SHGF = maximum solar heat gain factor for window glass (Table 5)
SC = shading coefficient (Table 6)
The corresponding space cooling load Qfs is:

$$Q_{fs} = Q_{fes} \cdot CLF \quad (4)$$

Table 4

Maximum Solar Heat Gain Factor of Shaded Area

Month	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
SHGFsh, W/m2	98	107	114	126	137	142	142	133	117	107	101	95

Table 5
Maximum Solar Heat Gain Factor for Sunit Glass on Average Cloudness Days

Month	Maximum solar heat gain factor for 22 degree north latitude, W/m2					
	North	North-east / north-west	East / west	South-east / south-west-	South	Horizontal
January.	88	140	617	789	696	704
February.	97	265	704	759	578	808
March.	107	404	743	663	398	882
April	119	513	719	516	210	899
May	142	572	687	404	139	892
June	180	589	666	355	134	880
July	147	565	671	391	140	877
August	123	502	694	496	223	879
September	112	388	705	639	392	854
October	100	262	676	735	563	792
November	88	142	606	786	686	699
December	84	101	579	790	730	657

Table 6
Shading Coefficient for Window Glasses with Indoor Shading Devices

Window glass	Nominal thickness, mm	Solar transmission	Shading coefficient

			Venetian		Roller shade, opaque		Draperies, light colour	
			Medium	Light	Dark	White	Openb	Closedb
Clear	3 - 12	0.78 - 0.79	0.64	0.55	0.59	0.25	0.65	0.45
Heat-absorbing	5 - 6	0.46	0.57	0.53	0.45	0.30	0.49	0.38
Heat-absorbing	10	0.34	0.54	0.52	0.40	0.28		
Reflective coated SCa=0.30 SCa=0.40 SCa=0.50 SCa=0.60			0.25 0.33 0.42 0.50	0.23 0.29 0.38 0.44			0.23 0.33 0.41 0.49	0.21 0.28 0.34 0.38
Insulating glass:								
Clear out-clear in SCa=0.84	6	0.80	0.57	0.51	0.60	0.25	0.56	0.42
Heat absorbing out-clear in SCa=0.55	6	0.56	0.39	0.36	0.40	0.22	0.43	0.35
Reflective SCa=0.20 SCa=0.30 SCa=0.40	6	0.80	0.19 0.27 0.34	0.18 0.26 0.33			0.18 0.27 0.36	0.16 0.25 0.29

a Shading coefficient with no shading device.
b Open weave means 40% openness, and closed weave indicate 3% openness.

Table 7
Overall Heat Transfer Coefficient for Window Glasses

Window Glass							
	Summer (outdoor wind velocity = 3.33m/s)						
	3 mm thicknes	5 mm thicknes	6 mm thicknes	12 mm thickness	3 mm thicknes	5 mm thicknes	6 mm thickn

	s	s	s		s	s	ess
Single-glazed Reflective Double-glazed 6mm airspace Double glazed 12mm airspace	5.4 3.2 2.8	5.2 3.0 2.7	5.0 4.7 2.9 2.6	4.3	6.1 3.1 2.7	5.7 2.9 2.6	5.4 5.0 2.8 2.4

5.3.1.2 Conduction Heat Gain through Fenestration Areas, Qfe

The space cooling load due to the conduction heat gain through fenestration area is calculated as:

$$Q = A \cdot U \cdot CLTD \quad (5)$$

Where A = fenestration area
U = overall heat transfer coefficient for window glass (Table 7)
CLTD = cooling load temperature difference (Table 1)

5.3.1.3 Conduction Heat Gain through Roofs (Qrs) and External Walls (Qws)

The space cooling load due to the conduction heat gain through roofs or external walls is calculated as:

$$Q_{rs} \ (or\ Q_{ws}) = A \cdot U \cdot CLTD \quad (6)$$

where A = area for external walls or roofs
U = overall heat transfer coefficient for external walls or roof
CLTD = cooling load temperature difference (Table 2)

5.3.1.4 Conduction Heat Gain through Interior Partitions, Ceilings and Floors, Qic

The space cooling load due to the conduction heat gain through interior partitions, ceilings and floors is calculated as:

$$Q_{ic} = A \cdot U \cdot (T_b - T_i) \quad (7)$$

where A = area for interior partitions, ceilings or floors
U = overall heat transfer coefficient for interior partitions, ceilings or floors
Tb = average air temperature of the adjacent area
Ti = indoor air temperature

5.3.2 Internal Cooling Loads

5.3.2.1 Electric Lighting

Space cooling load due to the heat gain from electric lights is often the major component for commercial buildings having a larger ratio of interior zone. Electric lights contribute to sensible load only. Sensible heat released from electric lights is in two forms:

(i) convective heat from the lamp, tube and fixtures.

