

Objective Type Questions

1. Load factor of a power station is defined as
 - (a) $\frac{\text{Average load}}{\text{Maximum demand}}$
 - (b) Average load \times Maximum demand
 - (c) $\frac{\text{Maximum demand}}{\text{Average load}}$
2. Diversity factor is always
 - (a) less than unity
 - (b) more than unity
 - (c) equal to unity.
3. Load factor of a power station is generally
 - (a) more than unity
 - (b) less than unity
 - (c) equal to unity.
4. It is generally seen that load factor of domestic load is
 - (a) 10 to 15%
 - (b) 60 to 70%
 - (c) 30 to 40%.
5. The load factor for heavy industries may be taken as
 - (a) 10 to 20%
 - (b) 25 to 40%
 - (c) 70 to 80%.
6. The load factor for street lighting on 24 hour basis may be taken as
 - (a) 20 to 25%
 - (b) 40 to 50%
 - (c) 80 to 90%.
7. A steam power station requires space
 - (a) more than diesel power plant
 - (b) less than diesel power station
 - (c) equal to diesel power station.
8. State whether the following statements are true or false :

- (a) The depreciation rate of diesel power station is more than steam power station of equal capacity.
 - (b) The depreciation rate of a hydro-power station is less than steam power station of same size.
 - (c) It is economical to use a few generating unit of large size than a large number of small size for the same total capacity.
 - (d) A diesel power station produces less noise than a steam power station of the same capacity.
 - (e) A diesel power station requires larger quantities of cooling water than a steam power station of the same size.
 - (f) A steam power station needs longer time for starting and for taking load as compared to diesel engine power plant.
 - (g) Diesel power stations are of smaller capacities.
9. In a diesel engine the heat lost to the cooling water is about
- (a) 30%
 - (b) 70%
 - (c) 10%.
10. State whether the following statements are true or false
- (a) Pulverised coal firing requires high percentage of excess air.
 - (b) It is economical to fire coal into furnace by stokers than hand firing.
 - (c) A steam station needs more space for storing fuel than a diesel power station.
11. Economiser is used to heat
- (a) feed water
 - (b) air
 - (c) flue gases.
12. Steam is supplied to the turbine through
- (a) safety valve
 - (b) throttle valve
 - (c) blow-off valve.
13. The function of a condenser is to
- (a) reduce the back pressure at the steam turbine exhaust
 - (b) increases the back pressure at the steam turbine exhaust
 - (c) make the steam pressure more than atmospheric pressure.
14. State whether the following statements are true or false

- (a) There is no direct contact between steam and cooling water in surface condensers.
- (b) Secondary air is not supplied in cyclone burner used to burn pulverised coal.
15. A venturimeter is generally used to measure rate of flow of
(a) air (b) steam
(c) water.
16. Pipes carrying steam are generally made up of
(a) cast iron (b) steel
(c) copper.
17. Running cost of a hydro-electric power plant is
(a) more than running cost of a steam power plant
(b) less than running cost of a steam power plant
(c) equal to running cost of a steam power plant.
18. The initial cost of erecting a nuclear power plant is
(a) equal to the initial cost of a steam power plant of same size.
(b) less than the initial cost of a steam power plant of same size.
(c) more than the initial cost of a steam power plant of same size.
19. State whether the following statements are true or false
(a) In fire tube boilers the gases pass through tubes and water surrounds these tubes.
(b) More heating surfaces is available in bent tube boilers.
20. The modern steam turbines are
(a) reaction turbines (b) impulse turbine
(c) impulse-reaction turbines.
21. The nuclear power plant at Tarapur has
(a) pressurised water reactors
(b) boiling water reactors
(c) sodium graphite reactors.
22. The boiling water reactor uses
(a) enriched uranium as fuel (b) plutonium
(c) thorium.
23. Fill in the blanks :
(a) Narora atomic power station is located in.....(M.P., U.P., Gujarat)

- (b) Kalpakkam atomic power station is located in.....(Andhra Pradesh, Maharashtra, Tamil Nadu)
- (c) Neyveli thermal power station is located in..... (M.P., Orissa, Tamil Nadu)
- (d) Badarpur thermal power station is located in.....(U.P., Haryana, Delhi).
24. The average thermal efficiency of a modern nuclear power plant is about
 (a) 80% (b) 60%
 (c) 30%.
25. Control rods used in a nuclear reactor are made up of
 (a) steel (b) cadmium
 (c) copper.
26. Reflector of a nuclear reactor are made up of
 (a) steel (b) boron
 (c) beryllium.
27. Mechanical efficiency of a diesel engine is defined as
 (a) $\frac{\text{I.H.P.}}{\text{B.H.P.}}$
 (b) $\frac{\text{B.H.P.}}{\text{I.H.P.}}$
 (c) $\text{B.H.P.} \times \text{I.H.P.}$
28. For the safety of a steam boiler the number of safety valves fitted are
 (a) two (b) three
 (c) one.
29. Natural draught in a steam power plant is produced by
 (a) chimneys (b) fans
 (c) steam jets.
30. Steam turbines commonly used in steam power station are
 (a) condensing type (b) non-condensing type
 (c) none of the above.
31. The temperature of the combustion gas at the gas turbine inlet is about
 (a) 900 C (b) 715 C
 (c) 1200 C.
32. Name two fuels used in a gas turbine.
33. Name three materials used for insulation of steam pipes.

