

Paper -3 Set B Solutions

13th NATIONAL CERTIFICATION EXAMINATION – September, 2012
FOR
ENERGY MANAGERS & ENERGY AUDITORS

PAPER – 3: Energy Efficiency in Electrical Utilities		
Date: 16.9.2012	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

1.	Which type of energy efficient dryer can be opted if a user in a plant requires compressed air at a dew point of -40°C ? a) heatless purge type dryer <u>b) heat of compression dryer</u> c) aftercooler d) refrigerant dryers
2.	Which one of the following is an incorrect statement? a) fluorescent lamp is an electric discharge lamp b) electronic ballasts make use of semi-conductor devices c) electronic ballasts have very low internal loss <u>d) fluorescent lamps can produce light by direct connection to the power source</u>
3.	Which one of the following device will help to eliminate the hunting problems normally associated with capacitor switching? <u>a) intelligent power factor controller</u> b) maximum demand controller c) soft starter d) eddy current drives
4.	Which of the following will not occur if a reciprocating compressor is operated at a lower discharge pressure? a) lower power consumption b) less load on the piston rods and hence reduced maintenance costs c) lower leakage losses <u>d) lower free air delivery than rated</u>

5.	<p>Which of the following statements is not true of maximum demand controller?</p> <p>a) switches off non-essential loads in logical sequence. b) alarm is sounded when demand approaches a preset value. <u>c) voltage level is closely regulated</u> d) plant equipment selected for the load management can be programmed</p>
6.	<p>Which of the following parameters is not required for evaluating volumetric efficiency of the compressor?</p> <p>a) FAD b) cylinder bore diameter c) stroke length <u>d) power input</u></p>
7.	<p>Which of the following is incorrect in the case of cooling towers ?</p> <p>a) "Range" is the difference between the cooling tower water inlet and outlet temperature. b) "Approach" is the difference between the cooling tower outlet cold water temperature and ambient wet bulb temperature. <u>d)'Range' is a better indicator of cooling tower performance.</u> e) Cooling capacity is the heat rejected in kcal/hr or TR</p>
8.	<p>Where transformer loading is known, the actual transformer loss at a given load can be computed as:</p> <p>a) No Load Loss+ (Actual kVA Load/rated kVA) X Load Loss <u>b) No Load Loss+ (Actual kVA Load/rated kVA)² X Load Loss</u> c) No Load Loss+ (Actual kVA Load/rated kVA) X Load Loss² d) [No Load Loss+{ (Actual kVA Load/rated kVA) X Load Loss}]²</p>
9.	<p>What is the reduction in distribution loss if the current flowing through the distribution line is reduced by 10% ?</p> <p>a)10% b) 90% <u>c) 19%</u> d) 81%</p>
10.	<p>Two energy auditors made following statements regarding vapour compression refrigeration system and what will be your judgement?</p> <p>Statement A: Reducing condensing temperature by 5.5°C, results in a 20 – 25% decrease in compressor power consumption Statement B: 5.5°C increase in evaporator temperature reduces compressor power consumption by 20 – 25%</p> <p>a) <u>statements A & B are True</u> b) statements A & B are False c) statement A is True & B is False d) statement A is False & B is True</p>
11.	<p>To optimize the voltage level fed to the lighting feeder, the best option is to install</p> <p>a) <u>servo stabilizer for lighting feeder</u> b) exclusive transformer for lighting c) microprocessor based controllers d) high frequency (HF) electronic ballasts</p>

12.	<p>The Solar Heat Gain Coefficient (SHGC) of window of a building is 0.30. This means that</p> <p>a) the window allows 70 % of the sun's heat to pass through into interior of the buildings b) <u>the window allows 30 % of the sun's heat to pass through into the building interior</u> 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</p>
13.	<p>The slip of a synchronous motor will be</p> <p>a) more than the induction motor b) less than the induction motor c) <u>zero</u> d) load dependent</p>
14.	<p>The refrigeration load in TR when 10 m³/hr of water is cooled from a 15 °C to 7 °C is about</p> <p>a) 10 b) 8 c) <u>26.5</u> d) none of the above</p>
15.	<p>The power factor of a squirrel cage induction motor</p> <p>a) <u>decreases at low motor loading</u> b) decreases at high motor loading c) remains constant and is independent of load d) cannot be predicted</p>
16.	<p>The power drawn by a centrifugal fan is</p> <p>a) <u>inversely proportional to fan efficiency</u> b) directly proportional to fan efficiency c) inversely proportional to static pressure d) inversely proportional to flow rate</p>
17.	<p>The order of movement of thermal energy in HVAC system is:</p> <p>a) <u>Indoor air - Chilled water - Refrigerant-Condenser water- Cooling tower</u> b) Chilled water - Indoor air - Refrigerant-Cooling tower - Condenser water c) Indoor air - Condenser water - Chilled water - Cooling tower - Refrigerant d) Indoor air - Chilled water – Refrigerant - Cooling tower - Condenser water</p>
18.	<p>The most energy intensive heat transfer loop of a vapour compression refrigeration system is:</p> <p>a) indoor air loop b) chilled water loop c) refrigerant loop d) <u>condenser water loop</u></p>
19.	<p>The main reason for using Variable Frequency Drive (VFD) for capacity control in electrical motor driven centrifugal fans with fluctuating load is :</p> <p>a) improved power quality b) <u>fan capacity is proportional to its speed whereas the power drawn by the fan is proportional to the cube of its speed</u> c) improved power factor d) precise closed loop process control</p>

