Regn No: ___________________

Name : ___________________
(To be written by the candidate)

17th NATIONAL CERTIFICATION EXAMINATION
FOR
ENERGY MANAGERS & ENERGY AUDITORS – September, 2016

PAPER – 3: Energy Efficiency in Electrical Utilities
Date: 25.09.2016 Timings: 0930-1230 HRS Duration: 3 HRS

General instructions:

- *Please check that this question paper contains **9** 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

1.	Which of the following is the most comfortable conditions for an office room? DBT = Dry bulb temperature, and RH = Relative humidity a) 20°C DBT and 80% RH b) 26°C DBT and 100% RH c) 15°C DBT and 30% RH **d) 25°C DBT and 55% RH**
2.	Energy Star Label Rating scheme for Fluorescent lamp is based on: **a) Lumens per Watt at 100, 2000 and 3500 hours of use** b) End of Lamp Life in terms of burring hours c) Lumen depreciation at 2000 hours d) Color Rendering Index
3.	The effect of increasing the air gap in an induction motor will increase: a) power factor b) speed c) capacity d) **magnetizing current**
4.	The formation of frost on cooling coils in a refrigerator:

	a) improves C.O.P. of the system b) increases heat transfer c) reduces power consumption **d) increases power consumption**
5.	In a refrigeration system, the expansion device is connected between the a. Compressor and condenser b. Condenser and receiver c. Condenser and evaporator d. Evaporator and compressor
6.	Which of the following is wrong with respect to Color Rendering Index (CRI)? a) The CRI is expressed in a relative scale ranging from 0 - 100 b) CRI indicates how perceived colors match actual colors **c) CRI of Sodium Vapour lamp is much higher than that of a normal Incandescent Lamp** d) The higher the color rendering index, the less color shift or distortion occurs
7.	Which of the following is wrong with reference to heat rate of a coal fired thermal power plant ? a) Heat rate indicates the overall energy efficiency of a power plant b) When calculating plant heat rate, the energy input to the system is GCV of the fuel c) Lower the heat rate the better **d) 860 kCal per kWh is practically achievable**
8.	Installing larger diameter pipe in pumping system results in reduction in: a) Static head **b) Dynamic head** c) Both (a) and (b) d) None of the above
9.	In electrical power system, transmission efficiency increases as **a) both voltage and power factor increase** b) both voltage and power factor decrease c) voltage increases but power factor decreases d) voltage decreases but power factor increases.
10.	Which of the following is wrong statement with reference to LED lamps? a) LED lamps are as energy efficient as CFL bulbs or better. b) LED lampas are more durable than CFLs c) LED lamps has no hazardous material like mercury **d) LED lamps are not suitable for Street Lighting purpose**

11.	In no load test of a poly-phase induction motor, the measured power by the wattmeter consists of: a) core loss b) copper loss c) core loss, windage & friction loss **d) stator copper loss, iron loss, windage & friction loss**
12.	A 10 MVA generator has power factor 0.86 lagging. The reactive power produced will be a) 10 MVAr b) 8 MVAr **c) 5 MVAr** d) 1.34 MVAr.
13.	The no-load loss and copper loss of a 500 kVA transformer is 900 watts and 6400 watts respectively. What is the total loss at 50% of transformer loading? a) 4100 watts b) 6850 watts **c) 2500 watts** d) 3650 watts
14.	Kg of moisture / kg of dry air is defined as **a) Absolute humidity** b) Relative humidity c) Variable humidity **d)** Dew Point
15.	The basic function of an air dryer in a compressor is to a) Prevent dust from entering the compressor b) Remove moisture before the intercooler c) Remove moisture in compressor suction **d) Remove moisture at the downstream of the after-cooler**
16.	The term “cooling range” in a cooling tower refers to the difference in the temperature of a) dry bulb and wet bulb b) hot water entering the tower and the wet bulb temperature of the surrounding air. c) cold water leaving the tower and the wet bulb temperature of the surrounding air. d) **hot water entering the tower and the cooled water leaving the tower**.
17.	The distinction between fans and blowers is based on a) impeller diameter **b) specific ratio** c) speed d) volume delivered
18.	A better indicator for cooling tower performance is