34. Laminated asbestos is recommended as insulation material for a temperature up to
 (a) 875°C (b) 150°C
 (c) 275°C.
35. State the approximate heads under which the following types of hydro-power plant work
 (a) high head power plant
 (b) medium head power plant
 (c) low head power plant.
36. State the range of specific speed for the following types of water turbines.
 (a) Pelton turbine (b) Francis turbine
 (c) Kaplan turbine.
37. Pelton turbines are mostly
 (a) horizontal (b) vertical
 (c) inclined.
38. Jet ratio of a Pelton turbine is defined as
 (a) $\frac{\text{Least diameter of jet}}{\text{Mean diameter of runner}}$
 (b) $\frac{\text{Mean diameter of runner}}{\text{Least diameter of jet}}$
 (c) $\frac{\text{Mean diameter of runner} - \text{Least diameter of jet}}{\text{Least diameter of jet}}$
39. The empirical relation for determination of number of buckets (Z) for Pelton turbine in terms of jet ratio (m) is given by
 (a) $Z = 15m + 0.5$ (b) $Z = 0.5m + 15$
 (c) $L = \frac{m}{0.5} + 15$
40. Francis turbine is usually used for
 (a) low heads (b) medium heads
 (c) high heads.
41. State whether the following statements are true or false
 (a) Turbine runner are made of cast steel and then coated with stainless steel.
 (b) Draft tube is not used in Pelton turbine.
 (c) Kaplan turbine is an impulse turbine.
 (d) Propeller turbine is used for low head of water.

- (e) The main function of water turbine governor is to maintain constant head when load on the turbine fluctuates.
- (f) Surge tanks are needed only for low head water plant and they are not required for high and medium head-power plants.
42. Sensitiveness of a water turbine governor is defined as
- (a)
$$\frac{\text{Mean speed}}{\text{Maximum speed} - \text{Minimum speed}}$$
- (b)
$$\frac{\text{Maximum speed} - \text{Minimum speed}}{\text{Mean speed}}$$
- (c) Mean speed \times Maximum speed - Minimum speed.
43. Fig. 14.1 illustrates the variation of water turbine efficiency with load. State which curve is for Pelton turbine and which curve is for Francis turbine.

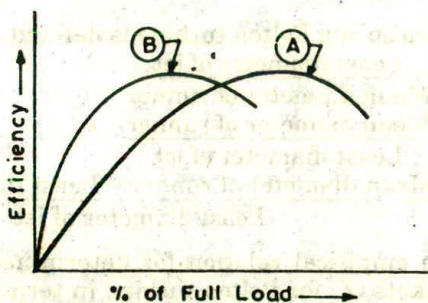


Fig. 14.1

44. State whether the following statements are true or false
- (a) Specific speed of a water turbine is directly proportional to its rotational speed.
- (b) Horizontal shaft arrangement is mostly employed for large size impulse turbines.
- (c) Vertical shaft arrangement is mostly employed for large size reaction turbine.
- (d) A vertical shaft turbine requires deeper foundation and a high building.
- (e) A horizontal shaft turbine does not require greater floor area.
- (f) In axial flow turbines the water flows through the vanes parallel to the axis of runner shaft.

(g) In impulse turbines the entire head of water available is converted in the velocity head by making it to pass through a nozzle.

45. Pelton turbine is suitable for
(a) high head high discharge
(b) high head low discharge
(c) low head high discharge.
46. Belt conveyor can be used to transport coal at inclinations upto
(a) 60° (b) 30°
(c) 90° .
47. The maximum length of a screw conveyor is about
(a) 60 metres (b) 100 metres
(c) 30 metres.
48. Fill in the blanks :
(a) Bhakhra dam is.....dam (earth, gravity, arch)
(b) The side of the dam to which water from the river or the stream approaches is called.....and the other is called..... (down stream, up stream)
49. The annual depreciation of a hydro power plant is about
(a) 10 to 20% (b) 10 to 15%
(c) 0.5 to 1.5%.
50. The function of a moderator in a nuclear reactor is
(a) to start the chain reaction
(b) to transfer heat produced inside the reactor to a heat exchanger
(c) to slow down the fast moving neutrons.
51. State the factors which influence the selection of steam pressure and temperature in a steam power plant.

Solution. Proper selection of temperature and pressure of steam is very essential for proper functioning of steam power plant. For each combination of fuel cost, load factor and capacity factor there is an economical pressure and temperature of steam which will result in the lowest total cost of power.

The following factors should be considered while selecting the proper steam pressure and temperature

- | | |
|-----------------------|----------------------------|
| (a) plant capacity | (b) annual capacity factor |
| (c) cost of plant | (d) annual costs |
| (i) fixed cost | (ii) variable cost |
| (e) total annual cost | (f) energy generated |
| (i) gross | (ii) net. |

(g) kilo calorie consumption per kilo watt hour

(h) cost of fuel per million kilo-calorie.

52. Discuss the factors which influence the selection of vacuum in condenser for a steam power plant.

Solution. The vacuum obtainable in a condenser is governed by outlet water temperature which in turn varies with the amount of condensing water used per kg of steam and its initial temperature. Air entrainment in the condenser has its effect upon the vacuum. The addition of air lowers the vacuum. In the condenser absolute vacuum is neither possible nor economical to maintain. A higher vacuum in a condenser results in increase the condenser size. It also results in lower temperature of the condensate and increase the rate of flow of cooling water and thus power required to drive the cooling water circulating pumps is increased. For steam turbines the most profitables vacuum is about 72 cm of mercury.

53. Vacuum efficiency of a condenser is defined as

- (a) $\frac{H}{h}$ (b) $H \times h$
 (c) $\frac{h}{H}$ (d) none of the above.

where h is the actual vacuum in the condenser and H is the theoretical vacuum in a condenser.

54. State whether the following statements are true or false

- (a) The theoretical vacuum in the condenser is the vacuum when no air is present in it.
 (b) The efficiency ratio of a steam turbine is defined as the ratio of the thermal efficiency of actual turbine to that of a perfect turbine.

55. A nuclear chain reaction is possible when

- (a) fission produces more neutrons than absorbed
 (b) fission produces less neutrons than absorbed
 (c) none of the above.

56. State whether the following statements are true or false

- (a) In a homogeneous reactors the fuel is uniformly distributed in the core.
 (b) In a heterogeneous reactor the fuel elements are separated by a moderator.
 (c) In a thermal reactor thermal neutrons are used.

