Sustainable and Renewable Energy Development Authority (SREDA)

Power Division, Ministry of Power, Energy and Mineral Resources

4th Energy Auditor Certification Examination-2023

Paper- 4

Candidate's Roll No. | 2 | 0 | 2 | 3 | 0 | 5 | | | |

Invigilator's Signature

Examinee's Name _____

B

Paper 4: Energy Performance Assessment for Equipment & Utility Systems
Total Marks- 100, Time- 3.00 Hours, Date: 26 May 2023

Invigilator's Signature

- Important Instruction:

1. This Paper has 20 MCQs + 4 Short Questions + 6 Long Questions = 30 Questions.
2. Mark indicated on the right side of each question.
3. Fill in correct circle with permanent ink ballpoint pen shown on the top sheet only corresponding to the MCQ given in Section A.
4. Answer in the blank space provided after each question (short/long).
5. Do not put any sign or write anything on the answer script except written answer.
6. Any unfair means, peer talking, keeping any communication device and misbehavior will lead to cancellation of examination.

MCQ Answer (Section A):

1	Ⓐ	Ⓑ	Ⓒ	Ⓓ	8	Ⓐ	Ⓑ	Ⓒ	Ⓓ	15	Ⓐ	Ⓑ	Ⓒ	Ⓓ
2	Ⓐ	Ⓑ	Ⓒ	Ⓓ	9	Ⓐ	Ⓑ	Ⓒ	Ⓓ	16	Ⓐ	Ⓑ	Ⓒ	Ⓓ
3	Ⓐ	Ⓑ	Ⓒ	Ⓓ	10	Ⓐ	Ⓑ	Ⓒ	Ⓓ	17	Ⓐ	Ⓑ	Ⓒ	Ⓓ
4	Ⓐ	Ⓑ	Ⓒ	Ⓓ	11	Ⓐ	Ⓑ	Ⓒ	Ⓓ	18	Ⓐ	Ⓑ	Ⓒ	Ⓓ
5	Ⓐ	Ⓑ	Ⓒ	Ⓓ	12	Ⓐ	Ⓑ	Ⓒ	Ⓓ	19	Ⓐ	Ⓑ	Ⓒ	Ⓓ
6	Ⓐ	Ⓑ	Ⓒ	Ⓓ	13	Ⓐ	Ⓑ	Ⓒ	Ⓓ	20	Ⓐ	Ⓑ	Ⓒ	Ⓓ
7	Ⓐ	Ⓑ	Ⓒ	Ⓓ	14	Ⓐ	Ⓑ	Ⓒ	Ⓓ					

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MCQ	:	[ ]	
Short Question	:	[ ]	
Long Question	:	[ ]	
Total Marks	:	[ ]	Signature of Examiner

Do not write or mark anything in this page

Section A: MCQ

Fill the appropriate circle in the OMR answer sheet at the top page. [1 x 20 =20]

1 Which of the following is not a part of vapor absorption refrigeration cycle

A) compressor
C) condenser
B) evaporator
D) generator

2 Which of the following parameters is not required for evaluating volumetric efficiency of the compressor?

A) FAD
C) Stroke length
B) Cylinder bore diameter
D) Power input

3 Higher chiller COP can be achieved with

A) higher evaporator temperature and higher condensing temperature
C) lower evaporator temperature and higher condensing temperature
B) higher evaporator temperature and lower condensing temperature
D) lower evaporator temperature and lower condensing temperature

4 The effect of increasing the air gap in an induction motor will increase

A) power factor
C) capacity
B) speed
D) magnetizing current

5 Installing larger diameter pipe in pumping system results in reduction in

A) Static head
C) Both (A) and (B)
B) Dynamic head
D) None of the above

6 Kg of moisture / kg of dry air is defined as

A) Absolute humidity
C) Variable humidity
B) Relative humidity
D) Dew Point

7 The efficiency of compressed air system is around

A) 90%
C) 50%
B) 60%
D) 10 %

8 Which among the following is the most energy efficient lamp for the same wattage rating?

A) HPMV
C) CFL
B) GLS
D) Metal halide

9 The fan system resistance is predominately due to

A) more bends used in the duct
C) volume of air handled
B) more equipment in the system
D) density of air

10 The inner tube of a L-type Pitot tube facing the flow measures _____ in the fan system

A) static pressure
C) total pressure
B) velocity pressure
D) All of the above

11 A pump discharge has to be reduced from 120 m^3/hr to 110 m^3/hr by trimming the impeller. What should be the percentage reduction in impeller size?

A) 10.52 %
C) 9.71%
B) 8.34%
D) 17.1%

12 A 22 kW, 415 V, 45 A, 0.8 pf, 1475 rpm, 4 pole 3 phase induction motor operating at 420 V, 40 A and 0.8 pf. What will be the motor efficiency?

