NATIONAL CERTIFICATION EXAMINATION 2004
FOR
ENERGY AUDITORS

PAPER – EA3: Energy Efficiency in Electrical Utilities

Date: 23.05.2004 Timings: 0930-1230 HRS Duration: 3 HRS Max. Marks: 150

General instructions:

- *Please check that this question paper contains **7** printed pages*
- *Please check that this question paper contains **65** 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**

(i) Answer all **50** questions
(ii) Each question carries **one** mark
(iii) Put a (√) tick mark in the appropriate box in the answer book

1.	In electricity distribution, if the voltage is raised from 11 kV to 22 kV for the same loading conditions, the voltage drop in the distribution system would be lower by a factor of a) 1/2 b) 1/4 c) 1/16 d) none of the above
2.	If the voltage level of the electricity distribution system is raised from 11 kV to 33 kV for the same loading conditions, the distribution losses are reduced by a factor of a) 1/3 b) 1/6 c) 1/9 d) none of the above
3.	If the reactive power drawn by a particular load is zero, it means the load is operating at a) unity power factor b) lagging power factor c) leading power factor d) none of the above
4.	Select the location of installing capacitor bank, which will reduce the electricity distribution losses to the maximum extent a) main sub-station bus bars b) distribution board bus bars c) motor control centre d) motor terminals
5.	A six pole induction motor operating at 50 Hz, will have a synchronous speed of a) 1500 RPM b) 1450 RPM c) 1000 RPM d) 960 RPM

6.	The nearest kVAr compensation required for improving the power factor of a 500 kW load from 0.8 lag to unity power factor is a) 375 kVAr b) 400 kVAr c) 500 kVAr d) none of the above
7.	A power factor capacitor designed for 5 kVAr at 415 V was found to be operating at 430 V. The effective capacity of the capacitor would be a) 5.181 kVAr b) 4.657 kVAr c) 5.367 kVAr d) none of the above
8.	The percentage increase in power consumption of a compressor with suction side air filter pressure drop of 250 mmWC is closest to a) 0.5% b) 2% c) 3% d) 4%
9.	A six pole induction motor operating at 50 Hz, with 1.2% slip will run at an actual speed of a) 880 RPM b) 988 RPM c) 1000 RPM d) none of the above
10.	With increase in design speed of induction motors the required capacitive kVAr for reactive power compensation for the same capacity range will a) increase b) decrease c) not change d) none of the above
11.	PF capacitor installed at the motor starter location will improve a) motor operating power factor from the starter to the motor terminals side b) motor operating power factor from the starter to the power supply side c) motor design power factor d) all of the above.
12.	For every 4°C reduction in the air inlet temperature of an air compressor, the power consumption will normally decrease by….. percentage points for the same output. a) 4 b) 3 c) 2 d) 1
13.	The acceptable pressure drop in the distribution system at the farthest point of an industrial compressed air network is a) 2.0 bar b) 1.0 bar c) 0.5 bar d) 0.3 bar
14.	The kW rating indicated on the name plate of an induction motor indicates a) rated output of the motor b) rated input of the motor c) maximum instantaneous input power of the motor d) maximum input power which the motor can draw
15.	A 500 cfm compressor has a loading and unloading period of 10 seconds and 20 seconds respectively during a compressed air leakage test. The air leakage in the compressed air system would be a) 166.6 cfm b) 250 cfm c) 333.3 cfm d) none of the above
16.	Higher chiller COP can be achieved with a) higher evaporator temperature and higher condensing temperature b) lower evaporator temperature and higher condensing temperature c) lower evaporator temperature and lower condensing temperature d) none of the above