57. When a nuclear reactor is operating at constant power the multiplication factor (K) is

- (a) less than unity (b) greater than unity
 (c) equal to unity (d) none of the above.

58. The critical mass of fuel in a nuclear reactor is the amount required to make the multiplication factor.

- (a) more than unity (b) equal to unity
(c) less than unity.

59. The efficiency of a gas turbine open cycle with regenerator, intercooler and reheater is about

- (a) 59% (b) 29%
(c) 39%.

60. The efficiency of a modern boiler using coal can heat recovery equipment is about

- (a) 65 to 70% (b) 85 to 90%
(c) 25 to 30%.

61. The temperature of cooling water leaving the diesel engine should not be more than

- (a) 80°C (b) 30°C
(c) 60°C.

62. **Statements**

(a) Nozzles are not provided in a reaction steam turbine.

(b) In a reaction steam turbine fixed blades act both as nozzles in which the velocity of the steam is increased and as the means of directing the steam so what it enters the ring of moving blades without shock.

(c) Modern steam turbines generally have the first stage velocity compounded and subsequent stages are either pressure compounded or reaction stages.

63. Compare the following properties of pressure compounded steam turbine and a velocity compounded steam turbine

- (a) efficiency (b) cost.

64. The compression ratio of an I.C. engine is given by

- (a) $\frac{V}{V_c}$ (b) $\frac{V_c}{V}$
(c) $V \times V_c$ (d) none of the above.

where V is the total volume (clearance vol. + swept vol.) and V_c is the clearance volume.

65. pH value of a neutral solution is

- (a) 1 (b) 7
(c) 14 (d) none of the above.

66. The conversion ratio (S) of a nuclear reactor is given by

- (a) $S = \frac{n_1}{n_2}$ (b) $S = \frac{n_2}{n_1}$

- (c) $S = n_1 \times n_2$ (d) none of the above.
 where n_1 is the number of secondary fuel atoms and n_2 is the number of consumed primary fuel atoms.
67. The conversion ratio of a breeder reactor is
 (a) Less than unity (b) equal to unity
 (c) more than unity.
68. Surge tank in a hydro power plant is placed as near as possible to the
 (a) reservoir (b) tail race
 (c) turbine (d) none of the above.
69. The average ash content in Indian coals is about
 (a) 5% (b) 20%
 (c) 10%.
70. The maximum inclination of belt conveyors for transporting coal is
 (a) 5° (b) 10°
 (c) 20° .
71. State five requirements of a good air preheater.
- 72. Statements**
- (a) Gas turbine plant has lower thermal efficiency as compared with a diesel plant.
 (b) The capital and maintenance costs of a gas turbine plant are higher than steam turbine plant.
 (c) Thermal efficiency of a gas turbine is more than steam turbine.
 (d) Gas turbine usually operates at higher temperature than steam turbine.
73. The ideal fuel for gas turbine is
 (a) natural gas (b) pulverised coal
 (c) producer gas.
74. Total cost of a diesel power plant per kW of installed capacity is less than that of steam power plant by about
 (a) 70 to 80% (b) 20 to 30%
 (c) 5 to 10%.
75. Compare steam power plant, nuclear power plant, diesel power plant and hydro-power plant, as regards
 (a) fixed cost (b) operating cost
 (c) reliability
 (d) ease in planning, design and construction.

76. The specific speed of Pelton turbines are around
(a) 12-45 (metric) (b) 150-300 (metric)
(c) 350-400 (metric).
77. In high head hydro power plant the velocity of water in penstock is about
(a) 2 m/sec (b) 7 m/sec
(c) 12 m/sec (d) none of the above.
78. Pelton turbine is suitable for high head and
(a) low discharge (b) high discharge
(c) both for low and high discharge.
79. In diesel engine power plant the heat lost to cooling water is about
(a) 90% (b) 60%
(c) 30% (d) none of the above.
80. In diesel power plant the maximum allowable difference between inlet and outlet temperature of cooling water is normally
(a) 5°C (b) 11°C
(c) 18°C.
81. State whether the following statements are true or false
(a) Nuclear power plant should be used as peak load plants.
(b) Steam power plants can be used both as base load and peak base load plants.
(c) Peak load plants work at low load factors.
(d) Gas turbine power plants are normally used as base load plants.
(e) The flow of water in Kaplan turbine is axial.
(f) In Francis turbine the flow of water is radial.
(g) The annual depreciation of a hydro electric station is about 0.5 to 1.5% of the capital cost.
(h) The nuclear power plants cannot be operated at varying load efficiently.
82. State three advantages of super charging in diesel engines.
83. Name four boiler accessories.
84. Name any four boiler mountings.
85. **Statements**
(a) Water tube boilers are used only for low pressures.
(b) All large power plants use water tube boilers.

- (c) In water tube boilers water flows through tubes and hot gases flow outside the tubes.
86. Name two fire tube boilers.
87. State three factors which affect the efficiency of a steam turbine.
88. State the pressure and temperature ranges commonly used for boilers.
89. (a) Define speed factors for a diesel engine.
(b) State speed factors for low speed, medium speed, and high speed diesel engines.
90. The approximate efficiency of a water tube boiler used for power purposes without heat recovery equipment using coal is
(a) 45% (b) 75%
(c) 95%.
91. The ratio of piston stroke to bore of cylinder for internal combustion engines varies between
(a) 0.9 and 1.9
(b) 0.5 and 0.8
(c) 0.3 and 0.6.
92. State basic characteristics of a boiler unit.
93. Compare a hydro power plant and steam power plant.
94. State the methods of feeding various types of fuels into furnace.
95. The velocity of water in the penstock for high head power plant is about
(a) 12 m/sec (b) 7 m/sec
(c) 3 m/sec.
96. The steam consumption in large turbines is about
(a) 5 kg per kWh (b) 10 kg per kWh
(c) 15 kg per kWh (d) None of the above.
97. The most economical average vacuum in a condenser for steam turbine is about
(a) 42 cm of mercury (b) 22 cm of mercury
(c) 72 cm of mercury (d) None of the above.
98. Statements (True or false)