	a) Heat load in tower b) Range c) RH of air leaving cooling tower **d) Approach**
19.	As per the building area method given in Energy Conservation Building Code (ECBC) compute the lighting power allowance; given that : the allowed LPD is 12 watt per square meter and enclosed office area is 500 square meter **a) 6 kW** b) 4.16 kW c) 6 W d) 4.16 W
20.	The power factor of a synchronous motor **a) Improves with increase in excitation and may even become leading at high excitations** b) Decreases with increase in excitation c) Is independent of its excitation
21.	A 4 pole 50 Hz induction motor is running at 1470 rpm. What is the slip value? a) 0.2 **b) 0.02** c) 0.04 d) 0.4
22.	As per Energy Conservation Building Code compute the Effective Aperture (EA); given that Window Wall Ratio (WWR) is 0.40 and Visible Light Transmittance(VLT) is 0.25 **a) 0.10** b) 0.65 c) 0.33 d) 0.15
23.	Increasing the impeller diameter in a pump **a. Increases the flow** b. decreases the head c. decreases the power d. all of the above
24.	The percentage reduction in distribution loses when tail end power factor is raised from 0.8 to 0.95 is: a**) 29%** b) 15.8% c) 71% d) 84%
25.	In a Three Phase Transformer, the secondary side line current is 139.1A, and secondary voltage is 415V. The rating of the transformer would be ___________. a. 50 kVA b. 150 kVA **c. 100 kVA**

	d. 63 kVA
26.	Power factor is highest in case of a. Sodium vapour lamps b. Mercury vapour lamps c. Tube Lights d. **Incandescent lamps**
27.	Shunt capacitors connection is normally adopted for: a. Distribution Voltage improvement. b. Power factor improvement. c. **Both a and b**. d. None of these
28.	A company installed a new 100 kVAr, 415Volt capacitor but the power analyzer indicates that it is operating at 93 kVAr. The reason could be a. Operation is at low load b. Higher Voltage at terminals c. **Lower voltage at terminals** d. None of the above
29.	The kVA reduction by improving the power factor of a plant operating at 400 kW load from 0.85 to 0.95 is a) 40 b) **49** c) 72 d) None of the above
30.	For a supply end Voltage of 10.6 kV and receiving end Voltage of 9.8 kV, the percentage regulation works out to: a) 0.80 **b) 8.16** c) 7.55 d) None of these.
31.	Which of the following can be attributed to Commercial Loss in Electrical Distribution System? a) Lengthy Low Voltage Lines b) Low Load side power factor **c) Faulty consumer service meters** d) Undersized conductors
32.	An Induction motor rated 15 kW and 90 % efficiency, at full load will: a) Draw 15 kW b) Draw 13.5 kW c) Deliver 16.66 kW d) **Deliver 15 kW**
33.	A 50 hp motor with a full load efficiency of 90 percent was found to be operating at 25 kW input. The percent Motor Load is a) 75% b) 67% c)**60%** d) 25%
34.	A DG set has a 300 HP engine drive and is connected to a 300 kVA alternator with 95% efficiency. When a plant load of 290 amps at 415 Volts and 0.76 power factor is connected, the engine loading works out to a) 52% **b) 74.51%** c) 55.4 % d) None of the above

35.	Which of the following devices do not produce any harmonics? a. Electric Motors **b. Filament Lamp** c. Switch Mode power supply of laptops d. Electromagnetic ballasts
36.	At which of the following discharge pressures, the same reciprocating air compressor will consume maximum power a) 3 bar b) 5 kgf/cm^2 c) **90 psi** d) 500 kPa
37.	In a DG set, the generator is consuming 70 litre per hour diesel oil. If the specific fuel consumption of this DG set is 0.33litres/ kWh at that load, what is the kVA loading of the set at 0.8 PF? a) 212 kVA **b) 262.5 kVA** c) 170 kVA d) None of these.
38.	If EER of One Ton Split AC unit is 3.51, what is its power rating? a) **1.0 kW** b) 1.5 kW c) 0.8 kW d) 2.0 kW
39.	As per the Inverse Square Law of illumination what will be the illuminance at half the distance? a) 50% **b) 4 times** c) double d)No change
40.	Find the air density at 35^{o}C temperature at one atmospheric pressure. It is given that at one atmospheric pressure the air density at 20 ^{o}C is 1.2041 kg/m^3 **a) 1.1455** b) 1.2657 c) 1.2024 d) none of the above
41.	A spark ignition engine is used for firing which type of fuels: a) high speed diesel b) light diesel oil **c) natural gas** d) furnace oil
42.	The blow down requirement in m^3/hr of a cooling tower with evaporation rate of 16 m^3/hr and CoC of 3 is a) 4 b) 2 c) **8** d) 16
43.	Which Loss in a Distribution Transformer is predominant if the transformer is loaded to75% of its rated capacity? a) core loss b) **copper loss** c) hysteresis loss d) magnetic field loss
44.	Which of the following power plants has the highest efficiency

