Sustainable and Renewable Energy Development Authority (SREDA)

Power Division, Ministry of Power, Energy and Mineral Resources

Invigilator's Signature

2nd Energy Auditor Certification Examination-2022

Paper- 4

Candidate's Roll

2	0	2	2	0	3			

Examinee's Name _____

B

Paper 4: Energy Performance Assessment for Equipment & Utility Systems

Total Marks- 100, Time- 3.00 Hour, Date: 7 March 2022

- **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.

Invigilator's Signature

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 on 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 equation is used to calculate the future value of the cash flow?

A) NPV $(1 - i)^n$

B) NPV / $(1 - i)^n$

C) NPV $(1 + i)^n$

D) NPV/ $(1 + i)^n$

2 The production factor is defined as the ratio of

A) current year production to the reference year production

B) current year production to the reference month production

C) reference month production to the current month production

D) reference year production to the current year production

3 If asset depreciation is considered, then net operating cash inflow would be

A) lower

B) higher

C) no effect

D) none of the above

4 For high static head application of pump which is true statement?

A) VFD is not suitable for flow control

B) small reduction of speed could give small reduction in flow rate

C) small reduction of speed could give small reduction in efficiency

D) all of the above

5 In a pumping system, the static head is 10 m and the dynamic head is 15 m. If the pump speed is doubled, then the total head will be

A) 50 m

B) 70 m

C) 40 m

D) none of the above

6 The refrigerant used in vapor absorption systems is

A) water + lithium bromide

B) water

C) freon

D) lithium bromide

7 COP of refrigeration can be increased by

A) increasing evaporator operating pressure

B) decreasing condenser operating pressure

C) sub-cooling

D) all of the above

8 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%

9 If the maximum demand is 3500 kVA at 0.88 PF, the maximum demand will reduce by kVA if PF is improved to 0.98

A) 3143

C) 3897

B) 357

D) maximum demand will not reduce

10 Ton of Oil Equivalent energy consumption / GDP in Million US $ is termed as

A) energy intensity

C) per capita energy consumption

B) per capita oil consumption

D) energy performance

11 Which loss is considered the most unreliable or complicated to measure in electric motor efficiency testing?

A) stator Cu loss

C) stator Iron loss

B) rotor Cu loss

D) stray loss

12 The FAD of a reciprocating compressor is directly proportional to

A) pressure

C) speed

B) volume

D) all of the above

13 Which of the following is incorrect in the case of cooling towers

A) "Range" is the difference between the temperature of cooling tower water inlet and outlet.

C) 'Range' is a better indicator of cooling tower performance.

B) "Approach" is the difference between the cooling tower outlet cold-water temperature and ambient wet bulb temperature.

D) Cooling capacity is the heat rejected in kCal/hr or TR

14 How the airflow of a fan in a duct can be measured?

A) average velocity X fan sweep area

C) pressure difference between inlet & outl cross section of the duct

B) maximum velocity X fan sweep area

D) none of the above

15 Assume CO_2 equivalent emissions by the use of a 60 W incandescent lamp are of the order of 60 g/hr. If it is replaced by a 5 W LED lamp then the equivalent CO_2 emissions will be

A) nil

C) 12 g/hr

B) 5 g/hr

D) 300 g/hr

16 The main precaution to be taken care of by the waste heat recovery device manufacturer to prevent the problem in a DG set during operation is