- (a) The mechanical efficiency of a Pelton turbine falls more rapidly with time as compared to Francis turbine.
 - (b) The variation in the operating head can be more easily controlled in Francis turbine than Pelton wheel.
 - (c) The thermal efficiency of a diesel engine power plant is less than thermal efficiency of a comparable size steam power plant.
 - (d) It is economical to run nuclear, power plants at low load factors.
99. State three characteristics of low grade coal.
100. **Statements**
- (a) Initial cost of a surface condenser is high.
 - (b) In surface condenser a slightly better vacuum can be obtained.
 - (c) A jet condenser requires less floor area.
 - (d) Cooling water need not be cleaned in Jet condenser.
 - (e) Moderators have low atomic numbers.
101. Name four moderators commonly used in nuclear power plant.
102. State the functions of a steam condenser.
103. State the functions of a carburettor used in S.I. engines.
104. **Statements**
- (a) In a smoke tube or fire tube boiler the hot gases flow through tubes.
 - (b) Locomotive boiler is water tube boiler.
 - (c) A boiler safety valve prevents the pressure in the boiler from rising above a certain safe limit.
 - (d) A pressure gauge fitted on the boiler shows the pressure of feed water in boiler.
105. In locomotive boiler draft produced is by
- (a) induced draft fan
 - (b) steam jet arrangement
 - (c) chimney
 - (d) forced draft fan.
106. The proper indication of incomplete combustion of coal in boiler is
- (a) high CO content in flue gases at exist
 - (b) high CO₂ content in flue gases at exist
 - (c) high temperature of flue gases
 - (d) the smoking exhaust from chimney.

107. The % O_2 by weight in atmospheric air is
(a) 20% (b) 23%
(c) 79% (d) 77%.
108. The % O_2 by volume in atmospheric air is
(a) 23% (b) 77%
(c) 21% (d) 79%.
109. Name two types of steam pressure gauges.
110. Economiser is used to heat
(a) boiler feed water (b) steam used in turbines
(c) condenser cooling water (d) air.
111. Draft is plus if
(a) $P_g > P_a$ (b) $P_g < P_a$
(c) $P_g = P_a$.
where P_g is gas pressure and P_a is atmospheric pressure.
112. In a nuclear power plant
(a) uranium 238 and thorium 232 are called fertile materials.
(b) moderator is used to slow the fast neutrons to a thermal speed.
(c) thermal shielding must surround the entire reactor core to absorb some of the radiations (beta particles, escaping neutrons and gamma rays) produced by the fissioning.
(d) the reflector usually completely surrounds the reactor core with in the shielding.
113. State the basic factors considered in the design of a nuclear power reactor.
114. State the formula for calculating the thickness of steel penstock used in hydro power plant.
115. State the purposes of draft tubes used in hydro-power plant.
116. What is a dam ? Define following types of dams
(a) Gravity dam (b) Arch dam
(c) Earthen dam.
117. Classify the dams based on material of construction.
118. Classify dams based on method of design and analysis.

119. The main force trying to stabilise the dam against water and other disturbing forces is
(a) Foundation reaction (b) Weight of dam
(c) Earth pressure (d) None of the above.
120. The power output from a hydro electric power plant depends on three parameters.
(a) Head, discharge and efficiency of the system
(b) Head, type of dam and discharge
(c) Type of dam, discharge and type of catchment area
(d) Efficiency of the system, type of draft tube and type of turbine used.
121. The low head hydro power plants are those which usually have water head
(a) less than 5 m (b) less than 15 m
(c) less than 30 m (d) None of the above.
122. Air fuel ratio required for the combustion in diesel engine is about
(a) 15 : 1 (b) 5 : 1
(c) 10 : 1 (d) none of the above.
123. The air-fuel ratio by weight required in gas turbine is
(a) 30 : 1 (b) 60 : 1
(c) 90 : 1 (d) none of the above
124. Name three gases used in closed cycle gas turbine plant.
125. Turbo alternators are generally rated at
(a) 0.8 power factor lagging
(b) 0.6 power factor lagging
(c) 0.5 power factor lagging
(d) None of the above
126. Define super structure and sub-structure of a hydro power plant.
127. Tick mark the correct answers
(A) The function of superheater is
(a) to increase steam temperature sufficiently above saturation temperature
(b) to preheat the air entering the furnace
(c) to heat the feed water entering the boiler.
(B) The capital cost of gas turbine power plant is about
(a) Rs. 500 to 700 per kW
(b) Rs. 1500 to 1700 per kW
(c) Rs. 2500 to 2700 per kW.

128. State five outstanding features of a gas turbine power plant.
129. State the functions of a super heater in a steam power plant.
130. State whether the following statements are true or false.
- (a) Francis turbine and propeller turbine are reaction turbines.
 - (b) Impulse turbine utilises the kinetic energy of a high velocity jet of water to transform the water energy into mechanical energy.
 - (c) Reaction turbine develops power from the combined action of pressure energy and kinetic energy of water.
 - (d) The operating cost of diesel power plant is less as compared to steam power plant of equal capacity.
 - (e) Diesel power plants have good over load capacity.
 - (f) A hydro-plant can be easily started from cold conditions.
 - (g) Major drawback of a diesel power plant is limited unit generation capacity.
 - (h) A diesel power plant has higher thermal efficiency than a steam power plant of comparable size.
131. State two factors to be considered while selecting generating units.
132. Name four effects of impurities present in feed water for boiler.
133. State the factor considered in selecting the coal handling system in a steam power plant.
134. The heating value of natural gas at S.T.P. is
- (a) 7000 kcal/m³
 - (b) 9000 kcal/m³
 - (c) 11000 kcal/m³
135. The national research centre for research and development work in nuclear energy in our country is
- (a) Bhabha atomic research centre (BARC)
 - (b) Tata institute of fundamental research
 - (c) Saha institute of nuclear physics.
136. State four limitations in the use of nuclear power plants.
137. State two limitations in the use of solar energy.
138. Name two materials used for making solar cells.
139. **Statements**

- (a) Tower concept type solar power plants uses an array of plane mirrors or heliostats.
- (b) The flat plate solar collectors are classified as low temperature collectors.

