14th NATIONAL CERTIFICATION EXAMINATION 2013
FOR
ENERGY MANAGERS & ENERGY AUDITORS

PAPER – 3:	**Energy Efficiency in Electrical Utilities**		
Date: 25.08.2013	Timings: 0930 – 1230 HRS	Duration: 3 HRS	Max. Marks: 150

Section – I: OBJECTIVE TYPE **Marks: 50 x 1 = 50**

(i) Answer all **50** questions
(ii) Each question carries one mark
(iii) Please hatch the appropriate oval in the OMR answer sheet with HB Pencil, as per instructions

1.	The gross efficiency of a coal based power generating unit with a gross heat rate of 2490 kcal/kWh is a) 40% **b) 34.5 %** c) 33.3% d) 45.2%
2.	The efficiencies of a power plant and transmission systems are 40%, and 97% respectively. The percentage loss of the distribution system of the same network is 23% . The cascade efficiency of generation ,transmission and distribution system is given by a)8,92 % **b) 29.87**% c) 40 % d) 23%
3.	The rating of power factor correction capacitors at induction motor terminals should be **a) 90% of no load magnetizing kVAr of induction motor** b)100 % of no load magnetizing kVAr of induction motor c) 80% of no load magnetizing kVAr of induction motor d) none of the above
4.	Select the correct statement: Power factor a) is the ratio of active and reactive power b) is the ratio of reactive and apparent power c) **is the ratio of active and apparent power** d) of a pure inductive and capacitive load is unity
5.	The Energy Performance Index (EPI) of a building as per Energy Conservation Building Code (ECBC) and as defined in the Energy Conservation Act,2001 is: **a) kWh per square meter per year** b) kWh per square meter c) kW per square meter d) kWh per year

6.	If the maximum demand is 3500 kVA at 0.88 p.f., the maximum demand will reduce by_____ kVA if PF is improved to 0.98 : a) 3143 b) **357** c) 3897 d) maximum demand will not reduce
7.	The performance of rewinding of an induction motor can be assessed by which of the following factors? a) no load current b) stator resistance per phase c) load current d) both no load current and stator resistance per phase
8.	For a synchronous speed of 1500 rpm, at a given mains frequency of 50 Hz, the induction motor will have _____number of poles. a) 8 b) 6 **c) 4** d) 2
9.	A 7.5 kW, 415 V, 14.5 A, 1460 RPM rated 3 phase induction motor with full load efficiency of 90%, draws 9.1 A and 4.6 kW of input power. The percentage loading of the motor is about a) **55.2 %** b) 61.3 % c) 67.5 % d) none of the above
10.	The power input to a rotor of three phase induction motor is 42.3 kW. If the induction motor is operating at a slip of 1.30 % the total mechanical power developed will be : a) 42.3 kW b) **41.75** kW c) 5.48 kW d) 47.79 kW
11.	If the apparent power drawn over a recording cycle of 30 minutes is 5000 kVA for 0.5 minutes, 3400 kVA for 20 minutes and 1800 for 9.5 minutes, the MD recorder will compute MD as a) 5000 kVA b) 3400 kVA c) **2920 kVA** d) 1800 kVA
12.	The rating of the p.f correction capacitors at motor terminals for a 37 kW, 2 poles induction motor will be_____ in comparison to the same sized induction motor of 6 poles a) more b) **less** c) same d) sometime less or more
13.	Which parameters need to be measured to assess the percentage loading of a motor by slip method neglecting voltage correction? a) motor speed b) synchronous speed c) **operating motor speed and frequency** d) operating current
14.	Isothermal power of a compressor depends on a) absolute intake pressure b) pressure ratio c) free air delivered **d) all of the above**

