16th NATIONAL CERTIFICATION EXAMINATION FOR ENERGY MANAGERS & ENERGY AUDITORS – September, 2015

PAPER – 1: General Aspects of Energy Management & Energy Audit

Date: 19.09.2015 Timings: 0930-1230 HRS Duration: 3 HRS Max. Marks: 150

General instructions:

- *Please check that this question paper contains **11** printed pages*
- *Please check that this question paper contains **64** 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**

a) Answer all **50** questions
b) Each question carries **one** mark
c) Please hatch the appropriate oval in the OMR answer sheet with Black Pen or HB pencil

1.	1 kg of wood contains 15% moisture and 7% hydrogen by weight. How much water is evaporated during complete combustion of 1 kg of wood a) 0.78 kg b) 220 grams c) 0.15 kg d) 0.63 kg
2.	100 tons of coal with a GCV of 4200 kcal/kg can be expressed in 'tonnes of oil equivalent' as a) 42 b) 50 c) 420 d) 125
3.	20 m^3 of water is mixed with 30 m^3 of another liquid with a specific gravity of 0.9. The volume of the mixture would be a) 47 m^3 b) 48 m^3 c) 50 m^3 d) 53 m^3
4.	A centrifugal pump draws 12 m^3/hr. Due to leakages from the body of the pump a continuous flow of 2 m^3/hr is lost. The efficiency of the pump is 55%. The flow at the discharge side would be a) 12 m^3/hr b) 10 m^3/hr c) 5.5 m^3/hr d) 6.6 m^3/hr
5.	A process requires 10 Kg of fuel with a calorific value of 5000 kcal/kg. The system efficiency is 80% and the losses will be a) 10000 kcal b) 45000 kcal c) 500 kcal d) 2000 kcal

6.	A waste heat recovery system costs Rs. 54 lakhs and Rs. 2 lakhs per year to operate and maintain. If the annual savings is Rs. 20 lakhs, the payback period will be a) 8 years b) 2.7 years c) 3 years d) 10 years
7.	Acid rain is formed due to contribution from the following pair of gases a) Methane and Ozone b) Sulphur Dioxide and Nitrous Oxide c) Methane and Sulphur Dioxide d) Carbon Dioxide and Sulphur Dioxide
8.	Air velocity in ducts can be measured by using pilot tube and _____ a) Manometer b) Orifice meter c) Bourdon guage d) Anemometer
9.	Among which of the following fuels, is the difference between the GCV and NCV the maximum? a) coal b) furnace Oil **c)** natural gas d) rice husk
10.	An activity has an optimistic time of 15 days, a most likely time of 18 days and a pessimistic time of 27 days. What is the expected time A) 60 days b) 20 days c) 19 days d) 18 days
11.	An oil-fired boiler operates at an excess air of 6 %. If the stoichiometric air fuel ratio is 14 then for an oil consumption of 100 kg per hour, the flue gas liberated in kg/hr would be a)1484 b) 1584 c) 106 d) 114
12.	At standard atmospheric pressure, specific enthalpy of saturated water, having temperature of 50 ^{O}C will be _____ kCal/kg. A) 1 b) 50 c) 100 d) Can't say
13.	Costs associated with the design, planning, installation and commissioning of a project are: a) variable costs b) capital costs c) salvage value d) none of the above
14.	Energy Intensity is the ratio of a) fuel Consumption / GDP b) GDP/fuel consumption c) GDP/ energy consumption d) energy consumption / GDP
15.	Energy sources which are inexhaustible are known as a) Commercial energy b) Primary energy c) Renewable energy d) Secondary energy
16.	For calculating plant energy performance which of the following data is not required a) current year's production b) reference year's production c) reference year energy use d) capacity utilization
17.	For expressing the primary energy content of a fuel in tonnes of oil equivalent (toe) which of the following conversion factors is appropriate a) toe=1x10^{6} kcal b) toe=116300 kwh c) toe=41.870 GJ d) all the above