A) voltage unbalance on generator

C) excessive steam generation

B) back pressure on engine

D) turbulence in exhaust gases

17 Usually which system has higher COP?

A) VRF

C) Air cooled chiller

B) Water cooled chiller

D) Window type AC

18 Color rendering index (CRI) is

A) a measure of the effect of light on perceived temperature of objects

B) a measure of the effect of light on perceived color of objects

C) a measure of color of light

D) a measure of color temperature of light

19 The illuminance is 10 lm/m² from a lamp at 1 meter distance. The illuminance at half the distance will be

A) 40 lm/m²

B) 10 lm/m²

C) 5 lm/m²

D) none of the above

20 In pumping systems where static head is a high proportion of the total, the appropriate solution is

A) install two or more pumps to operate in parallel

B) install two or more pumps to operate in series

C) install two or more pumps to operate in independent operation

D) none of the above

Section B: Short Question

		Marks
01	In a Commercial building, five window ACs each of 1.5 TR capacity, were evaluated for replacement with three stars labeled new ACs having Energy Efficiency Ratio (EER) of 2.50 kW/kW. The measured EER of existing ACs are as follows. Existing EER AC No 1 2.05 AC No 2 2.19 AC No 3 2.30 AC No 4 2.40 AC No 5 2.17 Calculate the total kW saving potential if all the existing ACs are replaced with 3 stars labeled ACs of same capacity?	5

02	Estimate the Cooling Tower (CT) capacity (TR) and approach with the following parameters: Water flow rate through CT = 120 m^3/hr Specific heat of water = 1 kCal/kg °C Inlet water temperature = 42 °C Outlet water temperature = 36 °C Ambient WBT = 32 °C	5
03	A performance analysis of a DG set was carried out. The following are the data obtained. Period of trial : 2 hrs Energy generated : 500 kWh Level difference in diesel day tank: 51.6 cm Diameter of day tank: 1m Calorific value of fuel : 10500 kCals/kg The air drawn by the DG set is 30 kg/kg of fuel. The energy auditor recommended for a waste heat recovery system. In addition, the auditor indicated waste heat recovery potential is $2.6x10^5$ kCal/hr if the flue gas temperature after waste heat recovery system is maintained at 1800C. a) Calculate the average efficiency of DG set and its specific fuel consumption b) Calculate present flue gas exit temperature if specific gravity of fired fuel oil of 0.86 and specific heat of flue gas is 0.25 kcal/kg ^{0}C.	5

04	An industrial plant is consuming 400 kW of power with a maximum demand of 520 kVA. The demand charge is Tk. 150/-per kVA. Determine the savings possible by improving power factor to 0.95 and payback period if investment on capacitor bank is Tk. 1, 50,000/-.	5