15.	Reduction in the delivery pressure of an air compressor working at 7 bar, by 1 bar would reduce the power consumption by a) 2 – 3 % b) 4 - 5 % **c) <u>6 - 10 %</u>** d) none of the above
16.	**Which of the following is correct for air compressors?** a) for every 5.5°C drop in the inlet air temperature, the increase in energy consumption is by 2% **b) <u>for every 4°C rise in the inlet air temperature, the increase in energy consumption is by 1</u>%** c) for every 4°C rise in the inlet air temperature, the decrease in energy consumption is by 1% d) the energy consumption remains same irrespective of inlet air temperature
17.	The Free Air Delivery of a reciprocating air compressor is directly proportional to a) **<u>speed</u>** b) pressure c) volume d) all of the above
18.	Which of these desiccant compressed air dryers uses dry compressed air for regenerating the desiccant? a) blower reactivated type **<u>b) heatless purge type</u>** c) heat of compression type d) all of the above
19.	The unit of specific humidity in a psychrometric chart is a) **<u>grams moisture/kg of dry air</u>** b) moisture percentage in air c) grams moisture/kg of air d) all of the above
20.	The COP of a vapour compression refrigeration system is 3.1 If the motor draws power of 9.3 kW at an operating efficiency of 88%, the tonnage of refrigeration system is about **a)** 8.2 b) 9.3 c) **<u>7.2</u>** d) none of the above
21.	Chilled water enters an evaporator at 10^0C and leaves at 6^0C. The flow rate of chilled water was measured as 200 m^3/hr. The tons of refrigeration capacity is **<u>a) 265</u>** b) 200 c) 661 d) 2.65
22.	In an air conditioning system analysis which one temperature is sufficient to determine the enthalpy of air? a) dry bulb temperature b) **<u>wet bulb temperature</u>** c) ambient temperature d) none of the above
23.	The head generated by a centrifugal pump is: **<u>a) independent of the density of the liquid being pumped</u>** b) directly proportional to the density of the liquid being pumped c) inversely proportional to the density of the liquid being pumped d) proportional to the square of the density of the liquid being pumped

24.	The driving force for refrigeration in a vapour absorption refrigeration system is a) mechanical energy b) electrical energy c) **thermal energy** d) chemical energy
25.	Which of the following happens to air when it is cooled through evaporation process? a) humidity ratio of the air decreases b) **dry bulb temperature of air decreases** c) dry bulb temperature of air increases d) enthalpy of outlet air is less than enthalpy of inlet air
26.	The relation between COP and kW/TR for a refrigeration system is given by a) **kW/TR = 3.516/COP** b) kW/TR = COP /3.516 c) kW/TR = 860/COP d) none of the above
27.	In which of the following fans the air does not change flow direction from suction to discharge? a) tube axial fan b) vane axial fan c) propeller fan d) **all of the above**
28.	The parameter used by ASME to classify fans, blowers and compressors is_____ a) volume ratio **b) specific ratio** c) blade ratio d) impeller ratio
29.	The pressure to be considered for calculating the power required for centrifugal fans is___ a) vapour pressure b) dynamic pressure c) **total static pressure** d) velocity pressure
30.	The inclined manometer connected to a pitot tube is used for measuring which pressure in a gas stream? a) **velocity** b) static c) total d) all of the above
31.	If the power drawn by the motor driving a pump is 20 kW at a 91% efficiency, and the hydraulic power of a motor pump set is 12.5 kW, the pump efficiency will be__ a) **68.7%** b) 62.5% c) 56.8% d) none of the above
32.	Which of the following is not true for impeller trimming? a) **pressure ✪ diameter** b) head ✪ diameter^2 c) power ✪ diameter^3 d) flow ✪ diameter
33.	If the speed of the pump is doubled, power goes up by a) 2 times b) 6 times **c) 8 times** d) 4 times
34.	The preferred method of flow control for reducing pump flow permanently in a pumping system is------- a) throttling b) speed control c) **impeller trimming** d) none of the above