18.	Having energy policy a) satisfies regulations b) shows commitment c) indicates energy audit skills d) adds to the list of number of other policies
19.	How much power generation potential is available in a run of river mini hydropower plant for a flow of 40 liters/second with a head of 24 metres. Assume system efficiency of 60%. a) 5.6 kW b) 9.4 kW c) 4.0 kW d) 2.8 kW
20.	If air consists of 77% by weight of nitrogen and 23% by weight of oxygen, the mean molecular weight of air is, a) 11.9 **b**) 28.8 c) 17.7 d) insufficient data
21.	If heat rate of power plant is 860 kcal/kWh then the cycle efficiency of Power plant will be a) 41% b) 55% c) 100% d) 86%
22.	If the pressure of water is 0.7 kg/cm^2 then boiling point will be approximately a) 100 b) 73 c) 114 d) can't say
23.	If the reactive power drawn by a particular load is zero it means the load is operating at a) lagging power factor b) unity power factor c) leading power factor d) none of the above
24.	If we heat the air without changing absolute humidity, % Relative Humidity will a) increase b) decrease c) no Change d) can't say
25.	In a 50 Hz AC cycle, the current reverses directions _____ times per second. a) 50 times b) 100 times c) Two times d) 25 times
26.	In a DG set, the generator is consuming 400 litres per hour diesel oil. If the specific fuel consumption of this DG set in 0.30 litres/kWh at that load then what is the kVA loading of the set at 0.6 power factor? a) 1200 kVA b) 2222 kVA c) 600 kVA d) 1600 kVA
27.	In a drying process moisture is reduced from 60% to 30%. Initial weight of the material is 200 kg. Calculate the weight of the product. a) 104 b) 266.6 c) 130 d) 114.3
28.	In an industry the average electricity consumption is 5.8 lakhs kWh for the period, the average production is 50,000 tons with a specific electricity of 11 kWh/ton for the same period. The fixed electricity consumption for the plant is a) 58000 kwh b) 30000 kwh c) 80000 kwh d) None of the above
29.	In project financing, sensitivity analysis a) is applied in almost all the cash flows method involve uncertainly b) assures how sensitive the project to change the input parameter c) enables the analysis of what if one or more factors are different from what is predicted d) is applicable for all the above situations

30.	PERT/CPM provides which of the following benefits a) predicts the time required to complete the project b) shows activities which are critical to maintaining the schedule c) graphical view of the project d) all the above
31.	Replacement of steam and hot water generation by solar system is an example of a) matching energy usage to requirement b) energy substitution c) maximizing system efficiency d) performance improvement
32.	The contractor provides the financing and is paid an agreed fraction of actual savings achieved. This payment is used to pay down the debt costs of equipment and/or services. This is known as a) traditional contract b) extended technical guarantee/service c) performance Contract d) shared savings performance contract
33.	The cost of replacement of inefficient compressor with an energy efficient compressor in a plant was Rs 50 lakhs. The net annual cash flow is Rs 12.5 lakhs. The return on investment is: a) 15% b) 20% c) 25% d) 19.35%
34.	The data and information sources related to energy use in a company may be obtained from a) plant level b) plant department level c) system level and equipment Level d) all of the above
35.	The fixed energy consumption for the company is 1,000 kWh. The slope in the energy – production chart is found to be 0.3. Find out the actual energy consumption if the production is 80,000 Tons. a) 25,000 b) 24,000 c) 26,000 d) 23,000
36.	The indicator of energy performance in a thermal power plant is a) heat rate (kcal/kWh) b) % aux. power consumption c) specific coal consumption **d**) all the above
37.	The ISO standard for Energy Management System is a) ISO 9001 b) ISO 50001 c) ISO 140001 d) none of the above
38.	The major share of energy loss in a thermal power plant is in the a) generator b) boiler c) condenser d) turbine
39.	The monthly electricity bill for a plant is Rs. 100 lakhs which accounts for 45% of the total monthly energy bill. How much is the plant's monthly energy bill a) Rs 222.22 lakhs b) Rs 45 lakhs c) Rs 138 lakhs d) None of above
40.	The number of moles of water contained in 54 kg of water is ---------- a) 2 b) 3 c) 4 d) 5
41.	The ozone depletion process is triggered by

