Regn No: _______________

Name: _________________

(To be written by the candidate)

9TH NATIONAL CERTIFICATION EXAMINATION– December, 2009 FOR ENERGY AUDITORS

PAPER – 4: Energy Performance Assessment For Equipment and Utility Systems

Date: 20.12.2009 Timings: 1400-1600 HRS Duration: 2 HRS Max. Marks: 100

General instructions:

- *Please check that this question paper contains **8** printed pages*
- *Please check that this question paper contains **16** 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: SHORT DESCRIPTIVE QUESTIONS Marks: 10 x 1 = 10

(i) Answer all **Ten** questions
(ii) Each question carries **One** mark

S-1	A cogeneration plant with a back pressure turbine has a constant steam demand and fluctuating power demand. What is the common option to meet the fluctuating power demand? **Ans** **Parallel operation with grid**
S-2	What are the two major sources of waste heat available from a water-cooled Diesel Generator set? **Ans** **Exhaust flue gases and jacket cooling water**
S-3	For determining heat loss in flue gases due to incomplete combustion which flue gas constituent needs to be measured? **Ans** **Carbon monoxide**

S-4	Which parameter needs to be measured to assess the percentage loading of a motor by slip method neglecting voltage correction? **Ans** **Motor speed**
S-5	How many volt-amperes (VA) does a 100 Watt incandescent light require? **Ans** **100 VA**
S-6	In the indirect method of boiler efficiency evaluation, list any two additional losses computed for solid fuel fired boilers as compared to liquid and gas fired boilers? **Ans.** **Unburnt losses in fly ash (Carbon)** **Unburnt losses in bottom ash (Carbon)**
S-7	Why do biomass combustion projects qualify for CDM benefits even though they emit carbon dioxide? **Ans:** **Because it absorbs the same amount of carbon in growing as it releases when consumed as fuel** Or **Biomass is carbon neutral**
S-8	Name two most common bio fuels used for transportation **Ans** **1. Biodiesel** **2. Ethanol**
S-9	Which loss is assumed in the determination of electric motor efficiency? **Ans** **The stray load loss is estimated and not measured for testing electric motor efficiency.**
S-10	In a shell and tube heat exchanger, engaged in heat transfer between fouling fluid and clear fluid, the fouling fluid should be put on shell side or tube side? **Ans** **Tube side**

…………. 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 The steam flow to a process plant is 5000 kg/hr. 2000 kg/hr of condensate at 173^{o}C is returned to boiler feed water tank due to its own pressure. However there is 10% heat loss in transit to boiler feed tank. The balance is made up as feed water at 30^{o}C. The final feed water temperature observed was 95^{o}C. Comment on the feed water temperature. The plant personnel are sure that the temperature gauge is in order.

Ans Heat in condensate (less 10%) + Heat in make up water = Heat in feed water

$$2000 \times 173 \times 0.9 + 3000 \times 30 = 5000 \times T_f$$
$$311400 + 90000 = 5000 \times T_f$$

$$T_f = 80.28^oC$$

(3 Marks)

The feed water temperature cannot be more than 80.28^{o}C. The high temperature of 95^{o}C is mostly due to live steam leakage, as the temperature gauge is OK.

(2 Marks)

L-2 The maximum demand registered by an automobile plant is 5000 KVA and the power factor is 0.95. The plant management converts the existing electrical resistance heated furnace with an average load of 750 kW to gas heating as a cost reduction measure. What will be effect on maximum demand and power factor with this conversion?

Ans. **Registered maximum demand = 5000 KVA**
Electrical load (real power) = 5000 X 0.95
= 4750 KW

$$KVAR^2 = KVA^2 - KW^2$$
$$KVAR^2 = (5000)^2 - (4750)^2$$

$$KVAR = 100\sqrt{(50^2) - (47.5)^2}$$
$$= 1561$$

(3 Marks)

KVAR in the system will remain same.
Reduction in real power by conversion is 750 KW.
Real Power = 4750 – 750 = 4000 KW

$$KVA^2 = KW^2 + KVAR^2$$
$$= (4000)^2 + (1561)^2$$
$$KVA = 4294$$

Power factor = 4000 / 4294 = 0.932

Reduction in Electrical Demand = 5000 – 4294
= 706 KVA

Reduction in Power Factor	**=**	**0.95 – 0.932**
	=	**0.018**

(2 Marks)