20.	The hydraulic power in a pumping system depends on a) motor efficiency c) both motor and pump efficiency	b) pump efficiency d) <u>none of the above</u>
21.	The head developed by a centrifugal pump is not directly proportional to a) impeller diameter c) number of impellers	
	b) shaft speed d) <u>diameter of discharge port</u>	
22.	The frictional loss in a piping system is proportional to a) flow b) <u>flow²</u> c) 1/flow d) 1/flow ²	
23.	The electricity bill shows an average power factor of 0.72 with an average kW demand of 627. How much kVAR is required to improve the power factor to 0.95? (Given Data: $\tan \Phi_1 = 0.964$, $\tan \Phi_2 = 0.329$) a) <u>398</u> b) 144 c) 95 d) 627	
24.	The efficiency of compressed air system is around a) 90% b) 60% c) 50% d) 10%	
25.	The efficiency of a pump does not depend on a) suction head b) discharge head c) <u>motor efficiency</u> d) density of fluid	
26.	The basic function of air dryer in a compressed air system is to a) <u>remove remaining traces of moisture after the aftercooler</u> b) store and smoothen pulsating air output c) reduce the temperature of the air before it enters the next state to increase efficiency d) prevent dust from entering compressor	
27.	Small by-pass lines are installed in pumps some times to _____. a) increase flow c) <u>prevent pump running at zero flow</u> b) control pump delivery head d) reduce pump power consumption	
28.	Select the incorrect statement: a) harmonics occur as spikes at intervals which are multiples of the supply frequency b) harmonics are multiples of the fundamental frequency c) <u>induction motors are the major sources of harmonics</u> d) transformers operating near saturation level create harmonics	

29.	<p>Select the correct statement for reciprocating air compressors:</p> <p>a) for every 4 °C drop in the inlet air temperature, the increase in energy consumption is by 1%. b) for every 4 °C rise in the inlet air temperature, the decrease in energy consumption is by 1% c) <u>for every 4 °C rise in the inlet air temperature, the increase in energy consumption is by 1%</u> d) the energy consumption remains same irrespective of inlet air temperature</p>
30.	<p>Rewinding can affect which of the following factors that contribute to deterioration in motor efficiency:</p> <p>a) winding & slot design and winding material selection b) heat applied to strip windings which damages the insulation between laminations, thereby increasing eddy current losses c) change in the air gap may affect power factor and output torque d) <u>all the above</u></p>
31.	<p>Power factor is the ratio of</p> <p>a) $kVAr/kW$ b) $(kW^2+kVAr^2)^{1/2}/kW$ c) <u>$kW/(kW^2+kVAr^2)^{1/2}$</u> d) $kVAr/(kW^2+kVAr^2)^{1/2}$</p>
32.	<p>Normally, the efficiency of distribution transformer at full load varies anywhere between</p> <p>a) <u>96 to 99 %</u> b) 80 to 85 % c) 60 to 70% d) 50% to 60%</p>
33.	<p>It is possible to run pumps in parallel if their _____ are similar.</p> <p>a) suction heads b) discharge heads c) <u>closed valve heads</u> d) none of the above</p>
34.	<p>Input power to the motor driving a pump is 20 kW. The motor efficiency is 0.9 and pump efficiency is 0.7. The power transmitted to the water is</p> <p>a) <u>12.6 kW</u> b) 18.0 kW c) 14.0 kW d) 31.75 kW</p>
35.	<p>In BEE star labeled distribution transformers, which of following losses are defined?</p> <p>a) <u>total loss at 50% and 100% loading</u> b) total loss at 75 % loading c) total loss at 75% and 100% loading d) total loss at 100% loading</p>
36.	<p>In an induction motor, the loss which is independent of motor load is</p> <p>a) I^2R loss of stator b) I^2R loss of rotor c) <u>friction and windage loss</u> d) all of the above</p>