	a) methane b) chlorine molecules c) carbondioxide d) Nitrogen
42.	The present value of Rs. 1,000 in 10 years' time at an interest rate of 10% is: a) Rs. 2,594 b) Rs. 386 c) Rs. 349 d) Rs. 10,000
43.	The quantity of heat required to raise the temperature of 1 kg of Water by 1 ^{O}C is termed as a) latent heat b) one kiloJoule c) one kilo calorie d) none of the above
44.	The simplest technique for scheduling of tasks and tracking the progress of energy management projects is called a) Gantt chart b) CPM c) PERT d) WBS
45.	To improve the boiler efficiency, which of the following needs to be done a) maximize O_2 in flue gas b) maximize CO_2 in flue gas c) minimize CO_2 in flue gas d) maximize CO in flue gas
46.	Transit time method is used in which of the instrument a) lux meter b) ultrasonic flow meter c) pitot Tube d) fyrite
47.	Which of the following GHGs has the longest atmospheric life time? a) CO_2 b) Sulfur Hexafluoride (SF_6) c) CFC d) per fluorocarbon (PFC)
48.	Which of the following is not a primary energy a) natural gas b) oil c) wood d) electricity
49.	Which of the following terms does not refer to specific energy consumption a) kWh/ton b) kcal/ton c) kJ/kg d) kg/kcal
50.	Which of the following will not be a major component of mass balance a) steam b) water c) raw materials d) lubricating oil

……. End of Section – I ……..

Section – II: SHORT DESCRIPTIVE QUESTIONS **Marks: 8 x 5 = 40**

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

S-1	In a process plant , an evaporator concentrates a liquor containing solids of 6% by w/w (weight by weight) to produce an output containing 30% solids w/w. calculate the

	evaporation of water per 300 Kgs of feed to the evaporator.
	Solution : Inlet solid contents = 6 % Output solid contents=30% Feed=300kgs Solid contents in kg in feed =300 x 0.06 = 18 Kg Outlet Solid contents in kg =18 kg **(2 marks)** Quantity of water evaporated=[300 – {(100) x 18}] = 240 kg **(3 marks)** 30
S-2	List down at least five scheme of BEE under the Energy Conservation Act – 2001.
	Solution **:** Schemes of BEE under the Energy Conservation Act – 2001 are as follows: • Energy conservation building codes(ECBC) • Standards and labeling(S&L) • Demand side management(DSM) • Bachat lamp yojana(BLY) • Promoting energy efficiency in small and medium enterprises(SME's) • Designated consumers • Certification of energy auditors and energy managers **(5 marks for any of the above 5 schemes)**
S – 3	What parameters are measured with the following instruments? a) Pitot tube b) Stroboscope c) Fyrite d) Psychrometer e) Anemometer
	Ans: a. Pitot tube — Static, Dynamic and Total Pressure of Gas b. Stroboscope — Speed, RPM c. Fyrite — CO_2 % or O_2 % d. Psychrometer — Dry Bulb Temperature and Wet Bulb Temperature e. Anemometer — Air or wind velocity **(1 mark for each)**
S - 4	Explain Time of Day (TOD) Tariff and how it is beneficial for the power system and consumers?
	Ans:

	i. In Time of the Day Tariff (TOD) structure incentives for power drawl during off-peak hours and disincentives for power drawl during peak hours are built in. ii. Many electrical utilities like to have flat demand curve to achieve high plant efficiency. iii. ToD tariff encourage user to draw more power during off-peak hours (say during 11pm to 5 am, night time) and less power during peak hours. Energy meter will record peak and off-peak consumption and normal period separately. iv. TOD tariff gives opportunity for the user to reduce their billing, as off peak hour tariff is quite low in comparison to peak hour tariff. v. This also helps the power system to minimize in line congestion, in vi. turn higher line losses and peak load incident and utilities power procurement charges by reduced demand **(5 marks for any of the above 5 relevant points)**
S - 5	Calculate the net present value over a period of 3 years for a project with the following data. The discount rate is 12%. Year | Investment (Rs) | Savings (Rs) 0 | 75,000 | 1 | | 25,000 2 | | 75,000 3 | 50,000 | 75,000 4 | | 35,000
	Ans: NPV = -1,00,000 + 25,000/(1+0.12) + 75,000/$(1+0.12)^2$ + (75,000 – 50,000)/$(1+0.12)^3$ + **(3 marks)** = -75,000 + 22,321 + 59,789 + 17, 794 = 24904 Rs. **(2 marks)**
S-6	A gas fired water heater heats water flowing at a rate of 20 litres per minute from 25^0 C to 85°C. If the GCV of the gas is 9200 kcal/kg, what is the rate of combustion of gas in kg/min (assume efficiency of water heater as 82%)
	Solution: Volume of water heated = 20 liters/min Mass of water heated = 20 Kg/min Heat supplied by gas * efficiency = Heat required by water. (1 mark) Mass of gas Kg/min * 9200 * 0.82 = 20 Kg/min * 1 kcal/Kg/°C)* (85-25)°C Mass of gas Kg/min = (20*1*60)/ (9200*0.82) (3 marks) = 0.159 Kg/ min

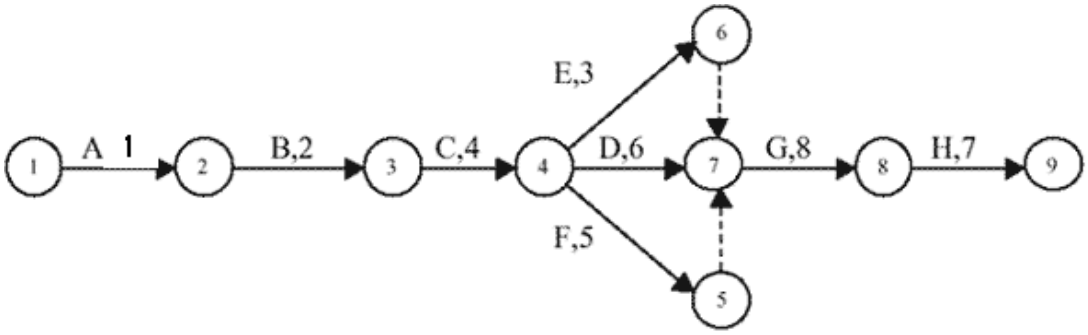
	(1 mark)
S-7	A thermal power plant uses 0.7 kg of coal to generate one KWh of electricity. If the coal contains 32% carbon by weight, calculate the amount of CO_2 emission/KWh under complete combustion.
	Solution: Amount of carbon present in coal= 0.7*32/100 = 0.224 kg As per chemical reaction, $C + O_2 = CO_2$ 1 kg of carbon generates 44/12 kg of carbon dioxide (CO_2) under complete combustion **(2 marks)** Amount of CO_2 generation while generating one KWh of electricity =0.224*44/12 = 0.81 Kg/KWh **(3 marks)**
S – 8	Pressure of a nitrogen gas supplied to an oil tank for purging is measured as 100 mm of Water gauge when barometer reads 756 mm of mercury. Determine the volume of 1.5 kg of this gas if it's temperature is 25 ^{0}C. Specific Gravity of Mercury: 13.6. Take R = 8.3143 kJ/(kMol x K)
	Ans: Nitrogen pressure = 100 mm of Water Gauge = 100 / 13.6 = 7.353 mm of Hg Absolute Temperature, T = 35^{o}C = 25 + 273 = 298 K, Mass = 1.5 kg & Barometric pressure = 756 mm of Hg. Absolute pressure = 756 + 7.353 = 763.353 mm of Hg Pressure, P = Density, ṕ(kg/m^3) x Gravity, g (m/s^2) x Mtr of Liquid, h (Mtr) / 1000 = (13,600 x 9.81 x 0.763)/1000 = 101.79 kPa **(2 marks)** Molar mass of Nitrogen = 28 kg/kMol. Number of kMol, n = Mass / Molar Mass = 1.5/ 28 = 0.0536 kMol Using the ideal gas equation and putting the above values; PV = nRT 101.79 x V = 0.0536 x 8.3143 x 298 V = 1.395 m^3 **(3 marks)**

