21st NATIONAL CERTIFICATION EXAMINATION
FOR
ENERGY MANAGERS & ENERGY AUDITORS
PAPER – 3 : ENERGY EFFICIENCY IN ELECTRICAL UTILITIES

Date : 28.03.2021 Timings : 09:30-12:30 HRS Duration : 3 HRS Max. Marks : 150

General instructions :

- *Please check that this question paper contains **8** printed pages*
- *Please check that this question paper contains **64** questions*
- *The question paper is divided into three sections*
- *All questions in all three sections are compulsory*
- *All parts of a question should be answered at one place*

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

1.	In a pumping system, if the temperature of the liquid handled decreases, then ________ **a) NPSHa increases** b) NPSHa decreases c) NPSHa remains constant d) NPSHa and NPSHr are independent of temperature	**A**
2.	If the COP of a vapour compression system is 3.5 and the motor draws a power of 10.7 kW at 80% motor efficiency, the cooling effect of vapour compression system will be________. **a) 30 kW** b) 42 kW c) 27 kW d) 2.99 kW	**A**
3.	One of the thermal power plants operating with 2 numbers of 500 MW units has reported the operating heat rate of 11250 kJ/kWh. The Plant Load Factor (PLF) of the power plant is 73 %. The operating efficiency of the power plant will be a) 38 % b) 35 % c) 30 % **d) 32 %**	**D**
4.	Aggregate Technical & Commercial losses in distribution system covers____________ a) only I^2R losses of all transformers b) only transmission & distribution loss c) only transmission losses **d) energy and monetary loss**	**D**
5.	The two part tariff structure for HT category consumers are **a) one part for capacity drawn and second part for actual energy drawn** b) one part for actual power factor and second part for actual energy drawn c) one part for capacity drawn and second part for actual reactive energy drawn d) one part for actual apparent energy drawn and second part for actual reactive energy drawn	**A**
6.	The illuminance is 10 lm/m² from a lamp at 1 meter distance. What will be the illuminance (in lm/m²) at 2-meter distance from lamp? a) 2.75 **b) 2.5** c) 40 d) 20	**B**

7.	A spark ignition engine is used for firing which type of fuels___________ a) gasoline b) land fill gas c) natural gas **d) all of the above**	**D**
8.	In a water Lithium bromide refrigeration system, the concentration of the lithium bromide gets diluted in_______. a) evaporator b) condenser c) generator **d) absorber**	**D**
9.	Increasing the cycles of concentration of circulating water in a cooling tower will ________. a) increase blow down quantity **b) decrease blow down quantity** c) increase drift losses d) decrease fan power consumption	**B**
10.	Which of the following is not true for energy efficient motors? **a) starting torque is higher than standard motors** b) starting torque is lower than standard motors c) slip is lower than standard motors d) speed is higher than standard motors	**A**
11.	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**	**D**
12.	The theoretical synchronous speed of 4 pole motor operating at 50 Hz will be **a) 1500 rpm** b) 3000 rpm c) 200 rpm d) none of the above	**A**
13.	If water is flowing through a cooling tower at 120 m^3/h with 5 ^0C range, the load on cooling tower at ambient wet bulb temperature of 33 ^0C is **a) 198.4 TR** b) 357 TR c) 158 TR d) none of the above	**A**
14.	When the evaporation of water from a wet substance at atmospheric condition is zero, it indicates _________. a) RH is 0% **b) RH is 100%** c) wet bulb temperature is greater than dry bulb temperature d) none of the above	**B**
15.	A hotel building has four floors each of 1000m^2 area. If the interior lighting power allowance for the hotel building is 43,000 W. The Lighting Power Density (LPD) is: **a) 10.75** b) 0.09 c) 43 d) data insufficient	**A**
16.	As per Energy Conservation Building Code, compute the Effective Aperture (EA) given that Window Wall Ratio (WWR) is 0.40 and Visible Light Transmittance (VLT) is 0.25 **a) 0.1** b) 1.6 c) 0.65 d) 0.625	**A**
17.	The Solar Heat Gain Co-efficient (SHGC) of a window of a building is 0.30. This means that a) The window allows 70% of the sun's heat to pass through into interior of the	**B**