	a. **Combined cycle gas turbine** b. Diesel Engine c. Conventional coal plants d. Open cycle Gas Turbine
45.	*The voltage unbalance in three phase supply is 1.5 %. If the motor is operating at 100 ^oC, the additional temperature rise in ^oC due to voltage unbalance is* a. **4.5** b. 9 c. 0 d none of the above
46.	Which of the following cannot be controlled by automatic power factor controllers a) **KW** _b) voltage c) Power factor d) KiloVAr
47.	The parameter used in Star labeling of air conditioner is a. COP **b. EER** c. KW/TR d. EPI
48.	The refrigeration load in TR when 30 m^3/hr of water is cooled from a 14 ^{o} C to 6.5 ^{o} C is about **a) 74.4** b) 64.5 c) 261.6 d) none of the above
49.	In a lithium bromide absorption refrigeration system a. lithium bromide is used as a refrigerant and water as an absorbent **b. water is used as a refrigerant and lithium bromide as an absorbent** c. ammonia is used as a refrigerant and lithium bromide as an absorbent d. none of these
50.	A good DG set waste heat recovery device manufacturer will take precautions to prevent which of the following problem while DG set is in operation a) voltage unbalance on generator **b) Excessive back pressure on engine** c) excessive steam generation d) turbulence in exhaust gases

…………. End of Section – I ………..…

Section – II: SHORT DESCRIPTIVE QUESTIONS

S-1	Why are Motors rated in kW whereas transformers are rated in kVA?
Ans	Transformer rating is expressed in kVA as the designer doesn't know the actual consumer power factor while manufacturing transformers i.e. the P.F (Power factor) of Transformer depends on the nature of connected load such as resistive load, capacitive load, and inductive load as Motors, etc. But Motor has fixed Power factor, i.e. motor has defined power factor and the rating has been mentioned in KW on Motor nameplate data table.
S-2	**Two industries at different locations each want to install an air compressor. The site conditions are as below:** **Industry A** i) Ambient temperature of 38 ^{o}C (ii) Adjacent to a stone crusher site (iii) Relative humidity is 80% **Industry B** i) Ambient temperature of 25 ^{o}C (ii) No major polluting industry near by (iii) Relative humidity is 50% **Discuss which of these compressors will perform better and why ?**
	Answer: Industry B **Reasons:** 1. Rise in inlet temperature results in higher energy consumption. 2. Dust free Air intake reduces choking of intake filter. Site A being near to stone crusher will make the environment dusty so extra filter need to be installed which will increase the power consumption. 3. Moisture at site A is more which make air intake damp
S-3	The measured consumption of a 15 kW rated motor is 12.5 kW. The efficiency of the motor is 89%. This motor is to be replaced by an IE3 (Premium Efficiency) motor of

	efficiency 92.5%. If the motor is operating for 6000 hrs in a year. calculate the annual cost savings at Rs 7 /kWh.
Ans	Solution The power output of the existing motor = 12.5 x 0.89 = 11.13 kW The power input to the new IE3 motor = 11.13 / 0.925 = 12.03 kW Annual savings = (12.5 – 12.03) x 6000 = 2820 kWh Cost savings = 2820 x 7 = Rs 19740 /year
S-4	The average velocity measured across the AHU filter of size 1m x 0.8m is 2.5 m/s. The following are the other data • Enthalpy of the return air to AHU = 50 kJ/kg • Enthalpy of the supply air from AHU = 30 kJ/kg • Air temperature before cooling coil = 25ºC • Air temperature after cooling coil = 12^0C • Density of air = 1.18 kg/m^3 • Static pressure across the fan = 45 mmWC • Power drawn by the fan motor = 3 kW Determine the following a. The TR of AHU b. Efficiency of the AHU fan
Ans	a. Volume Flow rate = Area x Velocity = 1 x 0.8 x 2.5 x 3600 = 7200 m^3/hr Mass flow rate = volume flow rate x density = 7200 x1.18 = 8496 kg/hr TR = (Mass x ΔH) / (4.18 x 3024) = (8496 x (50-30)) / (4.18 x 3024) = 13.44 b. Fan efficiency = Q x h / (102 x P_m x efficiency $_{motor}$) = (7200/3600) x 45 / (102 x 3 x 0.9) = 32.67 % ***Note : evaluator may please note that weightage is not given for part b of the question as fan efficiency has not been mentioned inadvertently in the question paper.***
S-5	State five possible methods of electrical demand management in a plant electrical system to minimize maximum demand.