……. End of Section – II ……..…

Section – III: LONG DESCRIPTIVE QUESTIONS **Marks: 6 x 10 = 60**

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

L – 1	A) Briefly explain the following terms with respect to energy management? I. Normalizing II. Benchmarking B) Explain the meaning of Fuel and Energy substitution with examples.
	Ans: A) I) Normalizing The energy use of facilities varies greatly, partly due to factors beyond the energy efficiency of the equipment and operations. These factors may include weather or certain operating characteristics. Normalizing is the process of removing the impact of various factors on energy use so that energy performance of facilities and operations can be compared. **(3 marks)** II) Benchmarking Comparison of energy performance to peers and competitors to establish a relative understanding of where our performance ranks. **(2 Marks)** B) Fuel and Energy substitution with examples. Substituting existing fossil fuels/energy with more efficient and / or less cost/less polluting fuel. **(1 mark)** Few examples of fuel substitution ▪ Natural gas is increasingly the fuel of choice as fuel and feedstock in the fertilizer, petrochemicals, power and sponge iron industries. ▪ Replacement of coal by coconut shells, rice husk etc. ▪ Replacement of LDO by LSHS **(2 marks)** Few examples of energy substitution ✓ Replacement of electric heaters by steam heaters.

	✓ Replacement of steam based hot water by solar systems. **(2 marks)**
L - 2	The details of activities for a pump replacement project is given below: a) Draw a PERT chart b) Find out the duration of the project c) Identify the critical path. Activity / Immediate Predecessors / Time (days): A / - / 1 B / A / 2 C / B / 4 D / C / 6 E / C / 3 F / C / 5 G / D, E, F / 8 H / G / 7
	Ans:  **(6 Marks)** Duration = 28 days **(2 Marks)** Critical Path: A-B-C-D-G-H **(2 Marks)**
L - 3	a) A furnace heating steel ingots is fired with oil having a calorific value of 10,500 kCal/kg and efficiency of 75%. Calculate the oil consumption per hour when the throughput of the furnace is 50 TPH and the temperature of the finished product is 600 ^{o}C. Take ambient temperature as 30 ^{o}C and Specific Heat of Steel as 0.12 kCal/kg ^{o}C b) In Steel industry, different types of gases are generated during steel making process. Volumetric Flow rate and Calorific Values of each gases are: Type of Gas / Flow (SM^3/hr) / CV (kCal/SM^3) Coke Oven Gas / 75,000 / 4,000

	COREX Gas	50,000	2,000
	BOF Gas	55,000	1,500
	Blast Furnace Gas	80,000	700

All these gases are mixed in the gas mixer before combustion. Find out the Calorific Value (in kCal/SM^3) of mix gas.