	building **b) The window allows 30% of the sun's heat to pass through into the building interior** c) 70% of the sun's heat is incident on the window d) The window reflects back to exterior a minimum of 30 % of the sun's heat	
18.	The purpose of after-cooler in a multistage compressor is to__________. **a) remove the moisture in the air** b) reduce the work of compression c) separate moisture and oil vapour d) none of the above	**A**
19.	The outer tube connection of the Pitot tube is used to measure_______in the fan system **a) static pressure** b) total pressure c) velocity pressure d) none of the above	**A**
20.	Which of the following contributes to increased technical losses? a) lower sized conductors b) low power factor c) lengthy distribution lines **d) all of the above**	**D**
21.	Which one has the maximum effect on cooling tower performance? **a) fill media** b) drift c) louvers d) casing	**A**
22.	Single stage Li-Br water absorption refrigeration systems have a COP in the range of a) 0.40 - 0.5 **b) 0.65 - 0.70** c) 0.75 - 0.8 d) 0.2 - 0.3	**B**
23.	Shaft power of the motor driving a pump is 20 kW. The motor efficiency is 0.9 and pump efficiency is 0.55 at that operating load. The power transmitted to the water is a) 12.2 kW b) 9.9 kW **c) 11 kW** d) 12.7 kW	**C**
24.	The unit of AAhEPI is given by a) $kWh/m^2/yr$ b) m^2 x kWh/hr **c) $(Wh/m^2)/hr$** d) $m^2/Wh/yr$	**C**
25.	A pump with 200 mm impeller is delivering a flow of 120 m^3/hr. If the flow is to be reduced to 100 m^3/hr by trimming the impeller, what should be the approximate impeller size? a) 60 mm b) 240 mm **c) 167 mm** d) 145 mm	**C**
26.	Hermetic system is used in **a) domestic refrigerator** b) centrifugal chillers c) screw chillers d) large reciprocating chillers	**A**
27.	Which of the following compressors do not use loading / un-loading method for capacity control? a) screw compresssor **b) centrifugal compresssor** c) reciprocating compresssor d) all of the above	**B**
28.	The input of a 900 kW rated motor operating with 90% efficiency is ___________. a) 900 kW **b) 1000 kW**	**B**

	c) 810 kW d) none of the above	
29.	Power factor is highest in case of a) sodium vapour lamps b) LED lamps c) tube Lights **d) incandescent lamps**	**D**
30.	A package air conditioner of 5 TR capacity delivers a cooling effect of 4 TR. If the Energy Efficiency Ratio (W/W) is 2.90, the power in kW drawn by the compressor would be: **a) 4.84** b) 1.38 c) 1.724 d) none of the above	**A**
31.	A fan is drawing 16 kW at 800 RPM. If the speed is reduced to 600 RPM then the power drawn by the fan would be a) 12 kW b) 9 kW **c) 6.75 kW** d) none of the above	**C**
32.	COP of an air-conditioner will be least with_____________. **a) lower evaporator temperature and higher condenser temperature** b) higher evaporator temperature and lower condenser temperature c) higher evaporator temperature and higher condenser temperature d) lower evaporator temperature and lower condenser temperature	**A**
33.	Which of following is not used for speed control ? a) fluid coupling b) eddy current **c) soft starter** d) variable frequency drive	**C**
34.	Which of the following compressed air dryer requires the use of activated alumina ? a) membrane dryer **b) heat of compression dryer** c) refrigerant dryers d) all of the above	**B**
35.	During a leak test of a compressed air system, the compressor's average load time was 1.5 minute, average unload time was 10.5 minutes and flow rate was 35 m^3/min. The leakage quantity is **a) 4.375** b) 5.125 c) 7.625 d) 6.250	**A**
36.	Which of the following is not an adsorption type of air drier for compressed air system? a) blower reactivated type b) heat less purge type c) heat of compression type **d) refrigerant type**	**D**
37.	At which of the following dew points of the compressed air, the moisture content would be maximum? a) -10^{o}C **b) -5^{o}C** c) -40^{o}C d) -20^{o}C	**B**
38.	Which of the following uses concept of evaporative cooling? **a) cooling tower** b) domestic refrigerator c) window air conditioner d) deep freezer	**A**
39.	Specific Ratio is maximum for a) backward curved fan b) forward curved fan c) blowers **d) Compressors**	**D**