140. Regenerators used in gas turbines have an efficiency of about

- (a) 45%
- (b) 75%
- (c) 95%.

141. **Statements :**

In a gas turbine

- (a) the work ratio is increased as compressor inlet temperature is decreased.
- (b) inter cooling and reheating improve the work ratio.

142. Name three types of compressors used in gas turbine plants.

143. State the water head for the following water turbines to be used as reversible pump turbines

- (a) Propeller and Kaplan turbines
- (b) Deriaz turbines
- (c) Francis turbines.

144. Classify dams for hydro plants according to construction materials.

145. State two situations under which the gravity dams can not be considered feasible.

146. Classify dams according to hydraulic design.

147. State three basic types of arch dams.

148. Classify dams according to design.

149. State the turbines used for the following heads

- (a) Medium heads
- (b) High heads
- (c) Very high heads.

150. Tick mark the correct answer

- (a) Francis turbines are radial/Axial flow turbines
- (b) Propeller turbines are radial/axial flow turbines.

151. Define the following :

- (a) Runner of a water turbine
- (b) Spillways for a dam.

152. State the actions by which the coal pulverising mills reduce the coal to powdered form.
153. Natural draft in a steam power plant is produced by
 (a) Fans (b) Steam jets
 (c) Chimney.
154. Which of the following coals has the highest calorific value
 (a) Peat (b) Legnite
 (c) Anthracite (d) Bituminous.
155. In a furnace 14 kg of air is required to burn one kg of coal while the theoretical amount of air needed is 8 kg. Find the percentage of excess air.
156. The commonly used steam pressure in steam power plants is
 (a) 20 kg/cm² (b) 40 kg/cm²
 (c) 80 kg/cm² (d) 150 kg/cm².
157. Capacity (C_1) of steam turbine in kW and capacity (C_2) of generator in kW are related as
 (a) $C_1 = C_2 \times \eta$ (b) $C_1 = \frac{C_2}{\eta}$
 (c) $C_2 = \frac{C_1}{\eta}$
 where η is the efficiency of generator.
158. Steam power plant basically works on
 (a) Dual cycle (b) Otto cycle
 (c) Rankine cycle.
159. State two main factors to be kept in view while deciding the size and number of generating units in a power plant.
160. pH value of water is numbered from
 (a) 0—7 (b) 0—10
 (c) 0—14.
161. Water having pH value 7 is called
 (a) neutral water (b) acidic water
 (c) alkaline water.
162. **Statements**
 (a) Sample of water having pH value less than 7 is said to be acidic.
 (b) Sample of water having pH value more than 7 is called alkaline.

- (c) The operating cost of diesel power plant is less than a steam power plant of equivalent capacity.
163. Fill in the blanks. Flue gas borne matter from steam plants
- (a) larger than 1μ in diameter is called.....
 - (b) larger than 100μ is called.....
164. Name two of the following equipments used in hydro power plant
- (a) water conveyance structures
 - (b) energy conversion equipments
 - (c) Distribution systems.
165. **Statements**
- (a) In a penstock, longitudinal stresses are much less than circumferential stresses.
 - (b) The length of penstock should be maximum as far as possible.
 - (c) Higher velocity of fluid in penstock increases friction loss.
 - (d) It is easier and economical to regulate power out put from a hydro-power plant than steam power plant.
 - (e) Draft tube has gradually increasing area from exit of turbine to the tail race.
 - (f) Governing of water turbines keeps the turbine speed constant under all working conditions.
166. The air fuel ratio used in gas turbines is
- (a) 15 : 1
 - (b) 50 : 1
 - (c) 100 : 1
 - (d) None of the above.
167. The air fuel ratio in diesel engine is
- (a) 15 : 1
 - (b) 50 : 1
 - (c) 100 : 1.
168. Without the use of superheater a boiler produces steam of about
- (a) 80% dryness fraction
 - (b) 90% dryness fraction
 - (c) 98% dryness fraction
 - (d) 88% dryness fraction.
169. How to increase efficiency of a boiler ?
170. Classify reaction turbines with reference to direction of flow of water.

171. State the basis on which penstocks may be classified.
172. Name five safety measure in hydro plant.
173. State the difference between base load power plant and peak load power plant.
174. Name five parts of a reaction turbine.

175. **Statements**

- (a) The capacity of a boiler is expressed in terms of the thousands of killogrammes of steam that it can supply per hour at rated pressure and temperature.
- (b) In steam power plants the efficiency of large turbo-alternators may be taken as 98% with air cooling and 99% with hydrogen cooling.
176. Where following power plants are located ?
- (a) Auraiya Gas power plant
- (b) Badarpur thermal power plant
- (c) Balco-captive power plant.

177. Define specific fuel consumption of an I.C. engine.

178. Solar cells are made of

- (a) Copper (b) Silicon
- (c) Aluminium (d) None of the above.

179. State two factor to be considered for site selection of WECS (wind energy conversion system).

180. State three advantages and three disadvantages of wind energy.

181. Power co-efficient (k) for wind power is given by

- (a) $K = \frac{P_1}{P_2}$ (b) $K = \frac{P_2}{P_1}$
- (c) $k = P_1 \times P_2$ (d) None of the above

where $P_1 =$ Power of wind rotor $P_2 =$ Power available in wind.

182. Name the raw materials for steam power plant.

183. In biogas plants the best pH value for fermentation and normal gas production is

- (a) 4 to 5 (b) 6.5 to 8
- (c) 9.5 to 11.5 (d) None of the above.