37.	<p>In a cooling tower, <u>Statement A:</u> Surface of heat exchange is the surface area of the water droplets, which is in contact with air. <u>Statement B:</u> Area of heat exchange is the surface area of the fill sheets, which is in contact with air.</p> <p>a) statements A & B are false b) statement A is True & B is false c) <u>statements A & B are True</u> d) statement A is false & B is True</p>
38.	<p>In a 22 kV feeder, if the voltage is raised from 22 kV to 66 kV for the same loading conditions, the voltage drop in the same feeder system would be lowered to</p> <p>a) 1/2 b) <u>1/3</u> c) 1/9 d) unpredictable value</p>
39.	<p>If the evaporation loss is 16 m³ /hr per cell and Cycles of Concentration is 3, the blow down requirement in m³ /hr per cell of a cooling tower will be</p> <p>a) <u>8</u> b) 5.33 c) 4 d) 2</p>
40.	<p>If measured line current of a 3 phase induction motor is 25.98 A, what will be the phase current?</p> <p>a) <u>15 A</u> b) 45 A c) 8.96 A d) 30 A</p>
41.	<p>Identify the wrong statement from the following regarding vapour compression refrigeration system</p> <p>a) condenser rejects heat to atmosphere b) evaporator removes heat from process or space c) compressor sends superheated vapor to condenser d) <u>high pressure sub-cooled liquid refrigerant returns back to evaporator</u></p>
42.	<p>Identify the correct statement:</p> <p>a) <u>the specific ratio of compressors is higher than blowers</u> b) the specific ratio of fans is higher than blowers c) the specific ratio of compressors is lower than fans d) the specific ratio of blowers is higher than compressors</p>
43.	<p>FRP fans consume less energy than aluminium fans because</p> <p>a) they are lighter b) <u>they have better efficiencies</u> c) they encounter less system resistance d) they deliver less air flow</p>
44.	<p>For the same flow, through which of the following diameter pipes, the pump will work with maximum pressure?</p> <p>a) <u>100 mm</u> b) 150 mm c) 200 mm d) 250 mm</p>

45.	Direct current motors are used in special applications where a) <u>high torque starting or where smooth acceleration over a broad speed range is required.</u> b) low torque starting or where steady acceleration over a narrow speed range is required. c) normal torque starting or where high acceleration over a broad speed range is required. d) low torque starting or where smooth acceleration over a broad speed range is required.
46.	Decreasing the rpm of a fan at partial loading by 10% results in: a) <u>decrease of 10% in flow rate and decrease of 27% in power requirement</u> b) decrease of 10% in flow rate and decrease of 19% in power requirement c) decrease of 10% in flow rate and increase of 10% in power requirement d) increase of 10% in flow rate and no appreciable change in power requirement
47.	Cycles of Concentration (C.O.C) of a cooling tower will depend on a) TDS in circulating water b) TDS in make-up water c) <u>both a & b</u> d) none of the above
48.	A 3-phase, 415 volts, 50 Hz, 100 kW, 6 pole squirrel cage induction motor with a rated slip of 2% will have a full load rotor speed of a) 1470 rpm b) <u>980 rpm</u> c) 1020 rpm d) none of the above
49.	A 2500 MW super thermal power station generated 15786 million units in the year 2011-12. Its Plant Load Factor (PLF) is: a) 60% b) 65% c) <u>72%</u> d) 79%
50.	A 1.5 TR room air conditioner having EER (W/W) of 3.0 , will draw input power of _____ kW a) <u>1.75</u> b) 3.00 c) 1.50 d) 2.00

Section – II: SHORT DESCRIPTIVE QUESTIONS

Marks: 8 x 5 = 40

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

S-1	List down any 5 energy conservation opportunities in compressed air system
Ans	§ Ensure air intake to compressor is not warm and humid by locating compressors in well-ventilated area or by drawing cold air from outside. Every 4 ⁰ C rise in air inlet temperature will increase power consumption by