Ans	a. Rescheduling operation time period of loads b. Storage of products, in process material or utilities such as refrigeration c. Shedding of non essential loads d. Reactive Power Compensation(PF improvement) e. Operation of Captive Power Generator ***Note: Each point carries one mark and marks can be given for relevant points also***
S-6	One unit of electricity in end-use application is equivalent to about two units of electricity generated. Substantiate your answer with the computation of cascade efficiency from generating plant ex-bus to end-use application. Assume: Efficiency of Generator yard substation as 98%; transmission and Distribution Loss = 20%; Efficiency of End-use application= 65%
	Ans. Cascade efficiency from ex-bus generator to end-use = Efficiency of Generator yard substation x Efficiency of transmission and Distribution x Efficiency of End-use application Which is approximately = 0.98x0.80x0.65 = 0.5096 Therefore one unit at end use application = [1/0.5096] = 1.96 Units, say 2 Units at ex-generator bus
S-7	a. The rated compressor capacity is 14.25 m^3/min. Evaluate if there is any capacity de-rating using the air- receiver tank filling method conducted at shop floor. The relevant data is given below. Volume of Air receiver including pipe and cooler = 9 m^3 Initial Pressure = 0.5 kg/cm^2 Final Pressure = 7.0 kg/ cm^2 Atmosphere pressure= 1.026 kg/ cm^2 Time taken to build up the pressure = 5 minutes b. What is the deficiency in this calculation and how can it be corrected ?.
	Ans a. Compressor output from tank filling method = [(7.0-0.5) x9/ (1.026x5)] = 11.40 m^3/min Capacity shortfall = 14.25-11.40 = 2.85 m^3/min, i.e., (2.85/14.25)x100 = 20% capacity de-rating b. The above calculation assumes the compression is isothermal. It can be corrected by introducing the temperature correction factor: $(273+T_1) /(273+T_2)$ where T_1 is suction Temperature and T_2 is receiver temperature.

S-8	A performance analysis of a DG set was carried out. The following are the data obtained. • Period of trial – 2 hrs • Energy generated -1500 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. Also 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 180^0C. 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 0C.
Ans	

1	Fuel consumption (litres) during 2 hrs of trail period { (area x height diff) of day tank} ={3.14x(1^2)/4 x0.516) lit	405	
2	Specific gravity of fuel oil	0.86	
3	Oil consumption (kg/hr) (405x 0.86 / 2)	174.18 kg/hr or 202.5 lit/hr	
4	Specific fuel consumption (kWh/lit) (Ans a)	3.7 kWh/lit or 4.3 kWh/kg	
5	Air supplied per kg of fuel (kg)	30	
6	Mass of flue gas (Sl.no 5)+1kg	31	
7	Mass of flue gas kg per hour (Sl.no 6x Sl.no 3)	5399.5	
8	waste heat recovery potential(kCal/hr) (given)	260000	
9	Delta T across waste heat recovery system (Heat kCal/hr)/(mass of flue gas/hr*specific heat)	192.61	
10	Exit flue gas temp. after waste heat recovery system	180	
11	Present Flue gas temp. or temp. before waste heat recovery system (180^0C+Delta T) (Ans b)	372.6	
12	Efficiency of DG set {750x860/(174.18x10500)} (Ans a)	35.3%	

……………… End of Section - II ……………..