184. State two main advantages of pulverised fuel firing method.

185. The particle size of coal used in pulverised fuel fired furnaces is limited to
 (a) 70—100 microns (b) 10—20 microns
 (c) 150—180 microns (d) None of the above.
186. Combustion in coal fired boilers usually takes place at
 (a) 600 to 800°C (b) 1400 to 1700°C
 (c) 200 to 300°C (d) None of the above.
187. In steam power plants the most commonly used device to remove SO_2 from flue gases is
 (a) Economiser (b) Heater
 (c) Scrubber (d) None of the above.
188. In fluidised bed combustion (FBC) system the combustion of fuel takes place at about
 (a) 300 - 400°C (b) 800 - 900°C
 (c) 1500 - 1700°C (d) None of the above.
189. Name three materials used as inert materials in fluidised bed combustion (FBC) system.
190. **Statements**
 (a) The SO_2 produced in fluidised bed combustion (FBC) system is less as compared to pulverised fuel firing method of coal.
 (b) In high pressure boilers the tendency of scale formation is eliminated due to high velocity of water through the tubes.
 (c) In high pressure boilers the steam can be raised quickly to melt the variable load.

191. Match the words of Column A and Column B.

	Column A		Column B
(a)	Pelton Turbine	(i)	Peak load plant
(b)	Reactor	(ii)	High head of water
(c)	Stokers	(iii)	Heavy water
(d)	Moderator	(iv)	Nuclear Power Plant
(e)	Run-of-river power plant	(v)	Low head of water
(f)	Propeller Turbine	(vi)	Steam Power Plant

192. Fill in the blanks

- (a) Diversity factor for residential consumers is nearly.....
 (b) Diversity factor for large industrial consumers is about.....
 (c) Pumped storage plant is used as.....

- (d) The combustion of fuel in F.B.C. system takes place at about.....

Statements

193. (a) During feed water treatment the suspended solids which can not be removed by sedimentation are removed with the help of filtration process.
 (b) The minimum generating capacity of power plant must be equal to the maximum demand.
194. Name two types of filters commonly used during filtration of feed water for boilers.
195. Electric power is generated at the power station by using number of alternators in
 (a) parallel (b) series
 (c) both parallel and series.

ANSWERS

1. (a) 2. (b) 3. (b) 4. (a)
 5. (c) 6. (a) 7. (a)
 8. (a) True (b) True (c) True (d) False (e) False (f) True (g) True.
 9. (a) 10. (a) False (b) True (c) True.
 11. (a) 12. (a) 13. (a) 14. (i) True (ii) False
 15. (c) 16. (b) 17. (b) 18. (c)
 19. (a) True (b) True 20. (c) 21. (b) 22. (a)
 23. (i) U.P. (ii) Tamil Nadu (iii) Tamil Nadu (iv) Delhi
 24. (c) 25. (b) 26. (c) 27. (b)
 28. (a) 29. (a) 30. (a) 31. (b)
 32. (i) Natural gas (ii) Blast furnace gas
 33. (a) Laminated asbestos (b) Mineral wool (c) Glass wool.
 34. (c)
 35. (a) 100 m and above (b) 30 to 50 m (c) 25 to 60 m
 36. (a) 10 to 35 (b) 60 to 300 (c) 300 to 1000. 37. (a)
 38. (a) 39. (b) 40. (b)
 41. (a) True (b) True (c) False (d) True (e) False (f) False.
 42. (a) 43. (a) Francis turbine (b) Pelton turbine.
 44. (a) True (b) True (c) True (d) True (e) False (f) True (g) True.
 45. (b) 46. (b) 47. (c)
 48. (a) Gravity (b) upstream, down steam.
 49. (c) 50. (c) 51. (c) 53. (c)
 54. (a) True (b) True 55. (a)
 56. (a) True (b) True (c) True
 57. (c) 58. (b) 59. (b) 60. (b)
 61. (c) 62. (a) True (b) True (c) True

63. (i) Pressure compounded steam turbine is the most efficient turbine because the ratio of blade velocity to steam velocity remains constant whereas velocity compounded turbine has low efficiency because the ratio of blade velocity to steam velocity is not optimum.
(ii) Pressure compounded steam turbine has large number of stages and, therefore, it is most expensive whereas a velocity compounded steam turbine has relatively fewer number of stages and hence its initial cost is less.
64. (a) 65. (b) 66. (a) 67. (c)
68. (c) 69. (b) 70. (c)
71. (i) It should have high thermal efficiency.
(ii) Its initial cost should be low.
(iii) It should occupy small space.
(iv) It should be easily accessible and serviceable.
(v) Its maintenance cost should be low.
72. (i) True (ii) False (iii) True (iv) True.
73. (c) 74. (b)
75. (a) Hydro electric power plants involve large capital expenditures. The capital cost of a diesel power plant is lowest.
(b) Operating cost of steam power plant is more than a hydro power plant.
(c) Reliability of hydro plant, steam power plant and nuclear power is almost equal whereas reliability of diesel power plant is more than other plants.
(d) Planning, design and construction of a nuclear power plant is very difficult and takes long time whereas planning design and construction of steam power plant is easier than hydro-power plant. Planning design and construction of a diesel power plant is the easiest.
76. (a) 77. (b) 78. (a)
79. (c) 80. (b)
81. (a) False (b) True (c) True (d) False (e) True (f) True
(g) True (h) True.
82. The advantages of super charging in diesel engine are as follows:
(i) It increases the output of the engine.
(ii) It overcomes the effect of high altitudes.
(iii) It reduces the weight of the engine per horse power developed.
83. (i) Feed pumps (ii) Feed water heater
(iii) Air preheater (iv) Draught equipment.
84. (a) Stop valve (b) Safety valve (c) Fusible plug (d) Pressure gauge.
85. (a) False (b) True (c) True.
86. (i) Locomotive boiler (ii) Cornish boiler
87. (i) Steam pressure and temperature at the throttle valve of turbine.
(ii) Exhaust steam pressure and temperature.
(iii) Number of bleedings.