	<p>1 percent.</p> <p>§ Clean air-inlet filters regularly. Compressor efficiency will be reduced by 2 percent for every 250 mm WC pressure drop across the filter.</p> <p>§ Keep compressor valves in good condition by removing and inspecting once every six months. Worn-out valves can reduce compressor efficiency by as much as 50 percent.</p> <p>§ Install manometers across the filter and monitor the pressure drop as a guide to replacement of element.</p> <p>§ Minimize low-load compressor operation; if air demand is less than 50 percent of compressor capacity, consider change over to a smaller compressor or reduce compressor speed appropriately (by reducing motor pulley size) in case of belt driven compressors.</p> <p>§ Consider the use of regenerative air dryers, which uses the heat of compressed air to remove moisture.</p> <p>§ Fouled inter-coolers reduce compressor efficiency and cause more water condensation in air receivers and distribution lines resulting in increased corrosion. Periodic cleaning of inter-coolers must be ensured.</p> <p>§ Compressor free air delivery test (FAD) must be done periodically to check the present operating capacity against its design capacity and corrective steps must be taken if required.</p> <p>§ If more than one compressor is feeding to a common header, compressors must be operated in such a way that only one small compressor should handle the load variations whereas other compressors will operate at full load.</p> <p>Any other relevant point</p>
<p>S-2</p>	<p>An energy audit of a fan was carried out. It was observed that the fan was delivering 18,500 Nm³/hr of air with static pressure rise of 50 mm WC. The power measurement of the 3-phase induction motor coupled with the fan recorded 2.9 kW/ phase on an average. The motor operating efficiency was assessed as 88% from the motor performance curves. What would be the fan static efficiency?</p>
<p>Ans</p>	<p> $Q = 18,500 \text{ Nm}^3 / \text{hr} = 5.13888 \text{ m}^3/\text{sec}$, $SP = 50 \text{ mmWC}$, $\eta_{st} = ?$, Power input to motor= $2.9 \times 3 = 8.7 \text{ kW}$ </p>