A) 85.0 %
C) 89.9 %
B) 94.5 %
D) None of the above

13 The parameter used in Star labeling of air conditioner is

A) COP
C) KW/TR
B) EER
D) EPI

14 Reduction in the delivery pressure of an air compressor working at 7 bar, 1 bar pressure reduction would reduce the power consumption by

A) 2 - 3%
C) 6 - 10%
B) 4 - 5%
D) None of the above

15 Which of the following is not required in the boiler efficiency evaluation by direct method

A) steam flow
C) feed water temperature
B) fuel flow
D) O_2 % in flue gas

16 The normal velocities encountered in pipes for saturated steam is

A) 60 to 80 m/sec
C) 5 to 10 m/sec
B) 10 to 20 m/sec
D) 30 to 40 m/sec

17 The measured O_2 in flue gas is 5.5% by volume, the excess air percentage will be

A) 41%
C) 35.5%
B) 55.9%
D) 67%

18 What is ESCO

A) Energy Supply Company
C) Energy System Company
B) Energy Storage Company
D) Energy service Company

19 The price of a unit of a fuel is BDT 290 as on may 2022. Let us consider this will increase 12% per year. Estimate the price of natural gas after 6 years.

A) 325
C) 901
B) 572
D) 1072

20 In a pumping system, if the temperature of the liquid handled decreases, then

A) NPSHA increases
C) NPSHA remains constant
B) NPSHA decreases
D) NPSHA and NPSHR are independent of temperature

Section B: Short Question

		Marks
01	Calculate the blow down rate for a boiler with an evaporation rate of 3 tons/hr, if the maximum permissible TDS in boiler water is 3000 ppm. The makeup water addition rate is 10 % and the feed water TDS is around 250 ppm.	5
02	In an air conditioning duct 0.5 m x 0.5 m, the average velocity of air measured by vane anemometer is 28 m/s. The static pressure at suction of the fan is -20 mmWC and at the discharge is 30 mmWC. The three-phase induction motor draws 10.8 A at 415 V with a power factor of 0.9. Find out the efficiency of the fan if motor efficiency = 90% (Neglect air density correction).	5
03	A gas turbine generator is delivering an output of 18 MW in an open cycle with a heat rate of 3000 kcal/kWh. It is converted to combined cycle plant by adding heat recovery steam generator and a steam turbine raising the power generation output to 23 MW. However, with this retrofitting and increased auxiliary consumption, the fuel consumption increases by 5% in the gas turbine. Calculate the combined cycle gross heat rate and efficiency.	5
04	Estimate the Cooling Tower (CT) capacity (TR) and approach with the following parameters: ◦ Water flow rate through CT = 100 m^3/hr ◦ Specific heat of water = 1 kCal/kg°C ◦ Inlet water temperature = 45°C ◦ Outlet water temperature = 35°C ◦ Ambient WBT = 30°C	5

Section C: Long Question

		Marks
01	Calculate the efficiency of the Atmospheric Fluidized Bed Combustion Boiler by indirect method using the following data: Analysis of blended coal (% by mass) Carbon : 53.9 % Hydrogen : 3.1 % Nitrogen : 1.1 % Sulphur : 0.3 % Ash : 23.8 % Oxygen : 10.5 % Moisture : 7.3 % GCV : 5060 kCal / kg The boiler operating parameters are given below. Steam pressure : 62.0 kg / cm^2g Steam temperature : 470 °C Actual air supplied : 8.91 kg/kg of coal	10

Mass of dry flue gas	:	9.31 kg/kg of coal
Specific heat of flue gas	:	0.23 kCal/kg ^{o}C
Flue gas temperature	:	160 ^{o}C
CO_2 in flue gas	:	14.7 %
CO in flue gas	:	325 ppm
GCV of bottom ash	:	800 kCal/kg
GCV of fly ash	:	452.5 kCal/kg
Ratio of bottom ash to fly ash	:	15: 85
Ambient temperature	:	32.4 ^{o}C
Loss due to hydrogen in fuel	:	3.54 %
Loss due to moisture in fuel	:	0.93 %
Loss due to moisture in air	:	0.2 %
Surface heat losses (As assessed)	:	2 %

02 In an air-cooled heat exchanger hot fluid (specific heat:1 kCal/kg ^{o} C) is entering at a temperature of 80 ^{0}C and leaving at a temperature of 38 ^{0}C. Flow rate of the hot fluid is 63450 kg/hr. Air is entering at a temperature of 30 ^{0}C and leaving at a temperature of 60 ^{0}C. Flow rate of the air is 370057 kg/hr. Power drawn by the fan is 30 kW. The plant persons want to replace it with a water-cooled counter flow plate heat exchanger. 10

Given data:
Annual operating hours : 4800 hrs
Pump Efficiency : 75%
Motor efficiency : 90 %
Effectiveness of water-cooled heat exchanger is 0.4
Water is available at 25 ^{O}C
Total head developed by the pump is 4 kg/cm^2
Overall heat transfer coefficient of PHE is 22300 kCal/m^2/^{O}C
For water cooled system the additional fan power consumption is 5 kW.