Section – III: LONG DESCRIPTIVE QUESTIONS

L-1	A fan handles 50,000 m^3/hr of air at 90^{o}C at static pressure difference of 70 mm WC. If the fan static efficiency is 55%, find out the shaft power of the fan. The plant proposes to cool the air from 90^{o}C to 45^{o}C before it enters the fan at an envisaged static presure difference of 60mmWC. What will be the power consumption of the fan after cooling?
	(a) Q_1 = 50,000 m^3 / hr. , $\Delta P_{1(static)}$ = 70 mmWC, Fan Effy Static = 55% , Fan Power P_{f1} = ? Q_1 = 50,000/3600 = 13.88 m^3/sec $$\text{Fan Effy Static} = \frac{\text{Volume in } m^3/\text{sec} \times \Delta\text{Pst in mmWc}}{102 \times \text{Power input to shaft in kW}}$$ 0.55 = (13.88) x 70 / 102 x P_{f1} Shaft power drawn = 17.3 kW (b) Q_1 = 50,000 m^3 / hr. , $\Delta P_{2(static)}$ = 60 mmWC, Fan Effy Static = 55% , Fan Power P_{f2}= ? Q_2= 50,000 x {(45 +273) / (90 +273)} = 43,802 m^3 / hr = 43,802/3600 = 12.2 m^3/sec $$\text{Fan Effy Static} = \frac{\text{Volume in } m^3/\text{sec} \times \Delta\text{Pst in mmWc}}{102 \times \text{Power input to shaft in kW}}$$ 0.55 = 12.2 x 60 / 102 x P_{f2} Shaft power drawn = 13 kW
L-2	The relevant data for a heat exchanger used for cooling oil with cooling water from a dedicated cooling tower is given below. Oil flow rate -100m^3/h specific heat of the oil - 0.5 kcal/kg^{o}C specific gravity of oil - 0.8 oil inlet temperature – 90^{o}C oil outlet temperature – 80^{o}C cooling tower effectiveness – 0.7 wet bulb temperature -23^{o}C temperature of water leaving the heat exchanger – 32^{o}C total head developed by pump -12m The efficiency of the pump is 54% and that of the motor is 90%. Calculate the power drawn by the pump

Ans

Solution

Specific gravity = 0.8
Heat load of the heat exchanger = 100 x 1000 x 0.8 x0.5 x (90 -80)=3.2 x 10^6 Kcal / hr

WBT= 23 ^{0}C
Cooling tower effectiveness = 0.7
Effectiveness = Range / (Range + approach)
= (Temp hot water Thw – Temp cold water Tcw)/ {(Temp hot water Thw – Temp cold water Tcw) + (Temp cold water Tcw- WBT)}

0.7 = (32- Tcw) / {(32- Tcw) + (Tcw – 23)}
Tcw = 25.7

Pump flow rate = 3.2 x 10^6 / (32-25.7)
= 507936 kg/hr

Power drawn by pump motor = ((508 /3600) x (12) x 9.81) / (0.54 x 0.9) = 34 kW

L-3

A) A medium sized engineering unit is involved in Die preparation and sheet metal activity. The plant has installed two screw compressors and one is in regular operation. The load and no load test were conducted during working day and also on a holiday. The compressor loading during working day covers air requirement for machine operation and also for the leakage. During holiday no machines were in operation. The details are given below.

Capacity of compressor 600 CFM

Parameter	During Production Day	Holiday
Load time	8 sec.	6 seconds
Unload time	2 sec.	12 seconds

The power drawn by the compressor during load is 98 kw and during unload 32 kw.

Estimate the following for per day for 16 hours operation
1. Energy consumed by compressor.
2. Quantity of air loss.
3. Actual air requirement of the plant.

B) List any five energy conservation opportunities in compressed air systems

Ans

Percentage loading during working day = 8 / 10 = 80%
Total air generated by compressor = % loading x capacity of compressor
= 0.8 x 600 = 480 cfm

Percentage loading during holiday = 6 / 18 = 33%
Total air generated by compressor = % loading x capacity of compressor
= 0.33 x 600 = 198 cfm

Energy consumed per day by compressor
= % loading x load power + % unloading x unload power
= 0.8 x 98 + 0.2 x 32 = 78.4 + 6.4 = 84.8 Kwh

Hours of operation per day = 16
Kwh per day = 16 x 84.8 = 1356.8 Kwh

Actual air requirement of plant = total air generated – air leakage
= 480-198 =282 CFM

b)