35.	A water pump is delivering 20 m^3/hr at ambient conditions. The impeller diameter is trimmed by 10%. This will reduce the pump discharge by a) 18 m^3/hr **b) <u>2 m^3/hr</u>** c) 0.2 m^3/hr d) none of the above
36.	Increasing the suction pipe diameter in a pumping system will a) reduce NPSHA b) **<u>increase NPSHA</u>** c) decrease NPSHR d) increase NPSHR
37.	The range of a cooling tower with inlet and outlet temperature as 41° C and 32° C respectively and wet bulb temperature as 29° is <u>a) **9°C**</u> b) 3°C c) 29°C d) 12°C
38.	Find the correct equation, if M = makeup water (from the mains water supply), E = losses due to evaporation, B = losses due to blow-down and D = drift losses of a cooling tower: **<u>a) M = E + B + D</u>** b) M = E + B - D c) M = E - B + D d) M = E - B - D
39.	If the wet bulb temperature of air is 38^0C, then its relative humidity in % is a) 38 % b) 90% c) 100% <u>d) **insufficient data**</u>
40.	For a cooling tower if blowdown is 10 m^3 /hour and Cycles of Concentration (CoC) is 2.5 the evaporation loss is equal to: a) 25 m^3/hour **<u>b) 15 m^3/ hour</u>** c) 0.25 m^3/hour d) 6.67 m^3/hour
41.	If the metered kWh is 95, kVAh is 100 and kVARh is 31, the power factor will be: **<u>a) 0.95</u>** b) 0.61 c) 0.69 d) unity
42.	In T-5 Fluorescent Lamp, "5" is indicative of: a) **<u>Tube diameter</u>** b) 5 watt loss c) 5% Energy Saving with respect to T8 d) 5th generation lamp
43.	Identify the statement that is not applicable to heat pumps a) transfers heat by refrigerant through a cycle of evaporation and condensation b) an air conditioner can work as a heat pump **<u>c) no external energy is required</u>** d) a vapour absorption refrigeration system can also work as a heat pump
44.	A refrigeration system using which of the following compressors is likely to be most efficient? a) reciprocating b) screw c) **<u>scroll</u>** d) all the above
45.	Which of the following is not true for a fluorescent lamp with electronic ballast **<u>a) presence of stroboscopic effect</u>** b) energy savings c) increased light output d) no starter required

46.	Which of the following with respect to turbocharger in a Diesel engine is true? a) **operates using energy of exhaust gases** b) decreases supply air pressure to engine c) preheats the combustion air using energy from exhaust gases d) all of the above
47.	The refrigerant which can be used both in vapour compression chillers and vapour absorption chiller is a) R22 b) R21 **c) ammonia** d) pure water
48.	Energy efficient distribution transformer core is made up of _____. a) silicon alloyed iron (grain oriented) b) copper c**) amorphous core - metallic glass alloy** d) none of the above
49.	In a transformer on load, if the secondary voltage is one-fourth the primary voltage, then the secondary current will be a) **four times the primary current** b) equal to the primary current c) one-fourth the primary current d) two times the primary current
50.	If V_1 is actual supply voltage and V_2 is the rated voltage of a capacitor, the reactive KVAr produced would be in the ratio of a) V_2^2/V_1^2 **b) V_1^2/V_2^2** c) 1 - V_2^2/V_1^2 d) 1 + V_2^2/V_1^2

……. End of Section – I …….