Calculate

1. Energy saving due to replacement
2. Area of the plate heat exchanger

03 a) In an 85 kW four pole induction motor operating at 49.9 Hz and rated for 415 V and 1440 RPM, the actual measured speed is 1470 RPM. Find out the percentage loading of the motor if the voltage applied is 430 V. 10

b) A 6 pole, 415 volt, 3 ø, 50 Hz induction motor delivers 20 kW power at rotor shaft at a speed of 975 rpm with PF of 0.86. The total loss in the stator including core, copper and other losses is 2kW.

Calculate the following.

i) Slip

ii) Rotor Copper Loss

iii) Total Input to motor

iv) Line current at 415 V and motor PF of 0.88

v) Motor operating efficiency

04 A pharmaceutical unit had installed a centralized refrigeration system of 200 TR Capacity several years ago. The refrigeration system operates 24 hours a day, 300 days per annum and the average electricity cost is BDT. 7.5/ kWh. The following are the key operational parameters. 10

- Compressor operating current and power factor: 255 amps, 0.9 pf
- Condenser pump operating current and power factor: 72 amps, 0.88 pf
- Chiller pump operating current and power factor: 42 amps, 0.9 pf
- CT fan operating current and power factor: 33 amps. 0.65 pf
- ΔT across the chiller (evaporator): 4.0 ^{o}C
- Chilled water flow: 38 liter / Sec
- Total head developed by chiller pump: 35 m
- Condenser water flow: 68 liter / Sec
- Total head developed by condenser pump: 30 m

PS: all the motors operate at 415 Volts and efficiency of 90%

Calculate:

- The power consumed by the compressor, condenser pump, chiller pump and CT fan.
- TR developed by the system
- Specific power consumption i.e., overall kW/TR and COP and Energy Efficiency ratio (EER)
- Combined efficiency (motor and pump) of condenser and chiller pumps

05 In an air conditioning system of a food processing industry, the cold air flow rate is 15,000 m^3/hr at a density of 1.15 kg/m^3. The inlet and outlet enthalpy of the air are 105 kJ/kg and 80 kJ/kg. The COP of the existing vapor compression system is 4.0. The efficiency of the motor coupled with the compressor is 92%. 10

The management wants to install a Vapor Absorption System (VAR). The saturated steam for VAR will be supplied either from a new waste heat boiler to be installed with the existing DG sets or from the existing FO fuel fired boiler. The plant is operating for 7500 hr/annum. The investment of VAR system is BDT. 15 lakhs. The investment for waste heat boiler is BDT. 5 lakhs. The power cost is BDT. 7.5/kWh.

As an energy auditor which one of the following options will you recommend to the management?

Option-1: Supply steam from the existing FO fuel fired boiler to VAR system and avoid the investment of waste heat boiler

Option-2: Supply steam from the waste heat boiler, which needs an investment in addition to VAR system

The steam consumption per TR will be 5.5 kg/TR. The cost of FO is BDT. 32,000/ ton. The evaporation ratio of the existing FO fired boiler is 14. Neglect losses in transmission of steam and chilled water.

06 A free air delivery test was carried out before conducting a leakage test on a reciprocating air compressor in an engineering industry and following were the observations: 10

- Receiver capacity: 10 m^3
- Initial pressure: 0.2 kg/cm^2g
- Final pressure: 7.0 kg/cm^2g
- Additional hold-up volume: 0.2 m^3
- Atmospheric pressure: 1.0 kg/cm^2 abs.
- Compressor pump-up time: 4.0 minutes

The following was observed during the conduct of leakage test during the lunch time when no pneumatic equipment/ control valves were in operation:

a) Compressor on load time is 20 seconds and unloading pressure is 7 kg/cm^2g

b) Average power drawn by the compressor during loading is 90 kW

c) Compressor unload time and loading pressure are 60 seconds and 6.6 kg/cm^2 g respectively.

Find out the following:

(i) Compressor output in m^3/hr (neglect temperature correction)

(ii) Specific Power Consumption, kW/m^3/hr

(iii) % air leakage in the system

(iv) leakage quantity in m^3/hr

(v) power lost due to leakage