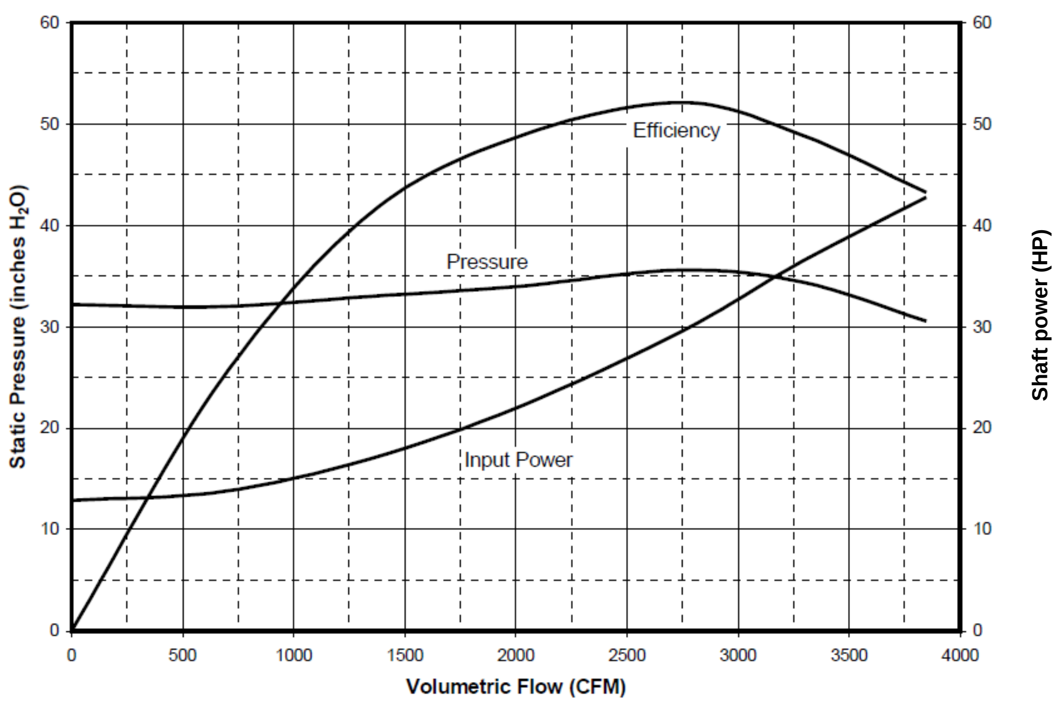
………… End of Section - II …………

Section - III: NUMERICAL QUESTIONS **Marks: 4 x 20 = 80**

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

N -1 Given below is a set of curves for a centrifugal fan. At its Best Efficiency Point (BEP) determine to the **nearest approximation** the following:

a) Static pressure in mmwc
b) Flow in m^3/hr
c) Shaft power in kW
d) Work out the static efficiency of the fan by calculation
e) Power drawn by the motor if the motor operating efficiency is 90%



Ans

Static pressure in inches H_2O	**36**
	(2 Marks)
Static pressure in mmwc	**914.4 mmwc**
	(2 Marks)
Flow in CFM	**2750**

	(2 Marks)
Flow in m^3/hr	**4672.28 m^3/hr ie 1.3 m^3/sec**
	(2 Marks)
Shaft power in hp	**29**
	(2 Marks)
Shaft power in kW	**21.6 kW**
	(2 Marks)
Fan Efficiency	**Q x dP/(102 x kW)**
	1.3 x 914.4 /(102 x 21.6)
	54 %
	(5 Marks)
Motor input power at 90%	**21.6 / 0.9**
	= 24 kW
	(3 Marks)

The data is read from the graph and hence a deviation of +/- 10% in values may be given full marks.