40.	Which of the following can be used to regulate the flow of fans? a) pulley change b) damper control c) inlet guide vane regulation **d) all of the above**	**D**
41.	What will be the blowdown loss of a cooling tower if evaporation loss is 15.32 m^3/hr and COC is 2.7 ? **a) 9.01 m^3/hr** b) 5.67 m^3/hr c) 41.3 m^3/hr d) 0.17 m^3/hr	**A**
42.	ECBC code is applicable to commercial buildings having connected load of_____________. **a) 100 kW** **b) 500 kW** **c) 250 kW** **d) 1000 kW**	**A,B, C,D**
43.	Which of the following pump is not a positive displacement pump a) piston pump b) rotary vane c) diaphragm pump **d) centrifugal pump**	**D**
44.	The power factor of an electrical system having an active power of 100 kW and reactive power of 80 kVAr will be ___________________ a) 0.81 b) 0.88 **c) 0.78** d) cannot be determined	**C**
45.	A 22 kW motor rated for 415 V, 42 A and 0.8 power factor will have an efficiency of______. **a) 91 %** b) 92 % c) 89.9 % d) none of the above	**A**
46.	If the power consumed by an air conditioner compressor is 1.7 kW per ton of refrigeration,then its energy efficiency ratio (Watt/Watt) is _____ a) 1.7 **b) 2.06** c) 0.59 d) none of the above	**B**
47.	Which of the following devices do not produce any harmonics? a) UPS **b) incandescent bulb** c) arc furnace d) electronic ballast	**B**
48.	A DG set is consuming 70 litres per hour diesel oil. If the specific fuel consumption is 0.33 litres/kWh, what is the kVA loading at 0.8 power factor? a) 212 kVA **b) 265 kVA** c) 170 kVA d) none of the above	**B**
49.	Flow control by damper operation in fan system will a) increase energy consumption **b) reduce energy consumption** c) reduce system resistance d) none of the above	**B**
50.	Which one of the following has the maximum CRI? **a) Incandescent lamp** b) LED lamp c) CFL lamp d) HPSV lamp	**A**

-------------------- **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 V-belt driven centrifugal fan is supplying air to a chemical process. Calculate the fan static efficiency for the following operating parameters.

5 Marks

Ambient temperature	40°C
Density of air at 40°C	1.127 kg/m³
Diameter of the discharge air duct	1 meter
Velocity pressure measured by Pitot tube in discharge duct	47 mm WC
Pitot tube coefficient	0.9
Static pressure at fan inlet	-22 mm WC
Static pressure at fan outlet	188 mm WC
Power drawn by the motor	72 kW
Belt transmission efficiency	95%
Motor efficiency at the operating load	90%

S-1 Sol

To Calculate fan static efficiency:

Air velocity $= Cp \times (2 \times 9.81 \times \triangle p / \gamma)^{0.5}$

$= 0.9 \times (2 \times 9.81 \times 47 / 1.127)^{0.5}$

$= 25.7$ m/s

Area of the discharge duct $= [3.14 \times 1 \times 1]/4 = 0.785\ m^2$

Volume $= 25.7 \times 0.785 = 20.17\ m^3/s$

Power input to the fan shaft $= 72 \times 0.95 \times 0.9 = 61.6$ kW

Fan static efficiency $= \dfrac{\text{Volume in } m^3/\text{sec X total static pressure in mm WC}}{102 \text{ x Power input to the shaft in (kW)}}$