Section – II: SHORT DESCRIPTIVE QUESTIONS **Marks: 8 x 5 = 40**

(i) Answer all **Eight** questions
(ii) Each question carries **Five** marks

S-1	**A 15 kW, 415 V, 4 pole, 50 Hz, 3 Phase squirrel cage induction motor has a full load efficiency of 92% and power factor of 0.89. Find the following if the motor operates at full load rated values.** **a) input power in kW** **b) current drawn by the motor** **c) RPM at a full load slip of 0.8%**
Ans:	a) P_{in} (Input power) = 15 / 0.92 = 16.304 kW b) I(Input current) = 16.304 / (√3 x 0.415 x 0.89) = 25.48 A c) Ns = 120 x f / p = 120 x 50 / 4 = 1500 RPM N = Ns (1- S) = 1500 (1- 0.008) = 1488 RPM
S-2	**In a pumping system the water level is 4 m below the pump centerline. The discharge**

	pressure is 2.60 kg/cm^2. The flow rate of water is 1.5 m^3 /min. Find out the pump efficiency if the actual power drawn by the pump motor is 14 kW at a motor operating efficiency of 0.88.
Ans	Discharge Head = 2.60 kg/cm^2 = 26 metre head. Suction Head = - 4 metre. Total Head = 26 – (-4) = 30 metre Hydraulic Power = (1.5/60) x 1000 x 9.81 x 30/1000 = 7.36 kW Shaft input = 14x.88=12.32 Pump Efficiency = 100 x 7.36/12.32 = <u>59.74 %</u>
S-3	**Harmonic measurements in an electrical system of an industry gave the following results.** **Current at 50 Hz : 300 A** **Current at 150 Hz : 42 A** **Current at 250 Hz : 33 A** **Calculate the Total Harmonic Distortion in current for the system.**
Ans	$I_{THD} = \sqrt{\left(\frac{42}{300}\right)^2 + \left(\frac{33}{300}\right)^2} x100$ $\sqrt{0.0196 + 0.0121} x100 = 17.8\%$
S-4	**Air flow measurements using the pitot tube, in the primary air fan of a coal fired boiler gave the following data** **Air temperature = 38°C** **Velocity pressure = 47 mmWC** **Pitot tube constant, Cp = 0.9** **Air density at 0°C (standard data) = 1.293 kg /m^3** **Find out the velocity of air in m/sec.**
Ans	Corrected air density: 273 x 1.293 /(273+38) = 1.135 kg/m^3 Velocity m/s: Cp x √2 x 9.81 x Δp x γ / γ 0.9 x √2 x 9.81 x 4

		x 1.135 / 1.135	25.6 m/s

S-5	**List five measures to reduce energy consumption in lighting system for buildings, industry and street lighting**
Ans	◷ Reduce excessive illumination levels to standard levels using switching, delamping, etc. (Know the electrical effects before doing delamping.) ◷ Aggressively control lighting with clock timers, delay timers, photocells, and/or occupancy sensors. ◷ Install efficient alternatives to incandescent lighting, mercury vapor lighting, etc. Efficiency (lumens/watt) of various technologies range from best to worst approximately as follows: low pressure sodium, high pressure sodium, metal halide, fluorescent, mercury vapor, incandescent. ◷ Select ballasts and lamps carefully with high power factor and long-term efficiency in mind. ◷ Upgrade obsolete fluorescent systems to Compact fluorescents and electronic ballasts ◷ Consider lowering the fixtures to enable using less of them. ◷ Consider daylighting, skylights, etc. ◷ Consider painting the walls a lighter color and using less lighting fixtures or lower wattages. ◷ Use task lighting and reduce background illumination. ◷ Re-evaluate exterior lighting strategy, type, and control. Control it aggressively. ◷ Change exit signs from incandescent to LED.
S-6	**Identify each of the following statement as applicable to Vapor Compression Refrigeration System (VCR) and to Vapor Absorption Refrigeration System(VAR).** **(Need not copy and write the following statements in the Answer book; only write against the statements A, B, C, D etc. whether it is applicable to VCR or VAR)** **A. No effect of reducing the load on performance.** **B. Uses low grade energy** **C. Liquid traces in suction line may damage the compressor.** **D. Moving parts are only in the pump and hence operation is smooth.** **E. The system can work on lower evaporator pressures also without affecting the COP.** **F. Performance is adversely affected at partial loads.** **G. Liquid traces of refrigerant present in piping at the exit of evaporator** **H. Using high-grade energy like mechanical work** **I. Moving parts are more; therefore, more equipment maintenance and noise** **J. The COP decreases considerably with decrease in evaporator pressure**
Ans	**A. VAR** **B. VAR** **C. VCR** **D. VAR** **E. VAR** **F. VCR** **G. VAR** **H. VCR**