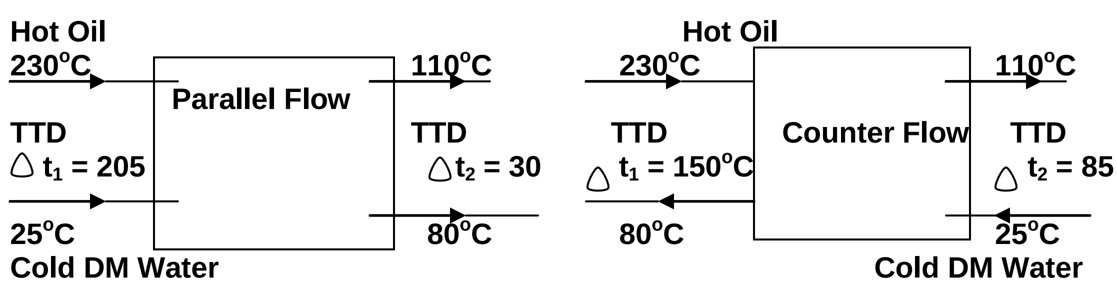
N-2 In a Continuous Process Industry 5 Tonne per hour hot oil on process stream has to be cooled from 230°C to 110°C by DM water at 25°C heated to 80°C on its route to boiler de-arator.

(i) Depict the heat exchange process on a schematic for both parallel and counter flow heat exchanger clearly indicating inlet and outlet temperature and terminal temperature difference.

(ii) Find out LMTD for parallel and counter flow heat exchangers and comment on the preference of the heat exchanger.

(iii) Find out the DM water flow rate through the heat exchanger. Assume specific heat of hot oil to be 0.5 kCal / kg°C.

Ans.



$$\text{LMTD parallel flow} = \frac{\Delta t_1 - \Delta t_2}{\ln \Delta t_1 / \Delta t_2}$$

$$= \frac{205 - 30}{\ln 205 / 30} = 91.15^oC$$

(8 Marks)

$$\text{LMTD counter-flow} = \frac{\Delta t1 - \Delta t2}{\ln \Delta t1 / \Delta t2}$$

$$= \frac{150 - 85}{\ln 150 / 85} = 114.44^oC$$

(8 Marks)

Counter flow heat exchanger is preferred as the LMTD is larger and hence heat exchanger area will be less and compact.

Mc X 1 X (80 – 25) = mh X Cph X (230 – 110)
Mc = 5000 X 0.5 X (230 – 110) / 55
= 5454.54 Kg / hr

DM water flow rate = 5454.54 Kg / hr

(4 Marks)

N-3 The following are the data collected for a boiler using furnace oil as the fuel. Determine the boiler efficiency based on GCV by indirect method ignoring radiation and convection losses.

Ultimate chemical analysis (% weight) : Carbon : 84, Hydrogen : 12, Nitrogen : 0.5, Oxygen : 1.5, Sulphur : 1.5, Moisture : 0.5, GCV of fuel 10,397 kCal/kg and humidity 0.015 kg moisture/kg of dry air.

Flue gas analysis: CO_2 : 12% volume, flue gas temperature : 180^{o}C and ambient temperature : 20^{o}C

Ans:

a) Theoretical Air = 11.43 x 0.84 + 34.5 x (0.12 – 0.015/8) + 4.32 x 0.015 = **13.74**

(or)

Theoretical Air = **11.6** x 0.84 + **34.8**x (0.12 – 0.015/8) + **4.35** x 0.015 = **13.92**

(2 Marks)

b) Theoretical % CO_2 = Moles of C/(Moles of N_2 + Moles of C + **Moles of Sulphur**)
= 100 x (0.84/12)/(13.74 x 0.77/28 + 0.005/28 +0.84/12 + 0.015/32) = **15.62%**
(or)

Theoretical % CO_2 = Moles of C/(Moles of N_2 + Moles of C + **Moles of Sulphur**)
= 100 x (0.84/12)/(**13.92** x 0.77/28 + 0.005/28 +0.84/12 + 0.015/32) = **15.44%**

(2 Marks)

Depending on the variation in the above values (a and b) the subsequent calculations will also have a minor variation in the end result, which can be ignored.