$= \dfrac{20.17 \times [188 - (-22)]}{102 \times 61.6}$

$= 67.4\%$

S-2	Fill in the blanks: **1 Mark each** a) Heat rate of a thermal power plant is expressed in________ b) The _________ loss is independent of load in a transformer. c) _________ is used to reduce the dew point in a compressed air system d) The difference between the total and static pressure in an air duct is_______ e) The speed of an energy efficient motor will be more than the standard motor of same capacity because_______ decreases.
S-2 Sol	a) kCal/kWh or kJ/kWh b) Core loss or iron loss or no-load loss c) Air dryer d) Velocity Pressure or Dynamic Pressure e) Slip
S-3	List five Energy Efficiency measures in buildings **5 Marks**
S-3 Sol	Refer Guidebook 3 (Pg 288-290)
S-4	a) Name six parameters along with units that a psychrometric chart provides to an air conditioning engineer. **3 Marks** b) Explain briefly about Thermal Emittance **2 Marks**
S-4 Sol	a) Following air parameters are being provided by psychometric chart. 1. Dry bulb temperature (°C) 2. Relative humidity (%) 3. Wet bulb temperature (°C) 4. Specific volume (m3/kg of dry air) 5. Enthalpy (kcal/kg of dry air) 6. Specific humidity or Humidity factor (grams/kg of dry air) b) Refer Guidebook-3, page no.- 272
S-5	A process plant has installed 5 MW DG set for base load operation, which is operating at 70% loading. Furnace oil is used as a fuel in the DG set. The DG set generates 8.6 kg of exhaust gas per kWh generation. The plant management has decided to install a heat recovery boiler to generate steam at 3 kg/cm^2(g) from the exhaust gas to reduce the exit flue gas temperature from 450^{o}C to 200^{o}C. The specific heat of flue gas is 0.26 kcal/kg^{o}C. The steam generated from waste heat boiler will be used in double effect Li - Br Vapor Absorption Chiller, with a COP of 1.12. How much TR will be generated through VAM? **5 Marks**
S-5 Sol	Loading of DG Set = 70% x 5 MW = 3.5 MW = 3500 kW Quantity of heat available from exhaust gas = 3500 kW x 8.6 kg gas generated/kWh x 0.26 kcal/kg^{o}C x (450 ^{o}C - 200^{o}C) =19,56,500 kcal/hr Potential TR generation through double effect VAM COP = (TR/ Heat input)

	TR= (COP X Heat input) / 3024 = (1.12*1956500) / 3024 = 724.6 TR
S-6	What are the advantages of using vapour absorption refrigeration system over vapour compression system? Under what condition it would be economical? **5 Marks**
S-6 Sol	**Refer Guidebook 3 (Pg 112-116)**
S-7	A process plant is situated 100 m above the ground level on the top of the hill. The plant requires 100 kL of water per hour. The management decides to install a pump at the ground level, with suction 3 meter below the ground level. The friction head is 12 meter. Evaluate the rating of the motor required considering 10% extra margin with respect to actual input pump power. The design pump efficiency is 65%. Also calculate the motor input power if the motor efficiency is 93%. **5 Marks**
S-7 Sol	Ans.- Q= 100/3600 =1/36 m3/s = 0.0277 m3/s ꝓ = 1000 kg/m3 Static Head = 100- (- 3) = 103 m Total Head = Static Head + Friction Head = 103 + 12 = 115 Hydraulic power required = Q*p*(hd-hs)*g/1000 = (0.0277* 1000 *115*9.81)/1000 = 31.25 KW Pump efficiency = 65% Pump input power (shaft power) required= 31.25/0.65= 48.07 KW Motor rating (shaft power) = 48.07kW Motor rating (shaft power) with 10% margin above pump input power = 48.07+ (0.1*48.07) =52.87 KW Motor input power = design rated power / motor efficiency = 48.07/0.93 = 51.69 kW
S-8	A small foundry has installed a reciprocating air compressor of 14.25 m^3/min. The plant could not meet the compressed air requirement and hence conducted a capacity test to determine the derating in the compressor capacity. Calculate the actual FAD delivered after considering the necessary temperature correction in m^3/min and also the percentage derating. **5 Marks** **The operating parameters are given below:** Volume of air receiver including pipe and cooler = 9 m^3 Atmospheric temperature (T1) = 35°C Receiver temperature (T2) = 44°C

