Regn No: _________________

Name: ___________________

(To be written by the candidates)

7^{th} NATIONAL CERTIFICATION EXAMINATION FOR ENERGY AUDITORS – Nov., 2008

PAPER – 4:	**Energy Performance Assessment for Equipment and Utility Systems**
Date: 23.11.2008	Timings: 1400-1600 HRS Duration: 2 HRS Max. Marks: 100

Section - I: SHORT DESCRIPTIVE QUESTIONS Marks: 10 x 1 = 10

(i) Answer all **Ten** questions
(ii) Each question carries **One** mark
(iii) Answer should not exceed 50 words

S-1	What will be the synchronous speed of a VFD driven 4-pole induction motor operating at 38 Hz ?
Ans.	Ns = 120 x f/P = 120 x 38/4 = 1140 RPM
S-2	If the power consumed by a refrigeration compressor is 2 kW per ton of refrigeration, what is the energy efficiency ratio?
Ans.	$EER = \frac{12000\ Btu}{2000\ W} = 6$
S-3	Explain why heat rate of back pressure turbine is greater than that of a condensing turbine.
Ans.	As it does not take into account of the heat content of the exhaust steam used in the process.
S-4	Why line current method used for estimating loading of a motor is not applicable for motor loading less than 75%.
Ans.	At lower loadings, power factor of a motor degrades significantly and ampere-load curve becomes nonlinear
S-5	Explain why actual air delivered is always converted to (FAD) while measuring delivered air volume flow rates in an air compressor.
Ans.	As air is compressible, its volume flow rate will vary with pressure on delivery side and hence for comparison purposes the volume flow rates are always converted to their value at standard atmospheric pressure.
S-6	What is the minimum wind speed which is acceptable for viable power generation from a

	wind turbine?
Ans.	15 kmph
S-7	If the dry bulb temperature of air is 35°C and the wet bulb temperature is 35°C what will be the relative humidity %.
Ans.	100 %
S-8	For which fuel the difference between GCV and NCV will be smaller, Coal or Natural Gas?
Ans.	Coal
S-9	What is the conversion efficiency range of a biomass gasifier ?
Ans.	60 – 70 %
S-10	How many units of energy will be generated by a wind turbine of 250 kW operating at a capacity factor 0.2 in 8760 hours ?
Ans.	250 x 0.2 x 8760 = 4,38,000kWh

-------- End of Section - I ---------

Section - II: LONG DESCRIPTIVE QUESTIONS Marks: 2 x 5 = 10

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

L-1 A trial for finding out the actual capacity of a reciprocating instrument air compressor of nominal capacity of 900 Nm^3/Hr was done.

The following observations were made:

Atmospheric pressure	: 1.033 kg/sq.cm
Ambient temperature	: 30 deg. C
Receiver capacity	12 m^3
Additional hold-up volume	: 10% of receiver volume
Initial pressure	: 0.2 kg/sq.cm g
Final pressure	: 7.0 kg/sq.cm g
Pump-up time	: 5 min:30sec
Motor power(avg)	: 115 kW (as per power analyzer)
Discharge temperature	: 45 deg.C

Calculate:

i) The actual compressor capacity
ii) The specific power consumption, in kW/m^3/hr

Ans.

i) Actual capacity,FAD Q= <u>(P2 – P1)</u> * <u>V</u> * <u>(273+t1)</u> Nm^3/mte

P0 T (273+t2)

where ,

P2 = final pressure at receiver after pump-up ,kg/sq.cm a
P1 = initial pressure at receiver after bleeding, kg/sq.cm a
P0 = atmospheric pressure, kg./sq.cm a
V = total storage volume , m^3
T = pump-up time ,mte

$$Q = \frac{(8.033-1.233)}{1.033} * 12*1.1/5.5 \ *303/318$$

= 15.05 Nm3/mte, say 15 Nm3/mte

ii) specific power consumption:= $\frac{115}{15*60}$ **kW/Nm3**
= 0.127 kW/Nm3/hr

L-2 The following parameters were observed during the performance testing of pump.

Flow rate of fluid	:900m^3/hr.
Density of fluid	:950kg/m^3
Discharge pressure	: 5.0kg/cm^2(a)
Suction head	:5 metre above the pump centerline.
Measured power	:190kW
Motor efficiency	:90%

Calculate the pump efficiency.