(ii) radiation absorbed by walls, floors, and furniture and convected by the ambient air after a time lag.

The sensible heat released (Qles) from electric lights is calculated as:

$$Q_{les} = Input \cdot F_{use} \cdot F_{al} \quad (8)$$

where Input = total light wattage obtained from the ratings of all fixtures installed

Fuse = use factor defined as the ratio of wattage in use possibly at design condition to the installation condition

Fal = special allowance factor for fluorescent fixtures accounting for ballast loss, varying from 1.18 to 1.30

The corresponding sensible space cooling load (Qls) due to heat released from electrical light is:

$$Q_{ls} = Input \cdot F_{use} \cdot F_{al} \cdot CLF \quad (9)$$

CLF is a function of

(i) number of hours that electric lights are switched on (for 24 hours continuous lighting, CLF = 1), and

(ii) types of building construction and furnishings.

Therefore, CLF depends on the magnitude of surface and the space air flow rates.

5.3.2.2 People

Human beings release both sensible heat and latent heat to the conditioned space when they stay in it. The space sensible (Qps) and latent (Qpl) cooling loads for people staying in a conditioned space are calculated as:

$$Q_{ps} = n \cdot SHG \cdot CLF \quad (10)$$

$$Q = n \cdot LHG \quad (11)$$

where n = number of people in the conditioned space

SHG = sensible heat gain per person (Table 8)

LHG = latent heat gain per person (Table 8)

Adjusted values for total heat shown in Table 8 is for normal percentage of men, women and children of which heat released from adult female is 85% of adult male, and that from child is 75%.

CLF for people is a function of

(i) the time people spending in the conditioned space, and

(ii) the time elapsed since first entering.

CLF is equal to 1 if the space temperature is not maintained constant during the 24-hour period.

Table 8

Heat Gain from Occupants at Various Activities (At Indoor Air Temperature of 25.5 oC)

Activity	Total heat, W		Sensible heat, W	Latent heat, W
	Adult, male	Adjusted		
Seated at rest	115	100	60	40
Seated, very light work, writing	140	120	65	55
Seated, eating	150	170b	75	95
Seated, light work, typing,	185	150	75	75
Standing, light work or walking	235	185	90	95
slowly,	255	230	100	130
Light bench work	305	305	100	205
Light machine work	470	470	165	305
Heavy work	400	375	120	255
Moderate dancing	585	525	185	340
Athletics				

b Adjusted for latent heat of 17.6W person released from food.

5.3.2.3 Power Equipment and Appliances

In estimating a cooling load, heat gain from all heat-producing equipment and appliances must be taken into account because they may contribute to either sensible or latent loads, and sometimes both. The estimation is not discussed in this lecture note. For more information, Chapter 26 of ASHARE Handbook - 1993 Fundamentals can be referred.

5.3.3 Loads from Infiltration and Ventilation

Infiltration load is a space cooling load due to the infiltrated air flowing through cracks and openings and entering into a conditioned room under a pressure difference across the building envelope. The introduction of outdoor ventilation air must be considered in combination with the infiltrated air. Table 9 shows the summer outdoor design dry bulb and wet bulb temperatures at 22 degree north latitude.

Table 9
Summer Outdoor Design Dry Bulb And Wet Bulb Temperatures At 22 Degree North Latitude

Solar time, hour	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
Dry bulb temp. oC	28.4	28.3	28.2	28.1	28.0	28.0	28.2	29.0	29.9	30.8	31.8	32.2	32.8	33.0	32.7	32.5	31.8	31.1	30.4	29.7	29

Wet bulb temp. oC	25.8	25.7	25.7	25.6	25.6	25.5	25.7	26.4	26.7	27.0	27.5	27.6	27.8	28.0	27.9	27.6	27.4	27.1	26.8	26.7	26

TOTAL COOLING LOAD = SUM OF ALL THE LOADS

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Experiment no 5

AIM: Visit to a central air conditioning plant for study of processes for winter and summer air conditioning.