Section C: Long Question

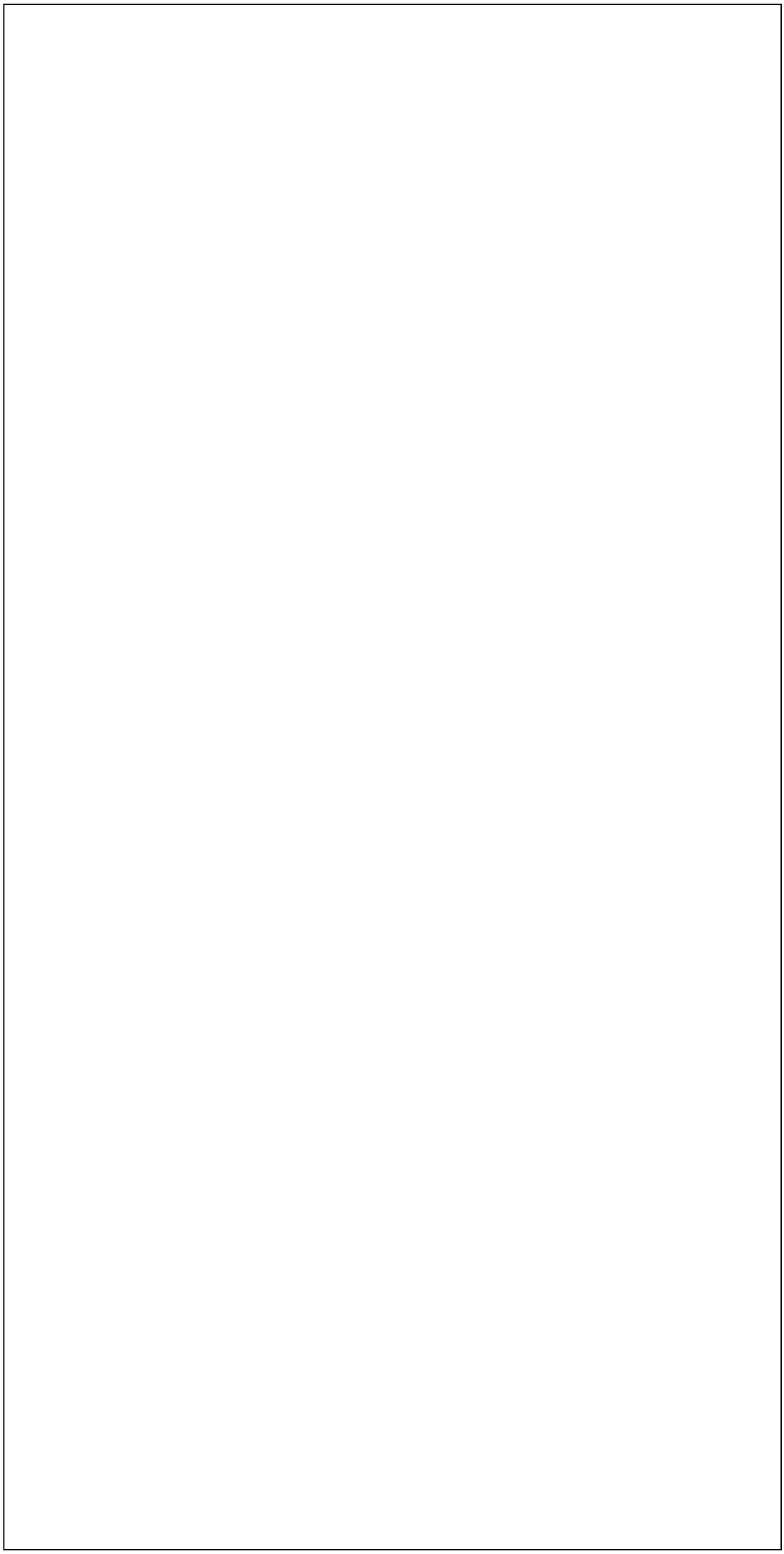
		Marks
01	MEP consultant of a textile industry is planning to switch over from the existing 300 TR directly-gas-fired double effect absorption water chiller to a 300 TR centrifugal water chiller, as a cost saving measure. The double effect absorption chiller is rejecting its heat into a cooling tower. The proposed centrifugal chiller will be rejecting its heat to the same cooling tower. The consultant is also planning to connect the heat load of a water-cooled process heat exchanger to the same cooling tower. The cooling water entering the heat exchanger will cool the hot oil from 110^0C to 50^OC. The hot oil flow rate in the heat exchanger is 20,000 kg/hr. Make use of the following data: C.O.P. of double effect absorption chiller = 1.2 Electrical energy input to centrifugal chiller motor = 0.8 kW/TR GCV of Natural Gas = 9450 kcal/m^3 Cost of Gas = Tk.27/m^3 Efficiency of gas firing = 80% Electrical energy cost = Tk.8.5 / kWh Specific heat of oil to be cooled by water = 0.5 kcal/kg OC Motor efficiency = 87.5 % Annual operating hours = 7920 hrs. Find out the following: a) The yearly monetary savings in operating centrifugal chiller in place of the double effect absorption chiller. b) C.O.P. of the centrifugal chiller. c) Whether the capacity of the cooling tower is sufficient to take the additional heat load of the process heat exchanger, in addition to that of centrifugal chiller.	10

02	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 30^0C No load power = 1152 Watts Calculate the following: (i) Iron plus friction and windage losses. (ii) Stator resistance at 120^oC. (iii) Stator copper loss at full load at operating temperature of 120^oC. (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	10