	<p>Power input to fan shaft=8.7 x0.88=7.656 kW</p> $\text{Fan static } \eta = \frac{\text{Volume in m}^3/\text{sec} \times \Delta P_{st} \text{ in mmWc}}{102 \times \text{Power input to shaft}}$ $= \frac{5.13888 \times 50}{102 \times 7.656}$ $= 0.329$ $= 32.9\%$																																				
S-3	<p>A DG set is operating at 700 kW load with 450°C exhaust gas temperature. The DG set generates 7.8 kg of exhaust gas/ kWh generated. The specific heat of gas at 430°C is 0.25 kCal/ kg°C. A heat recovery boiler is installed after which the exhaust temperature drops to 220°C. How much steam will be generated at 3 kg/ cm² with enthalpy of 650.57 kcal/ kg. Assume boiler feed water temperature as 30°C.</p>																																				
Ans	<p>= 700 kWh x 7.8 kg gas generated/ kWh output x 0.25 kCal/ kg °C x (450°C-220 °C) =3,13,950 kCal/hr</p> <p>Steam generation = 3,13,950 kCal/hr / (650.57 – 30) = 506 kg/ hr.</p>																																				
S-4	<p>Compute AT & C (Aggregate Technical and Commercial) Losses for the following data:</p> <table border="1" style="width: 100%; border-collapse: collapse;"> <thead> <tr> <th style="width: 10%;">S. No.</th> <th style="width: 60%;">Description</th> <th style="width: 30%;">Annual Data</th> </tr> </thead> <tbody> <tr> <td>1</td> <td>Input Energy = (Import-Export), MU</td> <td>10</td> </tr> <tr> <td>2a</td> <td>Energy Billed (Metered), MU</td> <td>7</td> </tr> <tr> <td>2b</td> <td>Energy Billed (Un-Metered), MU</td> <td>1</td> </tr> <tr> <td>2c</td> <td>Total Energy Billed (E1 + E2)</td> <td>8</td> </tr> <tr> <td>3</td> <td>Amount Billed (Rs. lakhs)</td> <td>450</td> </tr> <tr> <td>4a</td> <td>Gross Amount Collected (Rs. lakhs)</td> <td>460</td> </tr> <tr> <td>4b</td> <td>Arrears Collected (Rs. lakhs)</td> <td>40</td> </tr> </tbody> </table>	S. No.	Description	Annual Data	1	Input Energy = (Import-Export), MU	10	2a	Energy Billed (Metered), MU	7	2b	Energy Billed (Un-Metered), MU	1	2c	Total Energy Billed (E1 + E2)	8	3	Amount Billed (Rs. lakhs)	450	4a	Gross Amount Collected (Rs. lakhs)	460	4b	Arrears Collected (Rs. lakhs)	40												
S. No.	Description	Annual Data																																			
1	Input Energy = (Import-Export), MU	10																																			
2a	Energy Billed (Metered), MU	7																																			
2b	Energy Billed (Un-Metered), MU	1																																			
2c	Total Energy Billed (E1 + E2)	8																																			
3	Amount Billed (Rs. lakhs)	450																																			
4a	Gross Amount Collected (Rs. lakhs)	460																																			
4b	Arrears Collected (Rs. lakhs)	40																																			
Ans	<table border="1" style="width: 100%; border-collapse: collapse;"> <thead> <tr style="background-color: #ADD8E6;"> <th colspan="4">Estimation of AT & C Losses</th> </tr> <tr> <th style="width: 10%;">S. No.</th> <th style="width: 60%;">Description</th> <th style="width: 20%;"></th> <th style="width: 10%;">Annual Data</th> </tr> </thead> <tbody> <tr> <td>1</td> <td>Input Energy = (Import-Export), MU</td> <td>Ei</td> <td>10</td> </tr> <tr> <td>2a</td> <td>Energy Billed (Metered), MU</td> <td>E1</td> <td>7</td> </tr> <tr> <td>2b</td> <td>Energy Billed (Un-Metered), MU</td> <td>E2</td> <td>1</td> </tr> <tr> <td>2c</td> <td>Total Energy Billed (E1 + E2)</td> <td>Eb</td> <td>8</td> </tr> <tr> <td>3</td> <td>Amount Billed (Rs. lakhs)</td> <td>Ab</td> <td>450</td> </tr> <tr> <td>4a</td> <td>Gross Amount Collected (Rs. lakhs)</td> <td>AG</td> <td>460</td> </tr> <tr> <td>4b</td> <td>Arrears Collected (Rs. lakhs)</td> <td>Ar</td> <td>40</td> </tr> </tbody> </table>	Estimation of AT & C Losses				S. No.	Description		Annual Data	1	Input Energy = (Import-Export), MU	Ei	10	2a	Energy Billed (Metered), MU	E1	7	2b	Energy Billed (Un-Metered), MU	E2	1	2c	Total Energy Billed (E1 + E2)	Eb	8	3	Amount Billed (Rs. lakhs)	Ab	450	4a	Gross Amount Collected (Rs. lakhs)	AG	460	4b	Arrears Collected (Rs. lakhs)	Ar	40
Estimation of AT & C Losses																																					
S. No.	Description		Annual Data																																		
1	Input Energy = (Import-Export), MU	Ei	10																																		
2a	Energy Billed (Metered), MU	E1	7																																		
2b	Energy Billed (Un-Metered), MU	E2	1																																		
2c	Total Energy Billed (E1 + E2)	Eb	8																																		
3	Amount Billed (Rs. lakhs)	Ab	450																																		
4a	Gross Amount Collected (Rs. lakhs)	AG	460																																		
4b	Arrears Collected (Rs. lakhs)	Ar	40																																		

	4c	Amount Collected without Arrears (Rs. lakhs)	$A_c = A_G - A_r$	420
	5	Billing Efficiency (BE)	$= E_b / E_i * 100\%$ 8/10	80%
	6	Collection Efficiency (CE)	$= A_c / A_b * 100\%$ 420/450	93.3%
	7	AT& C Loss	$\{ 1 - (BE * CE) * 100\%$	25.36%
S-5	Explain briefly the difference between static and dynamic head of a centrifugal pumping system.			
	<p>Static head is simply the difference in height of the supply and destination reservoirs and it is independent of flow.</p> <p>Dynamic head is the friction loss, on the liquid being moved, in pipes, valves and equipment in the system. The friction losses are proportional to the square of the flow rate.</p>			
S-6	How do the Time-Of-Day (TOD) metering and billing benefit the utilities as well as consumers?			
Ans	<p>ToD meter records demand, time, and energy and the ToD tariff are set in such a way that higher rates at peak load periods and lower rates at off-peak load periods. The billing as per ToD tariff benefits the consumers to avail maximum power and energy at off-peak hours at lowest tariff; and the higher peak period tariff dis-incentivise for increased drawl at peak period. This results effective maximum demand reduction to the utility, and in turn savings in peak time power procurement at higher rate as well as maximising the load factor for resulting better financials to the utility.</p>			
S-7	A pump is delivering 64 m ³ /hr of water with a discharge head of 26 metres. The water is drawn from a sump where water level is 3 metres below the pump centerline. The power drawn by the motor is 8.89 kW at 84% motor efficiency. Find out the pump efficiency			
Ans	<p>Hydraulic power $P_h = Q (m^3/s) \times \text{Total head, } h_d - h_s (m) \times \rho (kg/m^3) \times g (m/s^2) / 1000$</p> <p>$Q = 64/3600 m^3/s, h_d - h_s = 26 - (-3) = 29 m$</p> <p>Hydraulic power $P_h = (64/3600) \times 29 \times 1000 \times 9.81 / 1000$</p> <p style="text-align: center;">$= 5.0576 kW$</p> <p>Pump shaft power $= 8.89 kW \times 0.84$</p>			