	Initial Pressure	=	0.5 kg/cm^2(g)
	Final Pressure	=	7.0 kg/cm^2(g)
	Atmospheric pressure	=	1.026 kg/cm^2 (a)
	Time taken to build up the pressure	=	5 minutes

S-8 Sol

Ans:-

FAD delivered in m^3/min :

FAD = ((P2-P1)/ Pa)* (Receiver & holding Volume in m^3/Time in min)*(Temp Corr Factor)

P1 = 7.0 kg/ cm^2(g)

P2 = 0.5 kg/ cm^2 (g)

Pa = 1.026 kg/ cm^2(a)

Receiver & holding Volume in m^3 = 9 m^3

Time in min = 5 minutes

= [(7.0-0.5) x 9/ (1.026x5)] = 11.40 m^3/min

FAD after temperature correction

Temperature correction factor = (273+T1) /(273+T2)

T1 is suction Temperature and

T2 is receiver temperature.

= (273+T1) /(273+T2)

= (273+35) /(273+44)

= 0.972

FAD after temperature correction is = 11.40 m^3/min*0.972

= 11.08 m^3/min

Capacity shortfall = 14.25-11.08

= 3.17 m^3/min,

% Capacity de-rating = (3.17/14.25) x100

=22.24%

--------------------- **End of Section - II** ---------------------

Section – III: LONG DESCRIPTIVE QUESTIONS

Marks: 6 x 10 = 60

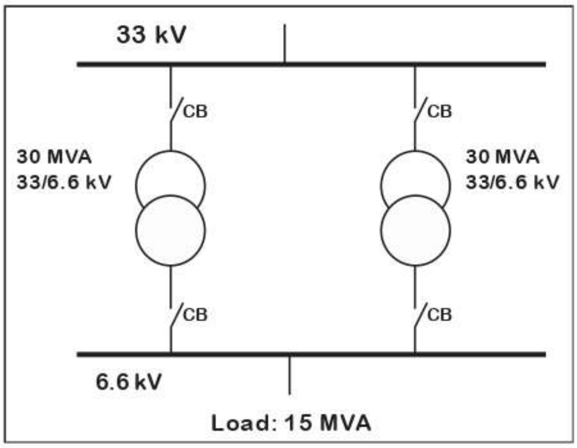
(i) Answer all **Six** questions

(ii) Each question carries **Ten** marks

L-1	In a Thermal Power Station, the steam input to a turbine operating on a fully condensing mode is 100 Tonnes/hr. The heat rejection requirement of the steam turbine condenser is 555 kcals/kg of steam condensed. The head developed by the cooling water pump is 2.5 kg/cm^2. During 4500 hours of normal operation per year, the cooling water temperatures at the inlet and outlet of turbine condenser are measured to be 27°C and 35°C and during the winter period operation of 3000 hours per year the cooling water temperatures at the inlet and outlet of turbine condenser are measured to be 15°C and 25°C. **Find out:** i. The circulating cooling water flow for normal operation as well as for winter operation. **5 Marks** ii. Calculate the annual energy reduction during winter operation if the combined efficiency of the pump and motor is 70%. **5 Marks**
L-1 Sol	**1. Cooling water requirement for normal operation at 27^0 C and 35^0 C (4500 Hours):** The quantity of heat rejected in the turbine condenser = Quantity of steam condensed in kg x heat rejection in kCal /kg **= 100,000 x 555 = 55.5 million kCals /hr** Heat gained by circulating cooling water = Heat rejected in the condenser Therefore, Cooling water flow = 55.5 x10^6 / (35-27) x specific heat (1)x1000 =**6937.5 m^3 /hr** Head developed by the pump = 2.5 kg/cm^2 Hydraulic power required = (6937.5/3600)*25*9.81 = 472.62 kW Combined efficiency of cooling water motor and pump = 70% Input power required = (472.62/0.7) = 675.16 kW