- Ensure air intake to compressor is not warm and humid by locating compressors in well-ventilated area or by drawing cold air from outside. Every 4°C rise in air inlet temperature will increase power consumption by 1 percent.
- Clean air-inlet filters regularly. Compressor efficiency will be reduced by 2 percent for every 250 mm WC pressure drop across the filter.
- Consider the use of regenerative air dryers, which uses the heat of compressed air to remove moisture.
- Fouled inter-coolers reduce compressor efficiency and cause more water condensation in air receivers and distribution lines resulting in increased corrosion. Periodic cleaning of inter-coolers must be ensured.
- If more than one compressor is feeding to a common header, compressors must be operated in such a way that only one small compressor should handle the load variations whereas other compressors will operate at full load.
- The possibility of heat recovery from hot compressed air to generate hot air or water for process application must be economically analyzed in case of large compressors.
- Consideration should be given to two-stage or multistage compressor as it consumes less power for the same air output than a single stage compressor.
- Reduce compressor delivery pressure, wherever possible, to save energy.
- Retrofit with variable speed drives in big compressors, say over 100 kW, to eliminate the `unloaded' running condition altogether.
- Keep the minimum possible range between load and unload pressure settings.
- Automatic timer controlled drain traps wastes compressed air every time the valve opens. So frequency of drainage should be optimized.
- Compressed air leakage of 40- 50 percent is not uncommon. Carry out periodic leak tests to estimate the quantity of leakage.

<table>
<tr><td>L-4</td><td>
A large luxury hotel has installed two 900 TR Double effect Vapor Absorption Machine (VAM) and two nos. 500 TR centrifugal chillers. In normal operation one VAM machine and two centrifugal machines are in operation.

VAM is running at full load and centrifugal machines are operated at 90% load.The electric power consumption for compressor is 0.744 KW/TR The heat consumption is 2770 Kcal/TR in VAM machine and steam is supplied at 8 kg/cm^2 hr. The cost of steam is Rs.2900/ton and cost of electricity is Rs.6.2/kWh. The enthalpy of steam at 8 kg. / cm^2 is 660 Kcal per kg.

The power consumed by chilled water pump, condenser water pump and cooling towers are not considered for comparing the operating economics.

1. Estimate the operating cost of VCR and VAM machine per hour.
2. Calculate COP of VCR and VAM machine.

The steam condensate temperature from VAM machine 80^{o}C.
</td></tr>
<tr><td>Ans</td><td>
Operating Cost of VCR machine:
Compressor power = 0.744 kW/TR
Cost of electricity = Rs.6.2 / kWh
Capacity of VCR machine = 500 TR
Loading of VCR machine = 90% = 500 x 0.9 = 450 TR
No. of machines in operation = 2
Refrigeration load supplied by VCR machine= 2 x 450 = 900 TR
Operating cost of VCR machine = 0.744 x 6.2 x 900 = Rs.4151/ hr

COP = 3024/(0.744 x 860)=4.726
Operating Cost of VAM machine:

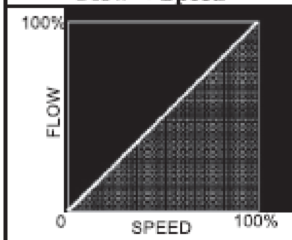
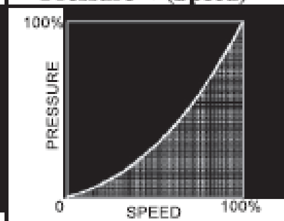
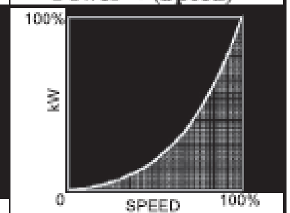
Capacity of VAM Machine = 900 TR
Heat Requirement = 2770 Kcal/TR
Enthalpy of Steam = 660 Kcal/Kg
Steam Requirement for 900 TR = 900 x 2770/(660 -80)= 3196 Kg/hr

Cost of Steam = Rs. 2900/tone
Operating Cost of 900 TR VAM =3196x2900 = Rs.9268.8/hour
COP = 3024/2770 =1.09
</td></tr>
<tr><td>L-5</td><td>
1. State whether following statements are True or false

a. DG sets output increases at higher attitude.(F)
b. Infra red radiation is very high in Incandescent type of lamps.(T)
c. A cooling tower operating at higher COC will increase blow down loss.(F)
d. Input power for a pump decreases when system resistance is increased.(F)
e. When approach is low, the size of the cooling tower will be bigger keeping the other operating parameters constant (T)
</td></tr>
</table>