	$= 7.47 \text{ kW}$ <p>Pump efficiency = hydraulic power / pump shaft power</p> $= 5.0576 / 7.47$ $= 67.7\%$
S-8	LIST any five industrial applications of a heat pump.
Ans	<p>Industrial heat pumps are mainly used for:</p> <ol style="list-style-type: none"> 1. Space heating 2. Heating of process streams 3. Water heating for washing, sanitation and cleaning 4. Steam production 5. Drying/dehumidification 6. Evaporation 7. Distillation 8. Concentration

----- 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	<p>a) In a cooling tower, the cooling water circulation rate is $1200 \text{ m}^3/\text{hr}$. The water enters the cooling tower at 35°C. The ambient wet bulb temperature is 26°C. The cooling tower operates with an approach of 4°C. If the blowdown rate of the cooling tower is 1 % of the circulation rate, calculate the evaporation loss in m^3/hr and COC.</p> <p>b) A medium scale industry has a load of 400 kVA. It has installed two transformers of 500 kVA each. The no load loss and full load copper loss are 760 W and 5400 W respectively. From the energy efficiency point of view the management wants to take a decision on whether to operate a single transformer on full load or two transformers equally sharing the load. What is your recommendation ? Why?</p>
------------	--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------

Ans	<p>a) Leaving cold water temperature = 26 + 4 = 30°C Evaporation Loss (m³/hr) = 0.00085 x 1.8 x circulation rate (m³/hr) x (T₁ - T₂)</p> $= 0.00085 \times 1.8 \times 1200 \times 5$ $= 9.18 \text{ m}^3/\text{hr}$ <p>Blowdown (1 % of 1200) = 12 m³/hr</p> <p>Blowdown = Evaporation loss / (COC - 1)</p> $12 = \frac{9.18}{(\text{COC} - 1)}$ $\text{COC} = 1.765$ <p>b)</p> <table border="1" style="width: 100%; border-collapse: collapse; margin-bottom: 10px;"> <tr> <td style="width: 50%; padding: 2px;">1 x 500 kVA</td> <td style="width: 50%;"></td> </tr> <tr> <td style="padding: 2px;">Transformer loss at 400</td> <td style="padding: 2px;">No load loss + [kVA load/Rated kVA]² x full load loss</td> </tr> <tr> <td style="padding: 2px;"></td> <td style="padding: 2px;">{760 + [400/500]² x 5400}</td> </tr> <tr> <td style="padding: 2px;"></td> <td style="padding: 2px;">760 + 3456</td> </tr> <tr> <td style="padding: 2px;"></td> <td style="padding: 2px;">4216 W</td> </tr> <tr> <td style="padding: 2px;">2 x 500 at 200 kVA each</td> <td style="padding: 2px;">2 x {760 + [200/500]² x 5400}</td> </tr> <tr> <td style="padding: 2px;"></td> <td style="padding: 2px;">2 (760+864)</td> </tr> <tr> <td style="padding: 2px;"></td> <td style="padding: 2px;">3248 W</td> </tr> </table> <p style="text-align: center;">Two transformers are better because the losses are the least.</p>	1 x 500 kVA		Transformer loss at 400	No load loss + [kVA load/Rated kVA] ² x full load loss		{760 + [400/500] ² x 5400}		760 + 3456		4216 W	2 x 500 at 200 kVA each	2 x {760 + [200/500] ² x 5400}		2 (760+864)		3248 W
1 x 500 kVA																	
Transformer loss at 400	No load loss + [kVA load/Rated kVA] ² x full load loss																
	{760 + [400/500] ² x 5400}																
	760 + 3456																
	4216 W																
2 x 500 at 200 kVA each	2 x {760 + [200/500] ² x 5400}																
	2 (760+864)																
	3248 W																
L-2	<p>The measured values of a water cooled 20 TR package air conditioning plant are given below: Average air velocity across suction side filter: 2.5 m/s Cross Sectional area of suction: 2.4 m² Inlet air : Dry Bulb:20 deg. C, Wet Bulb: 14 deg. C; Enthalpy: 9.37 k Cal per kg Outlet air: Dry Bulb: 12.7 deg. C, Wet Bulb: 11.3 deg. C; Enthalpy: 7.45 k Cal per kg Specific volume of Air: 0.85 m³/kg Power drawn: by Compressor : 19.52 k W by Pump : 2.1 k W by Evaporator Fan : 1.25 k W</p>																