	2. Cooling water requirement for winter operation at 15^0 C and 25^0 C (3000 Hours): The quantity of heat rejected in the turbine condenser = Quantity of steam condensed in kg x heat rejection in kCal /kg **= 100,000 x 555 = 55.5 million kCals /Hr** Heat gained by circulating cooling water = Heat rejected in the condenser Therefore, Cooling water flow = 55.5 x10^6 / (25-15) x specific heat (1)x1000= **5550 m^3/hr** Head developed by the pump = 2.5 kg/cm^2 Hydraulic power required = (5550/3600)*25*9.81 = 378.09 kW Combined efficiency of cooling water motor and pump = 70% Input power required = (378.09/0.7) = 540.13 kW Energy reduction during winter operation = (675.16 - 540.13) x 3000 = 405090 kWh
L-2	a) List five losses in electrical motors and discuss about the measures taken by the motor manufacturers to reduce the losses in energy efficient motor. **5 Marks** b) List five energy conservation opportunities in pumping system. **5 Marks**
L-2 Sol	a. Refer Guidebook-3, Page 51 b. Refer Guidebook-3, Page 193
L-3	a) List any three energy efficient lighting controls. Describe briefly about daylight linked control **5 Marks** b) Explain briefly about various water losses in cooling towers and how they can be minimized? **5 Marks**
L-3 Sol	a. Refer Guidebook-3, Page 243-244 b. Refer Guidebook-3, Page 205

L-4	Rated capacity of bottom ash disposal pump flow rate is 485 m^3/hr and discharge pressure is 13.5 kg/cm^2 at rated speed of 2950 rpm. It has been observed that 450 m^3/hr water is sufficient to dispose the ash. The suction pressure of the pump is 0.5 kg/cm^2. The management has decided to trim the impeller to satisfy the reduced flow requirement. **Calculate:** a) % reduction of impeller diameter. **5 Marks** b) The annual energy savings after modification, if the pump is operating for 6 hours/day and 330 days in a year. **5 Marks**
L-4 Sol	**a) % Reduction of Impeller Diameter** Flow rate ∞ impeller diameter Dnew/Dold = 450/485 Dnew = (450/485)*Dold = 0.928 * Dold % impeller diameter reduction = ((Dold- Dnew) / Dold)*100 = ((Dold- 0.928 * Dold)/ Dold)*100 = (1- 0.928)*100 = (0.072)*100 = 7.2 % **b) Annual energy saved after modification**: Hydraulic power required at rated condition = (Q* p * (hd-hs) * g) / 1000 = (485/3600)*(1000)*((135-5))*9.81/1000) = 171.81 kW New discharge Head: Old Flow=485 m^3/hr New Flow=450 m^3/hr Old discharge Head =13.5 x 10 = 135m New discharge Head=? (D2/D1)^2=(H2/H1) D2 =100-7.2 = 92.8% of D1 = 0.928 D1 H2=(D2/D1)^2*H1 = (0.928D1/D1)^2*135 = 116.25 Hydraulic power required at modified condition = (Q* p * (hd-hs) * g) / 1000 = (450/3600)*(1000)*((116.25-5)*9.81/1000 = 136.42 kW Power savings due to impeller size reduction by 7.2% = (171.81 -136.42) = 35.39 kW Annual energy savings = (35.39)*(6*330) = 69,894 kWh/year **OR**