17.	Squirrel cage induction motors, in general, have a …… design efficiency in comparison with the slip ring induction motors for similar ratings a) lower b) higher c) same d) none of the above
18.	One ton of refrigeration (TR) is equal to a) 4.51 kW b) 3024 kcal/hr c) 1,20,000 BTU/hr d) all of the above
19.	Approximate percentage reduction in power consumption with 1 °C rise in evaporator temperature in refrigerating systems is a) 1% b) 2% c) 3% d) 4%
20.	The refrigerant used in vapour absorption systems is a) pure water b) steam c) freon d) lithium bromide
21.	Li – Br water absorption refrigeration systems have a COP in the range of a) 0.4 – 0.5 b) 0.65 – 0.70 c) 0.75 – 0.80 d) none of the above
22.	Vertical type reciprocating compressors are used in the capacity range of a) 50 – 150 cfm b) 200 – 500 cfm c) 500 - 1000 cfm d) above 1000 cfm
23.	If the speed of a pump is doubled, pump shaft power goes up by a) 2 times b) 6 times c) 8 times d) 4 times
24.	The outer tube connection of the pitot tube is used to measure …… in the fan system a) static pressure b) velocity pressure c) total pressure d) dynamic pressure
25.	System resistance in water pumping system varies with a) square of flow rate b) cube of flow rate c) square root of flow rate d) none of the above
26.	If the speed of a pump is doubled, the pump head goes up by a) 2 times b) 4 times c) 8 times d) 16 times
27.	Friction loss in a piping system carrying fluid is proportional to a) $\frac{1}{\text{fluid flow}}$ b) $\frac{1}{(\text{fluid flow})^2}$ c) fluid flow d) $(\text{fluid flow})^2$
28.	Shaft power of the motor driving a pump is 20 kW. The motor efficiency is 0.9 and pump efficiency is 0.6. The power transmitted to the water is a) 10.8 kW b) 12.0 kW c) 18.0 kW d) none of the above

29.	If inlet and outlet water temperatures of a cooling tower are 39°C and 32°C respectively and atmospheric DBT and WBT are 35 °C and 30 °C respectively then the range of cooling tower is a) 4°C b) 5°C c) 7°C d) 9°C
30.	For fans, the relation between flow discharge Q and speed N is a) $\frac{Q_1}{Q_2} = \frac{N_1}{N_2}$ b) $\frac{Q_1}{Q_2} = \frac{N_1^2}{N_2^2}$ c) $\frac{Q_1}{Q_2} = \frac{N_1^3}{N_2^3}$ d) none of the above
31.	Which of the following ambient conditions will evaporate maximum amount of water in a cooling tower a) 35 °C DBT and 25 °C WBT b) 40°C DBT and 38°C WBT c) 35 °C DBT and 28 °C WBT d) 38 °C DBT and 37 °C WBT
32.	The lowest theoretical temperature to which water can be cooled in a cooling tower is a) WBT of the atmospheric air b) DBT of the atmospheric air c) average DBT and WBT of the atmospheric air d) difference between DBT and WBT of the atmospheric air
33.	Cooling tower effectiveness is a) range/ (range + approach) b) approach / (range + approach) c) approach / range d) none of the above
34.	Normally a manufacturer's guaranteed best approach of a cooling tower is a) 2.8 °C b) 5 °C c) 8 °C d) 12 °C
35.	In general, design chilled water temperature drop across chillers is approximately a) 1 °C b) 5 °C c) 10 °C d) 15 °C
36.	GLS lamp is a) general lighting service lamp b) general lighting source lamp c) glow light source lamp d) glow light service lamp
37.	Luminous efficacy of which of the following is the highest? a) CFL b) HPMV c) LPSV d) HPSV
38.	The unit of illuminance is a) lux b) luminaire c) lumens d) none of the above
39.	What is the typical frequency of a high frequency electronic ballast? a) 50 Hz b) 10 kHz c) 30 kHz d) 50 kHz
40.	If voltage is reduced from 230 V to 210 V for a fluorescent tube light, it will result in a) increased power consumption b) reduced power consumption c) increased light levels d) no change in power consumption and light levels

41.	The maximum unbalanced load between phases should not exceed …… % of the capacity of the DG set a) 1 b) 5 c) 10 d) none of the above
42.	The rated efficiency of a diesel generator captive power plant has a range of a) 43% – 45% b) 50% – 60% c) 60% – 70% d) above 70%
43.	The compression ratio in diesel engines is in the range of a) 5:1 to 10:1 b) 10:1 to 13:1 c) 14:1 to 25:1 d) none of the above
44.	The operating efficiency of a DG set also depends on a) inlet air temperature b) turbo charger performance c) % loading d) all of the above
45.	The exhaust gas waste heat recovery potential of a turbo charged genset at 500 kW loading and 480^{o}C exhaust gas is closest to …… (Assume exit gas temperature of 180^{o}C and 8 kg gas/ kWh generated) a) 1.6 lakh kCal/hr b) 2.2 lakh kCal/hr c) 3.0 lakh kCal/hr d) 3.5 lakh kCal/hr
46.	The basic functions of an electronic ballast fitted to a fluorescent tube light exclude one of the following a) to ignite the lamp b) to stabilize the gas discharge c) to supply power to the lamp at supply frequency d) to supply power to the lamp at very high frequency
47.	The core losses of a transformer are the least if the core is made up of a) silicon alloyed iron (grain oriented) b) copper c) amorphous core – metallic glass alloy d) none of the above
48.	Maximum demand controller is used to a) switch off non-essential loads in a logical sequence b) switch off essential loads in a logical sequence c) controls the power factor of the plant d) all of the above.
49.	The nearest kVA rating required for a DG set with 1000 kW connected load, with diversity factor of 1.5 and 84% loading and 0.8 power factor is a) 2000 kVA b) 1500 kVA c) 1000 kVA d) 500 kVA
50.	Modern electronic soft starters are used for motors to a) achieve variable speed b) provide smooth start and stop c) improve the loading d) none of the above