	<p>Calculate the following:</p> <ol style="list-style-type: none"> i. Air Flow rate ii. Cooling effect delivered iii. Compressor kW/TR iv. Overall kW/TR v. Overall Energy Efficiency ratio in W/W
<p>Ans</p>	<ol style="list-style-type: none"> i. Air flow rate = $2.5 \times 2.4 = 6 \text{ m}^3/\text{sec} = 21600 \text{ m}^3/\text{hr}$ ii. Cooling Effect delivered = $[(9.37-7.45) \times 21600] / (0.85 \times 3024) = 16.13 \text{ TR}$ iii. Compressor kW/TR = $19.42 / 16.13 = 1.2$ iv. Overall kW/TR = $(19.42 + 2.1 + 1.25) / 16.13 = 1.41$ v. Overall Energy Efficiency Ratio(EER) in W/W = $16.13 \times 3.51 / (19.42 + 2.1 + 1.25) = 2.486$
<p>L-3</p>	<p>Fill in the blanks for the following</p> <ol style="list-style-type: none"> 1. A motor which can conveniently be operated at lagging as well as leading power factors is the _____ motor 2. A 50 Hz, 3-phase induction motor has a full load speed of 1440 r.p.m. The number of poles of the motor are _____ 3. In a centrifugal pump the velocity energy is converted to pressure energy by _____ 4. In a centrifugal pump if the liquid to be pumped has density twice that of water, then the horse power required (as compared to that while pumping water) will be _____ times 5. The friction loss in a pipe carrying a fluid is proportional to the fifth power of _____ 6. A 10 MVA generator has power factor 0.866 lagging. The reactive power produced will be _____ MVAR 7. Totally-enclosed, fan cooled (TEFC) motors are _____ efficient than Screen – protected, drip-proof (SPDP) induction motors 8. Low speed Squirrel cage induction motors are normally _____ efficient than high speed squirrel cage induction motors 9. Harmonics in electricity supply are multiples of the _____ frequency 10. For the same rating, slip ring induction motors are normally _____ efficient than squirrel cage induction motors

<p>ANS</p>	<ol style="list-style-type: none"> 1. Synchronous 2. 4 3. volute 4. 2 5. pipe diameter 6. 5 7. more 8. less 9. fundamental 10. less
<p>L-4</p>	<p>Answer any two of the following :</p> <ol style="list-style-type: none"> a) two most important electrical parameters, which are to be monitored for safe operation of Diesel Generator set b) Slip method of motor load assessment c) Five options for electricity distribution loss optimization d) Five energy conservation opportunities in pumping system
<p>Ans</p>	<p>a) two most important electrical parameters, which are to be monitored for safe operation of Diesel Generator set</p>
	<p>KVA and kW</p>
	<p>b) Slip method of motor load assessment</p>
	<p>In the absence of a power meter, the slip method can be used which requires a tachometer. The percentage loading can be calculated as follows:</p> $Load = \frac{Slip}{S_s - S_r} * 100\%$ <p>Where: Load = Output power as a % of rated power Slip = Synchronous speed - Measured speed in rpm S_s = Synchronous speed in rpm at the operating frequency S_r = Nameplate full-load speed</p> <p>Slip also varies inversely with respect to the motor terminal voltage squared. A voltage correction factor can, also, be inserted into the slip load equation. The voltage compensated load can be calculated as shown</p> $Load = \frac{Slip}{(S_s - S_r) \times (V_r / V)^2} \times 100\%$ <p>Where:</p>