03	In a Petrochemical Industry a gas turbine cogeneration system comprising of 20 MW gas turbine generator along with a waste heat boiler (WHB) of 70 Tonne per hour capacity at 10 kg/cm^2 (g) are operated to meet the power and steam requirements. The existing operating data is given below: Power supplied by the Cogenerator = 16000 kW Power drawn from the grid = 1500 kW Grid power cost = Tk 5 /kWh Steam at 10 kgf/cm^2 (g) supplied by WHB = 48 Ton/hr (Without supplementary fuel firing) Efficiency of gas turbine on G.C.V. = 28% Efficiency of generator= 95% G.C.V. of fuel (Natural Gas) = 13000 kCal/Kg Density of natural gas = 0.7 Kg/m^3 Cost of natural gas = Tk.25/m^3 Temperature of gas turbine exhaust gas entering WHB = 515^{o}C Specific heat of exhaust gas =0.3 kCal/kg^{o}C Ambient temperature = 30^{o}C Air to natural gas ratio for gas turbine combustion = 60:1 Enthalpy of steam at 10 kgf/cm^2 (g) = 665 kCal/Kg Enthalpy of feed water = 105 kCal/Kg a) Find out the heat rate of the gas turbine generator and b) Estimate the efficiency of the waste heat boiler. The plant personnel claim and believe that by resorting to supplementary fuel firing to increase steam generation in the WHB is likely to improve its efficiency by 1.5%. c) Determine if it is economical to generate additional steam requirement of 10 Tonne per hour by supplementary fuel firing in WHB as against in a separate natural gas fired smoke tube boiler of 82% efficiency on G.C.V. The plant operations are steady and continuous with 8760 yearly hours of operation.	10

04	The operating details and particulars of a natural gas-fired, smoke tube boiler, are given below: Steam flow = 8 ton/hr steam Steam Pressure = 10 $kg/cm^2(g)$ Feed water temperature = 80 ^oC. % O_2 in dry flue gas = 4% Exit flue gas temperature = 215 ^oC. G.C.V. of natural gas = 13,500 kCal/kg Density of natural gas = 0.7 kg/m^3 Cost of natural gas = Tk 27/m^3 Enthalpy of steam at 10.0 $Kg/cm^2(g)$ = 666 kCal/kg. Inlet feed water temperature = 80 ^oC Loss due to Hydrogen = 9.92% Radiation losses in the N.G. boiler = 1.52% Specific heat of flue gases = 0.29 kCal/kg ^oC Ambient temperature = 30 ^oC Density of air = 1.125 kg/m^3 Daily hours of operation = 24 hours Yearly operation = 330 days Composition of natural gas (per kg) Carbon = 0.74 kg /kg Hydrogen = 0.22 kg /kg Nitrogen = 0.03 kg /kg Oxygen = 0.01 kg /kg Ignore Sulphur & Moisture Find out the following a. Steam to fuel ratio, in the existing case, in kg/kg b. Total combustion air required in m^3/min c. % improvement in the steam to fuel ratio, when the feed water temperature is raised to 95^OC due to improved condensate recovery d. Savings in gas consumption in m^3/hr e. Yearly monetary savings	10

05	In a Juice production industry the product stream (liquid) flowing at a rate of 5000 kgs/hr at 90°C is first cooled in counter type Cooling Water (CW) heat exchanger to 55 °C and then by a Chilled Water (ChW) heat exchanger, to reduce temperature of the product to 11°C. The specific heat of the product is 0.9 kCal/kg°C. The other operating data and parameters are: Cooling Water heat exchanger / Chilled Water heat exchanger Product: Inlet temp 90°C, Outlet temp 55°C Cooling Water: Inlet temp 25°C, Outlet temp 32°C Product: Inlet temp 55°C, Outlet temp 11°C Chilled water: Inlet temp 7°C, Outlet temp 12°C The chilled water is supplied by a reciprocating chiller, whose motor is drawing 60 KW with a motor efficiency of 87%. The management decides to upgrade cooling water heat exchanger by providing additional heat exchanger area to further enhance heat recovery i.e. to reduce the temperature of product at its outlet to 40°C. a. Depict the heat exchanger in existing and upgraded (improved) heat recovery case in a simple block diagram b. Calculate i. The additional heat exchanger area (as a % of the existing area) for cooling water heat exchanger, assuming there is no change in cooling water circulation rate and the overall heat transfer coefficient. ii. The COP of the chiller. iii. Reduction in refrigeration /chiller load and yearly energy savings at 600 hours per month operation, assuming energy consumption is proportional to load delivered.	10



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: 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: 1.026 kg/cm^2 abs. Compressor pump-up time: 4.5 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 30 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 70 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	10