	I. VCR **J. VCR**
S-7	**List any five factors that affect the rate of evaporation of water in cooling towers**
	Amount of water surface area exposed The time of exposure The relative velocity of air passing over the droplets The RH of air The direction of airflow relative to water. **Any other relevant point to be considered**
S-8	**Estimate the cooling tower capacity (TR) and approach with the following parameters** **Water flow rate through CT = 2 m^3/min** **Specific heat of water = 1 kcal/kg °C** **Inlet water temperature = 43 °C** **Outlet water temperature = 35 °C** **Ambient WBT = 30°C**
Ans	Cooling tower capacity (TR) = (flow rate x density x sp.heat x diff. temp)/ 3024 = (2X60) x 1000 x 1.0 x (43-35)/ 3024 = 317.5TR Approach = 35- 30 = 5°C

……. End of Section - II …….

Section – III: LONG DESCRIPTIVE QUESTIONS **Marks: 6 x 10 = 60**

(i) Answer all **Six** questions
(ii) Each question carries **Ten** marks

L-1	**An efficiency assessment test was carried out for a standard 4 pole squirrel cage induction motor in a chemical plant. The motor specifications are as under:** **Motor rated specification: 3 phase delta connected,37 kW, 415 Volt, 63 Amps, 1475 rpm,** **The following data was collected during the no- load test on the motor:** **Voltage= 415 Volts** **Current = 17 Amps** **Frequency = 50 Hz** **Stator resistance per phase = 0.260 Ohms at 30^{0}C** **No load power= 1152 Watts** **Calculate the following:** **(i) Iron plus friction and windage losses.** **(ii) Stator resistance at 120°C.** **(iii) Stator copper loss at full load at operating temperature of 120°C.**

	(iv)	**Full load slip and rotor input assuming rotor losses are slip times rotor input.**
	(v)	**Motor input assuming that stray losses are 0.5% of the motor rated output power.**
	(vi)	**Motor full load efficiency**
Ans		

Let Iron plus friction and windage loss, P_i + fw

No load power, Pnl = 1152 Watts

Stator Copper loss, P st-30^{0}C (Pst.cu)

= 3 ◈(17 / ⊠)^2 ◈0.260

= 75.13Watts

Pi + fw = P_{nl} – Pst.cu

= 1152 – 75.13

= 1076.87 W

(ii) Stator Resistance at 120^{0}C,

$R_{120^0C} = 0.260 \diamond \frac{120 + 235}{30 + 235}$

= 0.3483 ohms per phase

(iii) Stator copper losses at full load, Pst.cu 120^{0}C

= 3 ◈(63 / ⊠)^2 ◈0.3483

= 1382.3 Watts

(iv) Full load slip

S = (1500 – 1475) / 1500

= 0.01666 or 1.66%

Rotor input, Pr = P_{output}/ (1-S)

= 37000 / (1-0.01666)

= 37000/0.98334

= 37626.86 Watts

(v) Motor full load input power, P input

= P_r + Pst.cu 120^{0}C + (P_i + fw) + P_{stray}

= 37626.86 + 1382.3 + 1076.87 + (0.005* ◈37000)