	<p> Load = Output power as a % of rated power Slip = Synchronous speed - Measured speed in rpm S_s = Synchronous speed in rpm S_r = Nameplate full-load speed V = RMS voltage, mean line to line of 3 phases V_r = Nameplate rated voltage </p>
	<p>c) Five options for electricity distribution loss optimization</p>
	<ul style="list-style-type: none"> • minimising length of distribution lines • adequate Size of Conductors • installaing Distribution Transformers (DTR) at load center on the Secondary Distribution System • Maintaining high Power Factor • High Voltage Distribution System (HVDS) • Incorporating Amorphous Core Transformers <p>Any other relevant point</p>
	<p>d) Five energy conservation opportunities in pumping system</p>
	<ul style="list-style-type: none"> • Ensure adequate NPSH at site of installation • Operate pumps near best efficiency point. • Modify pumping system/pumps losses to minimize throttling. • Adapt to wide load variation with variable speed drives • Stop running multiple pumps - add an auto-start for an on-line spare or add a booster pump in the problem area. • Conduct water balance to minimise water consumption • Replace old pumps by energy efficient pumps <p>Any other relevant point</p>
L-5	<p>a) How do you calculate the velocity of air/gas in a duct using the average differential pressure and density of the air/gas?</p> <p>b) A no load test was conducted in a delta connected 37 kW induction motor.</p> <p><u>Nameplate data-</u> 3 Phase, 415 V, 50 Hz, 55 Amp</p> <p><u>Measured data at no load:</u></p> <p>Voltage, V = 415 Volts; Current, I = 17 Amps; Frequency, F = 50 Hz; Stator phase resistance at 30°C = 0.24 Ohms/ phase No load power = 925 Watts</p>

	<p>i. Find out Iron Loss plus Friction Loss plus Windage Loss</p> <p>ii. Stator Copper Loss at name plate ratings(full load), considering stator temperature =120 °C</p> <p>iii. No load power factor of the motor</p>
<p>Ans</p>	<p>a) Ans:</p> $\text{Velocity } V, \text{ m/s} = \frac{C_p \times (2 \times 9.81 \Delta p \times y)^{1/2}}{y}$ <p>C_p = Pitot tube constant, 0.85 (or) as given by the manufacturer Δp = Average differential pressure measured by pitot tube by taking measurement at number of points over the entire cross section of the duct. γ = Density at air/ gas at test condition</p> <p>b) Let Iron Loss plus Friction Loss plus Windage Loss be P_{i+fw} Stator Copper Loss, $P_{st}, 30^\circ\text{C} = 3X (17/\sqrt{3})^2 X 0.24 = 69.36 \text{ Watt}$ $P_{i+fw} = P_{nl} - P_{st} = 925 - 69.36 = 855.64$</p> <p>Stator resistance at 120 °C = $0.24x[(120+235)/(30+235)] = 0.322 \text{ Ohms}$ Stator Copper Loss at name plate ratings = $3x(55/\sqrt{3})^2 X 0.322 = 974.05 \text{ Watt}$ No load power factor = $925/(1.7321x415x17)=0.0757$</p>
<p>L-6</p>	<p>a) Calculate the free air delivery (FAD) in m^3/min of a compressor for the following observed data:</p> <p>Receiver capacity : 0.25 m^3</p> <p>Initial pressure : 1 kg/cm^2 (g)</p> <p>Final pressure : 7 kg/cm^2 (g)</p> <p>Initial temperature : 32 °C</p> <p>Final temperature : 72 °C</p> <p>Additional holdup volume: 0.05 m^3</p> <p>Compressor pump up time: 2.1 minutes</p> <p>b) Identify the following statements as applicable to Vapor Compression Refrigeration System (VCR) or to Vapor Absorption Refrigeration System(VAR).</p> <p>I. The system operates under vacuum - _____(VCR/VAR)</p> <p>II. Uses water as a refrigerant - _____(VCR/VAR)</p> <p>III. Uses large amount of high-grade energy - _____(VCR/VAR)</p> <p>IV. COP decreases considerably with decrease in evaporator pressure - _____(VCR/VAR)</p>

	<p>V. The system can work on lower evaporator pressures also without affecting the COP - _____(VCR/VAR)</p>
Ans	$Q = \frac{P_2 - P_1}{P_0} \times \frac{V}{t} \times \left(\frac{273 + t_1}{273 + t_2} \right)$ $= \frac{7 - 1}{1.026} \times \frac{(0.25 + 0.05)}{2.1} \times \left(\frac{273 + 32}{273 + 72} \right)$ $= \mathbf{0.738 \text{ m}^3/\text{min}}$ <p>I. The system operates under vacuum VAR II. Uses water as a refrigerant VAR III. Using large amount of high-grade energy VCR IV. The COP decreases considerably with decrease in evaporator pressure. VCR V. The system can work on lower evaporator pressures also without affecting the COP VAR</p>