	Power (P) α D^3 Flow (Q) α D So, Power α Q^3 Power new = $(Q2/Q1)^3$ x 171.81 = $(450/485)^3$ x 171.81 = (0.799) x 171.81 = 137.3 kW Power saving per year = (171.81 – 137.3) x 6 x 330 = 68,329.8 kWh/year
L-5	a) A cold rolling mill has a maximum demand of 7 MVA at a power factor of 0.95. The plant management converts the existing electrical resistance annealing furnace having steady load of 1250 kW to gas heating as a cost reduction measure. The existing capacitor banks (kVAr) continued to be in the electrical network. What will be the effect on maximum demand and power factor due to this conversion? **5 Marks** b) A cement plant has a constant load of 15 MVA. It has installed two transformers of 30 MVA each. The no load loss and full load copper loss of each 30 MVA transformer is 25 kW and 75 kW respectively. From the energy efficiency point of view the industry management wants to take a decision on whether to operate a single transformer or two transformers equally sharing the load. What is your recommendation? **5 Marks** 
L-5 Sol	**a)** Registered maximum demand = 7 MVA = 7000 kVA Electrical load (real power) = 7000 X 0.95 = 6650 kW kVAr = $\sqrt{(kVA^2 - kW^2)}$ kVAr = $\sqrt{}$sqrt $((7000)^2 - (6650)^2)$ kVAr = 2186 kVAr in the plant will remain same.

	Reduction in real power due to conversion is 1250 kW. Revised real Power = 6650 – 1250 = 5400 kW Revised kVA = $\sqrt{kW^2 + kVAR^2}$ = $\sqrt{(5400)^2 + (2186)^2}$ Revised kVA = 5825 Reduction in Electrical Demand = 7000 – 5825 = 1175 kVA Revised Power factor = 5400 / 5825 = 0.927 Reduction in Power Factor = 0.95 - 0.927 = 0.023 **B)** **Option 1: One transformer in operation** % load = 15/30 = 50% Total Loss = $P_{NOLOAD} + P_{COPPER\ LOSS} \times (\%load)^2$ = $25 + 75 \times (0.5)^2$ = 43.75 kW **Option II: Both transformers in operation** % load = 7.5/30 = 25% Total Loss = $[(P_{NOLOAD} + P_{COPPER\ LOSS} \times (\%load)^2]\times 2$ = $[25 + 75 \times (0.25)^2] \times 2$ = 59.37 kW It is economical to operate one transformer because the losses are less and there is a saving of 59.37 – 43.75 = 15.62 kW.
L-6	a) Calculate the filter area of Air Handling Unit (AHU) for Refrigeration Load of 50 TR. The air enthalpy at inlet of AHU is 85 kJ/kg and at outlet is of 60 kJ/kg. Air velocity at filter is 1.81 m/sec and air density is 1.26 kg/m³. **5 Marks** b) A no load test was conducted in a delta connected 37 kW induction motor. Name plate data : 3 Phase, 415 V, 50 Hz, 55 Amp **Measured data at no load:** Voltage, V = 415 Volts; Current, I = 18 Amps; Frequency, F = 50 Hz; Stator phase resistance at 30°C = 0.23 Ohms/phase No load power = 955 Watts

	Calculate: i. The iron loss plus friction loss plus windage loss **2 Marks** ii. Stator copper loss at name plate ratings (full load), considering stator temperature as 120 °C **2 Marks** iii. No load power factor of the motor **1 Mark**
L-6 Sol	Ans: **Answer (a):** TR of AHU = (Enthalpy difference x density x area x velocity x3600)/ (4.187 x 3024) Filter Area = TR *(4.187*3024)/(Enthalpy difference*density*Velocity*3600) = (50) *(4.187*3024)/(25*1.26*1.81*3600) = **3.08 m²** Where, TR = 50 TR Enthalpy difference = (85 – 60) = 25 kJ/kg Air density at filter inlet = 1.26 kg/m³ Air velocity at filter inlet =1.81 m/s **Answer (b):** Let iron loss plus friction loss plus windage loss be P_i + fw Stator copper loss, P_{st}, 30°C = 3x $(18/\sqrt{3})^2$x0.23 = 74.51 Watt P_i + fw = P_{nl} - P_{st} = 955 – 74.51 = 880.49 W Stator resistance at 120 °C = 0.23 x [(120+235) / (30+235)] = 0.308 Ohms Stator copper loss at name plate ratings = 3 x $(55/\sqrt{3})^2$ x 0.308 = 931.65 Watt No load power factor = 955 / (1.7321 x 415 x 18) = 0.0738

--------------------- **End of Section - III** ---------------------