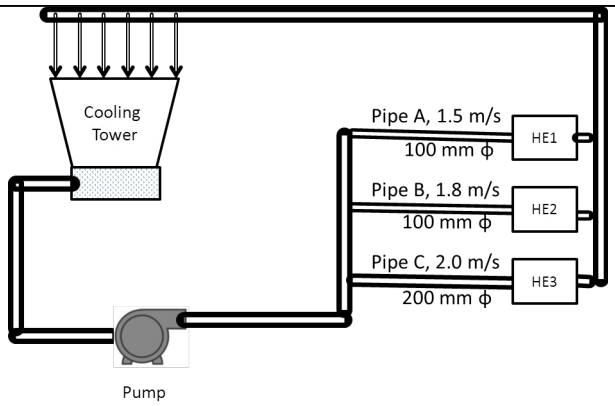
= 40271.03 Watts

*where, stray losses = 0.5% of rated output (assumed)

(vi) Motor efficiency at full load

Efficiency = $\frac{P_{output}}{P_{input}} \diamond 100$

	= (37000 / 40271.03) x 100 = 91.87 %
L2	**Fill in the blanks:** **1. Cavitation may occur in a pump when the local static pressure in a fluid reaches a level below the _____pressure of the liquid at the actual temperature.** **2. In a vapour absorption system using ammonia as refrigerant, the absorbent is _____** **3. The system resistance of a fan system is proportional to the _____of flow rate or velocity** **4. If the dry bulb temp.is 30^0C and the wet bulb temp. is 30^0C, then the % relative humidity will be _____** **5. Slip ring induction motors are comparatively _____efficient than of the squirrel cage motors of same ratings.** **6. In a pumping system with a horizontal discharge, the suction static head is 3 m and the friction head is 21 m. The total head developed by the pump will be _____** **7. The lowest theoretical temperature to which water can be cooled in a cooling tower is the _____ of atmospheric air** **8. The measure of illuminance of a surface in metric units is _____** **9. It is acceptable to run pumps in parallel provided their_____heads are similar** **10. When heat load, range and wet bulb temperature are held constant, the cooling tower size is _____proportional to the approach.**
Ans	1. Vapour 2. Water 3. Square 4. 100% 5. Less 6. 18 m 7. Wet bulb temperature 8. Lux 9. Closed valve heads 10. Inversely
L-3	**The cooling water circuit of a process industry is depicted in the figure below. Cooling water is pumped to three heat exchangers via pipes A,B and C where flow is throttled depending upon the requirement. The diameter of pipes and measured velocities with non-contact ultrasonic flow meter in each pipe are indicated in the figure.**



<u>The following are the other data:</u>

Measured motor power : 50.7 kW

Motor efficiency at operating load: 90%

Pump discharge pressure : 3.4 kg/cm^2

Suction head : 2 meters

Determine the efficiency of the pump

Ans

Flow in pipe A	22/7 x $(0.1)^2$/4 x 1.5
	0.011786 m^3/s
Flow in pipe B	22/7 x $(0.1)^2$/4 x 1.8
	0.014143 m^3/s
Flow in pipe C	22/7 x $(0.2)^2$/4 x 2.0
	0.062857 m^3/s
Total flow	0.088786 m^3/s
Total head	34 m – 2 m = 32 m
Pump hydraulic power	0.088786 x 32 x 9.81
	27.9 kW
	27.9 x 100/50.7 x 0.9
Pump efficiency	61 %

L4

a) The size of an engine room to be ventilated is 30 m x 20 m x 5 m. The number of air changes per hour is designed to be 20. If the static pressure rise across the ventilator fan is 15 mm WC and fan efficiency is 70 % find out the motor power drawn at a motor efficiency of 90%.