……. End of Section – I …….

Section – II: SHORT DESCRIPTIVE QUESTIONS

Marks: 10 x 5 = 50

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

S-1. Calculate the transformer total losses for an average loading of 80%. Assume no load and full load losses as 0.9 kW and 7.3 kW respectively.

S-2. A consultant works out the percentage loading of a particular induction motor as a ratio of current drawn to the rated current of the motor. Do you agree with the above methodology adopted by the consultant? Justify your answer with reasons.

S-3. How does efficiency and power factor of an induction motor changes with the variation in the applied load on the motor? Draw a curve depicting efficiency and power factor vs percentage loading of the motor.

S-4. A fan is operating at 800 RPM developing a flow of 3000 Nm^3/hr. at a static pressure of 600 mmWC. What will be the flow and static pressure if the speed is reduced to 600 RPM.

S-5. How do you calculate the TR across Air Handling Units (AHU)?

S-6. In a cooling tower, the Cycle of Concentration (C.O.C) is 3 and evaporation losses are 1%. The circulation rate is 1500 m^3 /min. Find out the blow down quantity required for maintaining the desired level of dissolved solids in the cooling water.

S-7. What are the various methods of flow control in centrifugal pumps?

S-8. How are energy savings achieved through electronic ballast in a fluorescent tube light in comparison to the conventional magnetic ballast?

S-9. Whether it is advisable to install a servo transformer for controlling the operating voltage of the lighting circuit? Justify your answer.

S-10. A 2.0 MW DG set with an average load of 1.5 MW running in parallel with the grid was found to be exporting 80 kVAr. Without calculating, explain what could be the possible reasons for the export of reactive power to the grid. List advantages/disadvantages of the above situation.

……. End of Section - II …….

Section – III: LONG DESCRIPTIVE QUESTIONS **Marks: 5 x 10 = 50**

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

L-1. A plant has 2 identical 1000 kVA transformers. The plant average load is 700 kVA and has never exceeded 900 kVA in the past.

(a) Compare the transformer losses when single transformer is in operation and when both transformers are in parallel operation.

(b) What would you like to advise to the plant's management on transformer operation keeping in view the energy saving potential, reliability and safety of the system.

Assume no load loss of 2.1 kW and full load copper loss of 12 kW for each transformer.

L-2. A centrifugal pump is delivering 60 m^3/s of water at a discharge pressure of 3 kg/cm^2g. The pump suction is 2 meter below the pump center line. Find out the power drawn by the motor if the pump efficiency is 70% and motor efficiency is 90%.

L-3. A compressed air leakage test was conducted in an engineering industry, which employs a 500 cfm reciprocating compressor. The compressed air system is maintained at the normal loading-unloading settings of 6.2 kg / cm^2g and 7 kg / cm^2g respectively. The following was observed for a period of 10 minutes trial:

On load time = 50 secs
Unload time = 110 secs.

Subsequently some of the air leakage points were attended and the leakage test was repeated. The following was observed while maintaining the same loading & unloading pressure settings and trial period:

On load time = 30 secs
Unload time = 130 secs.

The average power drawn during the above 2 trials was observed as 70 kW during load and 15 kW during unload condition. Calculate the annual cost savings for 4000 hr/ year of compressor operation. Assume energy charge of Rs. 4.50 per kWh.

L-4. List 10 energy saving opportunities in fan systems.

L-5. Briefly explain the step by step approach for the conduct of energy audit of vapour compression refrigeration unit.

……. End of Section – III …….