Ans. Hydraulic power = (900/3600) x 45 x 950 x 9.81/ 1000
= 104.7 kW

Pump shaft power= 190 x 0.9

= 171kW

Pump efficiency = 104.7/171
= 61.2 %

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

Section - III: Numerical Questions   Marks: 4 x 20 = 80

(i) Answer all **Four** questions
(ii) Each question carries **Twenty** marks

N-1

A furnace oil fired boiler is generating steam 20 t/hr @10 kg/cm^2 (enthalpy – 650 kcal/kg & feed water temp-80 ^{0}C) The evaporation ratio of the oil fired boiler is 14. The GCV of the fuel is 10,200 kCal/kg. Due to high furnace oil cost the management wants to covert from oil firing to Agro residue briquettes firing with a GCV of 3200 kcal/kg. The expected efficiency of the new Briquette fired boiler is 75%. The cost of furnace oil is Rs.28000/t and briquette cost is Rs.4000/t. The annual operating hrs of the boiler is 8000 hrs. The emission factor for furnace .oil is 3 t CO_2/ton.

a. Find out the annual savings for the company by shifting to Briquettes.
b. In addition the management wants to claim carbon credits for fuel switch. Calculate the estimated carbon credits for this measure.

Ans.

Parameter	Unit	F.Oil	Briquettes
Steam Generation	T/hr	20	20
Steam Enthalpy	kcal/kg	650	650
Feed water temp	°C	80	80
Evap. Ratio	t/t	14	
Efficiency	%		0.75
GCV	kcal/kg	10200	3,200
Fuel Consumption	t/hr	(20/14)	20(650-80) /(3200*0.75)
		1.43	4.75
fuel cost	Rs/T	28000.00	4000
Cost of operation		(1.43 x 28000)	(4.75x 4000)
	Rs./hr	40000	19000
Energy Cost Savings			(40000-19000) =
			21000
annual operating hrs	hrs	8000	8000
annual cost Savings	Rs. Lakh/hr		(21000 x 8000) /100000=
			1680 lakhs
Carbon Credits			

	Emission Factor	t CO_2/Ton	3	
	annual F.Oil savings	Ton/year	(1.43x 8000)	
			11440	
	Expected Carbon Credits	CERs	11440x 3	
			34320	

N-2

The following are the operating parameters of rerolling mill furnace

Weight of input material - 10 T/hr
Furnace oil consumption - 600 litres/hr
Specific gravity of oil - 0.92
Final material temperature - 1200°C
Initial material temperature - 40°C
Outlet flue gas temperature - 650°C
Specific heat of the material – 0.12 kCal/kg/°C
GCV of oil - 10,000 kCal/kg
Percentage yield - 92 %

a. **Calculate furnace efficiency by direct method**
b. **Calculate Specific fuel consumption on finished product basis**

The management installed a recuperator to preheat combustion air from 40°C to 300°C resulted in following benefits:

Increase in material input by 10 %
Reduction in fuel consumption by 13 %
Yield improvement from 92% to 95%

c. **Calculate the furnace efficiency after the modifications**
d. **Reduction in specific fuel consumption after installing the waste heat recovery**

Ans.

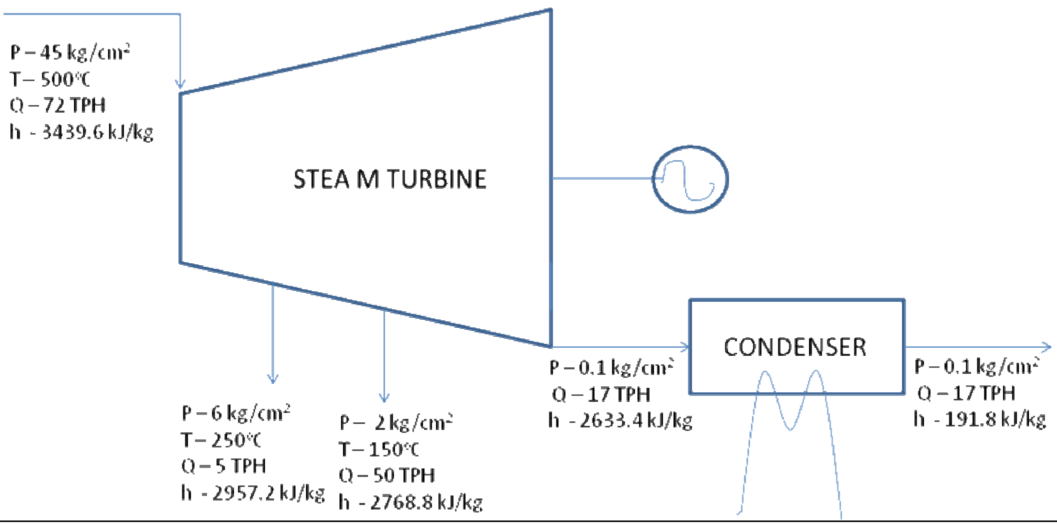
a) Furnace efficiency by direct method	
Heat input	600 lit/hr x 0.92 x 10000
	55,20,000 kCal/hr
Heat output	10,000 x 0.12 x (1200 – 40)
	1,39,2000 kcal/hr
Efficiency	1,39,2000 /55,20,000
	25.21 %
b) Specific fuel consumption on finished product basis	
Weight of finished products	10 x 0.92
	9.2 T/hr