88. The pressure and temperature ranges for steam generators are as follows :

- (i) 70 to 140 kg/cm² steam temperature range of 450 to 560°C.
- (ii) 56 to 70 kg/cm² steam pressure with temperature range of 440°C to 480°C.
- (iii) 28 to 56 kg/cm² steam with temperature range of 400 to 440°C.
- (iv) 17.5 to kg/cm² saturated at 400°C.
- (v) 9 to 17.5 kg/cm² saturated steam superheated to 65°C super heat.

89. (a) The speed factor (S.F.) of diesel engine is given by

$$\text{S.F.} = \frac{NV}{3048 \times 10^3}$$

where N = Rotational speed in R.P.M.

V = Piston speed in centimetres per second.

Speed factor is also given by

$$\text{S.F.} = \frac{N^2L}{1524 \times 10^3}$$

where

L = stroke of piston in centimetres.

- (b) The speed factor for low speed engine is less than 1.2 whereas for medium speed engine it varies between 1.2 and 3.5. For high speed engines the speed factor is between 3.5 and 11.

90. (b) 91. (a)

92. Boiler units consists of a steam boiler, a furnace a non auxiliary device for heating water and air, and draught equipment etc. The basic characteristics of a boiler unit are its capacity and steam parameters. The capacity of boiler unit is the amount of steam in kilograms produced per second. The parameters characterising steam are pressure and temperature of superheated steam and pressure and dryness fraction for saturated steam.

93. Comparison of hydro and steam power plants.

These plants are compared as follows :

(i) *Capital Cost.* The capital cost of hydro power plant is high as compared to steam power plant of equal size.

(ii) *Operating Cost.* The operating cost of both the plants is about same.

(iii) *Maintenance Cost.* Maintenance cost of steam power plant is high as compared to hydro power plant.

(iv) *Location near load centre.* Steam power plant can be easily located near load centre. Whereas hydropower plant cannot be located near load centre.

(v) *Starting period.* Hydro power plant can be quickly started from cold conditions whereas it takes about 5 to 10 hours to put steam power plant in operation.

(vi) *Load Sharing.* When both steam power plant and hydro power plants are used to supply the given load it is preferable to use hydropower plant as base load plant if sufficient amount of water is available at power plant site and steam power plant is used as peak load plants. However if the amount of water available at hydro power plant site is small then it is desirable to use steam power plant as base load plant and hydro power plant as peak load plant.

94. Solids fuels like coal, cock etc. are burnt on grate in the furnace stokers are used to feed the fuel automatically. Air enters from bottom of grate and burns the fuel.

Pulverised fuels enter the furnace through burners. The flame in the furnace ignites the fuel and it burns in suspension.

Oil fuel is supplied to furnace through burners which atomise the oil into minute droplets and mix it with air. The mixture ignites and burns.

Gas fuel is also supplied through burners. However gas needs no atomisation.

95. (b) 96. (a) 97. (c)

98. (i) True (ii) True (iii) False (iv) False.

99. (a) High ash contents (b) Excessive moisture content (c) Low calorific value.

100. (a) True (b) True (c) True (d) True (e) True.

101. The moderators commonly used are as follows :

- (i) Light water (H_2O)
- (ii) Deuterium or heavy water (D_2O)
- (iii) Carbon
- (iv) Beryllium.

102. The function of a steam condensers are as follows :

- (i) Exhaust pressure or back pressure of steam is reduced thereby the capability of prime mover to work is increased.
- (ii) Exhaust steam from prime mover is condensed into water which is re-used as hot feed to boiler. By doing so saving in water cost may be substantial in large steam power plant.

103. The function of a carburettor is to discharge into air steam the desired quantity of liquid fuel, to atomise it and to produce a homogeneous air fuel mixture.

104. (a) True (b) False (c) True (d) False.

105. (b) 106. (a) 107. (b)

108. (c)

109. There are usually two types of steam pressure gauges

- (i) Bourdon pressure gauge
- (ii) Diaphragm pressure gauge

110. (a) 111. (a) 112. (a) True (b) True (c) True (d) True.

113. The basic factors considered during the design of a nuclear power reactor are as follows :

- (i) Reactor type
- (ii) Power rating of reactor in megawatts
- (iii) Coolant system
- (iv) Control system
- (v) Rates of neutron production and absorption

(vi) Safety of the reactor.

114. The thickness of a steel penstock depends on head and hoop stress allowed in the material. It is given by the following formula :

$$t = \text{Thickness of penstock}$$

$$= \frac{0.1 HD}{2f\eta}$$

where

H = Head in metres

D = Diameter of penstock in centimetre

f = Permissible stress in kg/cm^2

η = Joints efficiency

115. The purposes of a draft tube are as follows :

- (i) To reduce velocity head losses of water and to use head on reaction turbine to the maximum extent.
- (ii) To permit the installation of runner of reaction turbine at a level above that of water in tail race.

116. **Dam.** A dam is defined as the structure built across a river to store water.

Gravity Dam. Depending upon the material of construction a gravity dam may be either masonry gravity or concrete gravity. A gravity dam resists the forces mainly water pressure acting to disturb it by its weight, hence the name is gravity. Therefore, a gravity dam has to be very massive, so as to be able to withstand large pressure due to water.

Arch dam. An arch dam is usually made in the shape of a circular arc and is made of concrete or masonry. Whole of water load is transferred to the abutment of sides due to arching action of dam section. This type of dam is specially suited in narrow valleys.

Earth dam. When a dam is made of earth of locally available soil it is called earth dam. It is used when effective height of dam is not large.

117. Based on material of construction the dams are classified as follows :

(i) Masonry dam

(ii) Arch dam

(iii) Earth dam

(iv) Rockfill dam

(v) Timber dam

(vi) Steel dam.

118. Based on method of design and analysis the dams are classified as follows :

(i) Gravity dam

(ii) Arch dam

(iii) Buttress dam

(iv) Others as steel, timber etc.