	f. Operating pump with bypass line partially open is an energy inefficient method of capacity control. (T) g. Estimating fan static efficiency in closed ducts require dynamic pressure in mmWC.(T) h. The enthalpy of air can be from Mollier chart.(F) i. Energy consumption of Pneumatic tools is less than equivalent electric tools. (F) **j.** A bottoming cycle is one which generates electricity first and then meets the power requirements (F)
L-6	**Write short notes on <u>any three</u> of the following** **(i) Effect of supply voltage on capacitor kVAr rating** **(ii) Pump impeller trimming** **(iii) Affinity laws for centrifugal machines** **(iv) Trigeneration** **(v) Maximum demand controller**
Ans	***(i)*** **Voltage effects**: Ideally capacitor voltage rating is to match the supply voltage. If the supply voltage is lower, the reactive kVAr produced will be the ratio V_1^2/V_2^2 where V_1 is the actual supply voltage, V_2 is the rated voltage. On the other hand, if the supply voltage exceeds rated voltage, the life of the capacitor is adversely affected. ***(ii)*** **Effects of impeller diameter change** Changing the impeller diameter gives a proportional change in peripheral velocity, so it follows that there are equations, similar to the affinity laws, for the variation of performance with impeller diameter D: $Q \propto D$ $H \propto D^2$ $P \propto D^3$ Efficiency varies when the diameter is changed within a particular casing. Diameter changes are generally limited to reducing the diameter to about 75% of the maximum, i.e. a head reduction to about 50%. Beyond this, efficiency and NPSH are badly affected. However speed change can be used over a wider range without seriously reducing efficiency. ***(iii)*** Centrifugal Machines

operate under a predictable set of laws concerning speed, power and pressure. A change in speed (RPM) will predictably change the pressure rise and power necessary to operate it at the new RPM.

Flow ∞ Speed	Pressure ∞ (Speed)^2	Power ∞ (Speed)^3
		
$\frac{Q_1}{Q_2} = \frac{N_1}{N_2}$	$\frac{SP_1}{SP_2} = \left(\frac{N_1}{N_2}\right)^2$	$\frac{kW_1}{kW_2} = \left(\frac{N_1}{N_2}\right)^3$
Varying the RPM by 10% decreases or increases air delivery by 10%.	***Reducing the RPM by 10% decreases the static pressure by 19% and an increase in RPM by 10% increases the static pressure by 21%.***	***Reducing the RPM by 10% decreases the power requirement by 27% and an increase in RPM by 10% increases the power requirement by 33%.***

Where Q – Flow, SP – Static Pressure, kW – Power and N – Speed (RPM)

(iv)

In order to further optimize fuel utilization Trigeneration systems are developed which involves the simultaneous production of electricity, heat and cooling. The prime mover used for power generation includes diesel engines/gas engines. The waste heat recovery system in captive power generation units consists of waste heat recovery boiler for generating steam and use of jacket cooling water for operating Vapor Absorption Machines (VAM) to meet Air conditioning requirements.

(v)

When the maximum demand tends to reach preset limit, shedding some of non-essential loads temporarily can help to reduce it. It is possible to install direct demand monitoring and control systems (Figure 1.8), which will switch off non-essential loads when a preset demand is reached. Simple systems give an alarm, and the loads are shed manually. Sophisticated microprocessor controlled systems are also available, which provide a wide variety of control options like:

- Accurate prediction of demand
- Graphical display of present load, available load, demand limit
- Visual and audible alarm
- Automatic load shedding in a predetermined sequence
- Automatic restoration of load
- Recording and metering

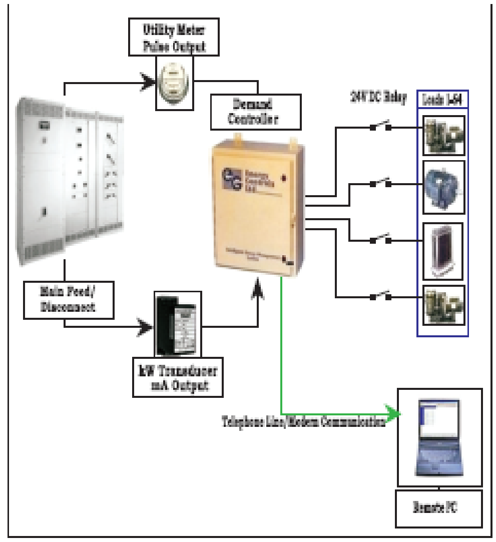


Figure 1.8 Maximum Demand Controller

Any three of the above and relevant answers can be awarded marks

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