Furnace oil consumption	600 litres/hr
Specific fuel consumption	600/9.2
	65.2 litres/ton
c) Furnace efficiency with 10 % increase in material input	
Fuel consumption after modification	600 x 0.87
	522 litres/hr
Production after modification	10 + 10 x 0.1
	11 T/hr
Heat input	522 lit/hr x 0.92 x 10000
	48,02,400 kCal/hr
Heat output	11,000 x 0.12 x (1200 – 40)
	15,31,200 kcal/hr
Efficiency	15,31,200/48,02,400
	31.9 %
d) Reduction in Specific fuel consumption	
Yield of finished product	11 x 0.95
	10.45 T/hr
Fuel consumption	522 litres
Specific fuel consumption	522/10.45
	49.95 litres/T
Original specific fuel consumption	65.2 litres/T
	65.2 – 49.95
	15.25 litres/T

N-3

For a double extraction cum condensing turbine with data as given in the following diagram, evaluate

a. Power generated if the efficiency of the turbine is 90 %
b. Cooling water flow rate circulation in the condenser if the range is 8°C



<table>
<tr><td>Ans.</td><td>

a. Power generated if the efficiency of the turbine is 90 %

Input heat to turbine = 72000 x 3439.6
= 2.477 x 10^8 kJ/hr
= 2.477 x 10^8 / 3600
= 68792 kW

Output heat of different streams

1st extraction = 5000 x 2957.2
= 0.148 x 10^8 kJ/hr
= 4107 kW

2nd t extraction = 50,000 x 2768.8
= 1.38 x 10^8 kJ/hr
= 38456 kW

Condenser input heat load
= 17,000 x 2633.4
= 0.448 x 10^8 kJ/hr
= 12436 kW

Total heat leaving the turbine = 4107 + 38456 + 12436
= 54999 kW

Heat available for power generation = 68792 – 54999

= 13793 kW

Power generation at 0.9 turbine efficiency = 13793 x 0.9
= 12414 kW

b. Cooling water flow rate circulation in the condenser if the range is 8°C

Condenser heat load = 17,000 x (2633.4 – 191.8)
= 2442 kJ/hr
= 2442 x 4.18
= 10208000 kCal/hr

At a range of 8°C cooling water flow rate = 10208000 / 8

= 1276 m^3/hr

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<tr><td>N-4</td><td>A steam radiator is used for heating air with steam. Saturated steam enters the radiator at a temperature of 133°C. Air enters the radiator at 30°C and leaves at 85°C. The heat transfer area is 862 m^2. The heat duty of the radiator is 14,50,000 kCal/hr. If the correction factor is 0.95 calculate the overall heat transfer coefficient in kW/m^2 K.</td></tr>
<tr><td>Ans.</td><td></td></tr>
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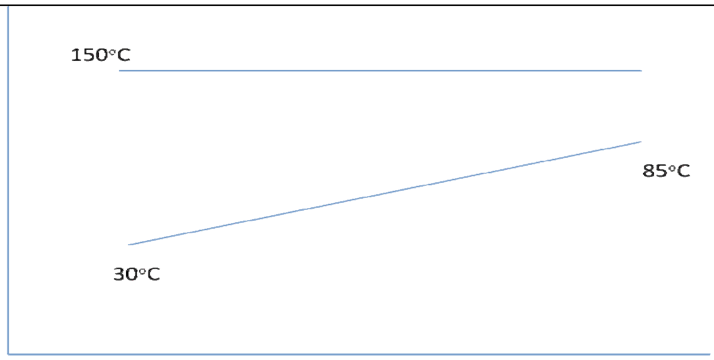

LMTD, counter flow	[(133-30) – (133-85)]/ln [(133-30)/133-85)]
	$72^{o}C$
Corrected LMTD	72 x 0.95
	$68.4^{o}C$
Heat duty, Q	14,50,000 kCal/hr
	1683 kW
Area	862 m^2
Overall heat transfer coefficient	Q/ A x corrected LMTD
	1683 / (862 x 68.4)
	0.0285 kW/m^2 K

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