c) Excess air supplied = 7900 x(15.62 -12)/(12(100-15.62)) = **28.24%**

(2 Marks)

d) Actual mass of air supplied = (1+0.2824) x 13.74 = **17.62 kg/kg of oil.**

(2 Marks)

e) Actual mass of dry flue gas =
0.84 x 44/12 + 0.005 + 17.62 x 0.77 + 0.015 x 64/32 + 3(17.62-13.74) x 0.23
= **19.3596 kg/kg oil**

(2 Marks)

f) % loss by dry flue gas = **19.3596** x 0.23 x (180-20)/10,397 = 0.0685 or **6.85%**

(2 Marks)

g) % loss by formation of water from Hydrogen in the fuel
9 x 0.12 x (584 + 0.45 (180-20))/10,397 = 0.681 or **6.81%**

(2 Marks)

h) % loss due to moisture in fuel = 0.005 x (584 +0.45 (180-20))/10,397 = **0.03%**

(2 Marks)

i) % loss due to moisture in air = 17.62 x 0.015 x 0.45 (180-20)/10,397 = **0.183%**

(2 Marks)

j) Boiler efficiency = 100- 6.85 – 6.81 – 0.03 – 0.183 = **86.127%.**

(2 Marks)

N-4 A process plant is installing a 5 MW gas turbine cogeneration system with 12 TPH waste heat boiler to meet the power and steam demand of the plant. The plant will operate at 90% of capacity, meeting the entire power requirement of the plant, which is presently drawn from grid supply. The co-gen plant will also meet the steam requirement of 10 TPH, which is presently generated in a gas fired boiler with 86% efficiency on N.C.V. basis. Calculate the differential cost between cogenerated power and grid power per unit and also the additional natural gas requirement per day based on the following data.

Capacity of gas turbine	=	5000 kW
Plant load factor	=	90%
Auxiliary power consumption	=	1%
Operating hrs. per annum	=	8000
Net calorific value of natural gas	=	9500 kCal / Sm^3
Cost of natural gas	=	Rs.8 / Sm^3
Steam produced by co-gen waste heat	=	10 TPH boiler
Annual expenditure towards depreciation and interest	=	Rs 500 lacs
Annual expenditure for operation &		

maintenance of co-gen plant	=	Rs 200 lacs
Heat Rate of gas turbine on NCV	=	3050 kCal / kWh
Cost of electric power from grid supply	=	Rs. 4.5/ kWh
Enthalpy of steam	=	665 kCal/ kg
Feed water temperature	=	85^oC

Ans **Power generation from cogen plant = 5000X 0.9 X 8000 = 360 lac Kwh**

Auxiliary power = 1%

Net power generation = 0.99 X 360 = 356.4 lac Kwh

Natural gas requirement for power generation = 360 X 3050 / 9500 = 115.57 lac Sm^3

(4 Marks)

Cost of fuel per annum = 115.57 X 8 = Rs.924.56 lacs

Annual expenditure for interest, depreciation and O&M = 500 + 200 = 700 lacs

Total cost of generation = Rs.1624.56 lacs.

Cost of cogeneration power =1624.56 X 10^5 / 356.4 X 10^5

=Rs.4.56 / Kwh.

(4 Marks)

Gas consumption in existing gas fired boiler = [10000 (665 – 85) / (0.86 X 9500)]

= 710 Sm^3/hr

= 17040 Sm^3/day

Cost of steam = 710*Rs. 8/10

= Rs. 568/Ton

Annual savings by avoiding steam In the existing gas fired Boiler = 10 X 568 X 8000

= Rs. 454.4 Lacs.

Cost of generation after giving credit for steam generation = 1624.56 – 454.4 = Rs.1170.16 lacs

Cost of generation after accounting for steam cost = 1170.16 X 10^5 / 356.4 X 10^5

= Rs. 3.28 / Kwh

(5 Marks)

Grid power cost = Rs. 4.5 / Kwh

Cost advantage for cogen plant generation = 4.5 – 3.28 = Rs.1.22 / Kwh

Daily gas requirement for operating GT cogen plant $= 5000 \times 0.9 \times \frac{3050}{9500} \times 24$

= 34673.68 Sm^3 / day

(3 Marks)

Additional gas requirement for co-gen plant = 34673.68 – 17040 = 17633.68 Sm^3/day

(4 Marks)

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