	b) A seal air fan for a coal mill is operating with suction damper in 25 % open condition. The power drawn at 50 Hz by fan motor is 120 kW. A VFD is to be installed eliminating the damper operation. It is found that the damper can be completely opened and the fan motor can be operated at 33 Hz. Calculated the power drawn by the fan motor at 33 Hz, assuming that motor and fan efficiency remains constant.
	a) Flow rate - 30 x 20 x 5 x 20 = 60,000 m^3/hr Motor power - (60,000/3600) x 15/ (102 x 0.7x0.9) - 3.89 kW b) Power at 50 Hz - 120 kW Power at 33 Hz - 120 x $(33/50)^3$ - 34.5 kW
L-5	**a) In an automobile industry a pump-up test was conducted to determine the free air delivery (FAD) of a reciprocating compressor and the following data were obtained:** **Receiver capacity and additional holdup volume in piping and after-cooler : 4100 litres** **Initial pressure: : 1 kg/cm² (g)** **Final pressure: : 8.5 kg/cm² (g)** **Atmospheric Pressure: : 1.026 kg/cm² (a)** **Ambient air temperature: : 32 °C** **Final compressed air temperature: : 52 °C** **Compressor pump up time : 65 secs** **Calculate the FAD of the compressor in cubic foot per minute.** **b) Further a leakage test was carried out in the same compressed air system and with the same compressor as in problem a) above and following were the observations:** - **Compressor was on load for 03 minutes** - **Compressor was unloaded for 13 minutes** - **Compressor was drawing 145 kW during load** **Calculate the following:** **i. % leakage in compressed air system** **ii. Leakage quantity** **iii. Specific power consumption** **iv. Power lost due to leakage**
Ans	**a)** Q = $\frac{P_2 - P_1}{P_0} \times \frac{V}{t} \times \left\{\frac{273 + t_1}{273 + t_2}\right\}$ Time = 65 sec=1.0833 secs

	= (8.5 - 1)/1.026X 4.1 /1.0833) X (305/325) = 25.96 m^3/min = 25.96 x $(3.28)^3$ = 916 cfm **b)** i) % Leakage in the system Load time (T) : 03 minutes Un load time (t) : 13 minutes % leakage in the system $\frac{T}{(T + t)} x100$ $\frac{3}{(3 + 13)} x100$ = 18.75 % ii) Leakage quantity : 0.1875 x 916 : 171.75 cfm iii) Operating capacity (FAD) : 916 cfm Actual power consumption : 145 kW **Specific power consumption** : 145/916 **= 0.1583 kW/cfm** **iv)** Power lost due to leakage : leakage quantity x sp power consumption : 171.75 x 0.1583 : 27.19 kW
L-6	**Answer any two of the following :** **(i) In a throttle valve-controlled pumping system with oversized pump list any five options to improve energy efficiency? (Note: Name only options, no explanation required)** **(ii) Define one 'Ton of Refrigeration (TR)'. How do you calculate TR across the Air Handling Units?** **(iii) List five energy conservation opportunities in fan system.**
Ans	i) Trim impeller, replace with smaller impeller, install variable speed drive, change pulley if it is belt driven, change to two speed drive, and lower rpm drive ii) A ton of refrigeration is defined as the quantity of heat to be removed in order to form one ton of ice in 24 hours when the initial temperature of water is 0 °C. This is equivalent to 50.4 Kcal/min or 3024 Kcal/h in metric system Refrigeration load in TR is assessed as ;

$$TR = \frac{Q \times \rho \times (h_{in} - h_{out})}{3024}$$

Where Q is the air flow in CMH

× is density of air kg/m^3

h_{in} is enthalpy of inlet air kCal/kg

h_{out} is enthalpy of outlet air kCal/kg

iii) **Energy conservation opportunities in fan system**

- Use smooth, well-rounded air inlet cones for fan air intakes.
- Avoid poor flow distribution at the fan inlet.
- Minimize fan inlet and outlet obstructions.
- Clean screens, filters, and fan blades regularly.
- Use aerofoil-shaped fan blades.
- Minimize fan speed.
- Use low-slip or flat belts.
- Check belt tension regularly.
- Eliminate variable pitch pulleys.
- Use variable speed drives for large variable fan loads.
- Use energy-efficient motors for continuous or near-continuous operation
- Eliminate leaks in ductwork.
- Minimise bends in ductwork
- Turn fans off when not needed.

……. End of Section – III ……