During the visit the students will study the following components/parameters in central air conditioning plant:

1. Draw a detailed block diagram of the plant(s).
2. Construction of the main components of air conditioning systems.
3. Note down the capacity of each unit i.e. evaporator coil(s), compressor condenser etc.
4. Type of evaporator coil(s), condenser(s), compressor(s), expansion valves, control Valves, ducts, fans and materials used in construction.
5. Name of refrigerants and flow rates.
6. Temperature and pressure variation in evaporators and condensers.
7. Comparison between theoretical and actual COP of the system.
8. Capacity control of the plant under various load conditions in summer and winter.
9. Types of insulation materials used.
10. Suggest various methods to improve plant performance.

1. Construction of the main components of refrigerating systems.
2. Draw a detailed block diagram of the plant(s).
3. Note down the capacity of each unit i.e. evaporator, compressor condenser etc.
4. Type of evaporator(s), condenser(s), compressor(s), expansion valves, control valves and materials used in construction.
5. Name of refrigerants primary and secondary and flow rates.
6. Temperatures and pressures in evaporators and condensers
7. Comparison between theoretical and actual COP of the system.
8. Capacity control of the plant under various load conditions.

9. Types of insulation materials used.
10. Suggest various methods to improve plant performance.
11. Comparison between ice plant and cold storage.

Experiment no 6

AIM: To study the various elements of Mechanical Refrigerator System through cut sections, models/actual apparatus.

STUDY: - Main Components of Refrigeration System are:-

1) Refrigerant
2) Compressor
3) Condenser
4) Evaporator
5) Expansion Devices

DESCRIPTION:

The detail study of every component of refrigeration system is as follows:-

1) **REFRIGERANT**:- It is a heat carrying medium which during their cycle in the refrigeration system absorb heat from a low temperature system and discard the heat so absorbed to a higher temperature system. The properties of an ideal refrigerant are:-
   (1) Low Boiling Point
   (2) High critical temperature
   (3) Low specific heat of liquid
   (4) Low specific volume of vapour
   (5) High latent heat of refrigeration
   (6) Non corrosive to metal
   (7) Non flammable or non-explosive
   (8) Non- toxic
   (9) Low in cost
   (10) Easy to liquefy at moderate pressure and temperature.

2) **COMPRESSER:** It is a machine to compress the vapour refrigerant from the evaporator and to raise its pressure so that the corresponding saturation temp. is higher than that of cooling medium. It also circulates the refrigerant through the system.

Classification of Compressor:-

(a) According to method of compression
   i) Reciprocating compressor
   ii) Rotary compressor
   iii) Centrifugal compressor.

(b) According to number of stages.
   i) Single acting compressor
   ii) Multi acting compressor

(c) According to number of stages
   i) Single stage compressor

ii) Multi stage compressor

(d) According to method of drive employed.

iii) Direct drive compressor.

iv) Belt drive compressor.

(e) According to location of prime-mover

i) Semi – hermetic compressor

ii) Hermetic compressor

3) **CONDENSER:** It is an important device used in the high pressure side of a refrigeration system. Its function is to remove heat of hot vapour.

Classification of Condenser:

i) Air cooled condenser

ii) Water cooled condenser

iii) Evaporative condenser.

4) EVAPORATOR: It is the device which is used in low-pressure side of refrigeration system. The liquid refrigerant after passing through the expansion value enters into the evaporator, here it provides cooling effect and absorbs heat, and so it changes the liquid refrigerant into vapour refrigerant form.

Classification of Evaporator:-

a) According to the type of construction

i) Bare Tube coil evaporator.

ii) Finned tube type evaporator.

iii) Plate evaporator.

iv) Shell and tube evaporator.

v) Shell and coil evaporator.

vi) Tube-in-tube evaporator.

b) According to method in which liquid refrigerant is fed

i) Flooded evaporator

ii) Dry expansion evaporator

c) According to mode of heat transfer

i) Natural convection evaporator

ii) Forced convection evaporator.

d) According to operating conditions.

i) Frosting evaporator.

ii) Non-frosting evaporator.

iii) Defrosting evaporator.

5) EXPANSION DEVICE:- It is an important device which divides high pressure side and low pressure side of a refrigerator system. It reduces the high pressure liquid refrigerant to low pressure refrigerant before being fed to evaporator. It also controls the flow of refrigerant according to the load on evaporator

Classification of Expansion Devices:-

i) Capillary tube

ii) Hand operated expansion valve

iii) Automatic or constant pressure expansion
iv) Thermostatic expansion valve
v) Low side float valve
vi) High side float valve