Ans:

a) Oil Consumption / hr

$$= \frac{50\ (TPH) \times 0.12\ (kCal/kg\ ^oC) \times (600 - 35)\ (^oC)}{0.75\ (\%) \times 10{,}500\ (kCal/kg)}$$

$$= 0.43\ TPH$$

(5 marks)

b)

Total flow of Mix Gas = 75,000 + 50,000 + 55,000 + 80,000 = 2,60,000 SM^3/hr

(1 marks)

CV of Mix Gas =

[(75,000 x 4,000) + (50,000 x 2,000) + (55,000 x 1,500) + (80,000 x 700)] / 2,60,000

= 2,071 kCal/SM^3 **(4 marks)**

L - 4

Use CUSUM technique to develop a table and to calculate energy savings for 8 months period. For calculating total energy saving, average production can be taken as 6,000 MT per month. Refer to field data given in the table below.

Month	Actual SEC, kWh/MT	Predicted SEC, kWh/MT
May	1311	1335
June	1308	1335
July	1368	1335
Aug	1334	1335
Sept	1338	1335
Oct	1351	1335
Nov	1322	1335
Dec	1320	1335

Ans

Month	Actual SEC, kWh/MT	Predicted SEC, kWh/MT	Diff = (Act - Pred) (- = Saving)	CUSUM (- = Saving)
May	1311	1335	-24	-24
June	1308	1335	-27	-51
July	1368	1335	33	-18
Aug	1334	1335	-1	-19
Sept	1338	1335	3	-16
Oct	1351	1335	16	0
Nov	1322	1335	-13	-13
Dec	1320	1335	-15	-28

(7 marks)

Savings in energy consumption over a period of eight months are 28 x 6,000 = 1,68,000 kWh **(3 marks)**

L – 5

The production capacity of a paper drying machine is 500 TPD and is currently operating at an output of 480 TPD. To find out the steam requirement for drying, the Energy Manager measures the dryness of the paper both at inlet and outlet of the paper drying machine which found to be 60% and 95% respectively.

The steam is supplied at 4 kg/cm^2, having a latent heat of 510 kCal/kg. The evaporated moisture temperature is around 100 ^{0}C having enthalpy of 640 kCal/kg. Plant operates 24 hours per day. Assume only latent heat of steam is being used for drying the paper and neglect the enthalpy of the moisture in the wet paper.

i) Estimate the quantity of moisture to be evaporated per hr.
ii) Input steam quantity required for evaporation per hr.

Ans:

Output of the drying machine = 480 TPD with 95% dryness.

Bone dry mass of paper at the output = 480 x 0.95 = 456 TPD **(2 marks)**

Since the dryness at the inlet is 60%,
Total mass of wet paper at the inlet = (456 x 100) / 60 = 760 TPD **(2 marks)**

Moisture evaporated per hour = (760 – 480)/ 24 = 11.67TPH **(3 marks)**

Mass of Steam, m = (11.67 x 640)/ 510 = 14.6 TPH **(3 marks)**

L-6

Write short notes on?

1) Net calorific value
2) Maximum Demand
3) Contract Demand

	4) Load factor
	Ans: Net Calorific Value (NCV) The heating value of fuel is the measure of the heat released during the complete combustion of unit weight of fuel. It is expressed as Gross Calorific Value (GCV) or Net Calorific Value (NCV). The difference between GCV and NCV is the heat of vaporization of the moisture and atomic hydrogen (conversion to water vapour) in the fuel. **(2.5 Marks)** Maximum Demand Maximum demand is the highest average kVA recorded during any one-demand interval within the month. The demand interval is normally 30 minutes, but may vary from utility to utility from 15 minutes to 60 minutes. The demand is measured using a tri-vector meter / digital energy meter. **(2.5 Marks)** Contract Demand Contract demand is the amount of electric power that a customer demands from utility in a specified interval. Unit used is kVA or kW. It is the amount of electric power that the consumer agreed upon with the utility. This would mean that utility has to plan for the specified capacity. **(2.5 Marks)** Load factor It is the ratio of average load to maximum load. In other words, it is the ratio of energy consumed during a given period of time to the maximum energy demand if maximum load is maintained throughout that time period. **(2.5 Marks)**

……. End of Section – III ……