119. (b)

120. (a)

121. (b)

122. (a)

123. (b)

124. Helium carbon dioxide and ammonia.

125. (a)

126. The super structure provides protective housing for the generator and control equipment as well as structural support for the cranes :

The sub-structure consists of steel and concrete components necessary to form draft tube, support the turbine staying and generator and encase the spiral case.

127. A (a) B (a)

128. The outstanding features of a gas turbine power plant are as follows.
- Low capital cost.
 - Quick starting.
 - Capability of using wide variety of fuels from natural gas to residual oil or powdered coal.
 - High reliability and flexibility in operation.
 - Higher efficiency (about 37%).
129. The functions of a super heater are as follows :
- It removes the last traces (1 to 2%) from the saturated steam coming out of boiler.
 - It raises the temperature of steam sufficiently above the saturation temperature.
 - It avoids too much condensation in the last stages of turbine which avoids blades erosion.
 - It raises over all efficiency of the cycle.
130. (a) True (b) True (c) True (d) True (e) True (f) True (g) True (h) True.
131. (i) A power station should have at least two generators.
 (ii) The best way of deciding the size and number of generating sets in a power plant is to select the number of sets in such a way so as to fit in the load curve as closely as possible so that the capacity of plant is used efficiently.
132. Feed water impurities may cause
- Scale formation
 - Corrosion
 - Carry over
 - Embrittlement.
133. Mechanical systems in a steam power plant move the coal to storage or to the furnace. Significant factors considered in selecting coal handling systems are as follows :
- Plant fuel rate
 - Coal storage area
 - Plant location in respect to coal shipping.
134. (b) 135. (a)
136. Limitations in use of nuclear power plants are as follows :
- High capital cost of nuclear power plants.
 - Limited availability of raw materials.
 - Difficulties associated with disposal of radioactive wastes.
 - Shortage of well trained personnel to handle the nuclear power plants.
137. Limitations in the use of solar energy are :
- Solar energy is not available at night or when local weather conditions obscure the sun.
 - Solar energy is diffused in its nature and is at a low potential. Consequently if solar energy is to be economically competitive then it must be converted into a usable form of energy with maximum effectiveness to reduce the capital cost of solar plants.
138. (i) Silicon (ii) Gallium arsenide. 139. (a) True (b) True
 140. (b) 141. (a) True (b) True

142. (i) Axial flow (ii) Centrifugal type (iii) Positive displacement.
143. (a) Less than 20 m (b) Less than 150 m (c) Less than 500 m.
144. (i) Stone masonry (ii) Concrete and R.C.C (iii) Earth (iv) Rock pieces and fragments.
145. (i) When good rocky foundation strata are not available
(ii) When height of dam is more than approximately 250 m.
146. (i) Over flow dams
(ii) Non over flow dams.
147. Arch dams can be described under the following three types.
(i) Constant radius arch dam
(ii) Constant angle arch dam
(iii) Variable radius and variable angle arch dam.
148. (i) Gravity dam (ii) Arch dam (iii) Buttress dam (iv) Earthen dam.
149. (i) Kaplan or Francis turbine
(ii) Francis or Pelton turbine
(iii) Pelton turbine.
150. (i) Radial (ii) Axial.
151. (i) Runner is that portion of a reaction turbine which revolves and converts the water head into mechanical energy.
(ii) Spillways are the structures provided with a dam to allow a safe passage of excess water from the reservoir to the down stream side of a dam without over toppling the dam.
152. (i) Impact (ii) Attrition (iii) Crushing.
153. (c) 154. (c)
155. % excess air = $\frac{14 - 8}{8} \times 100$
= 75%
156. (d) 157. (b) 158. (c)
159. (i) A power plant should have at least two generators
(ii) The generating units should be selected in such a way so as to fit in the load curve as closely as possible in order that the capacity of the plant is used efficiently.
160. (c) 161. (a)
162. (a) True (b) True (c) True.
163. (a) dust (b) cinders.
164. (a) Penstocks, draft tube (b) Turbine, generator (c) Substation, transformer.
165. (i) True (ii) False (iii) True (iv) True (v) True (vi) True
166. (c) 167. (a) 168. (c)
169. Efficiency of a boiler is increased by the use of
(i) air preheater (ii) super heater
(iii) economiser (iv) feed water heater.
170. With reference to direction of flow of water, reaction turbines are of following types.

(i) **Radial flow inward** : In such turbines the runner receives water under pressure in a radially inward direction and discharges it in a substantially axial direction. Francis turbine is radial flow inward turbine.

(ii) **Axial flow turbines** : In these turbines the runner vanes are either fixed or adjustable. Fixed vane type is preferred where head and flow are substantially constant and where base load operation is possible. Adjustable, vane type is preferred where head and flow vary over a very wide range and the plant is subjected to variable head operation. These are propeller type turbines.

171. The penstocks may be classified on the basis of

(i) the material of fabrication

(ii) the method of support

(iii) rigidity of connections and supports

172. (i) Surge tanks (ii) Spillways (iii) Relief valve (iv) Trash screen (v) Sand traps.

173. Base load plants run throughout the year

They operate at high load factors.

Nuclear power plants are used as base load plants and have as high as 80% and more load factor. Hydropower plants with ample storage are used as base load plants.

Peak load plants run for a few hours in the year and operate at low load factors. Hydro power plants with limited storage of water are used as peak load plants. Pumped storage plants are always used as peak load plants. Steam power plants can be used both as base load plants and peak load plants. Diesel and gas turbine plants are used as peak load plants.

174. (i) Spiral casing (ii) Runner (iii) Runner shaft (iv) Guide wheel (v) Draft tube

175. (a) True (b) True

176. (i) **Auraiya Gas Power plant** : It is located in Uttar Pradesh.

It is India's largest combined cycle module which has an installed capacity of 652 MW.

(ii) **Badarpur thermal power plant** : It is of 720 MW capacity and is located at Badarpur in New Delhi.

It is being managed by National thermal power corporation (N.T.P.C.) of India.

(c) Balco captive power plant is located at Korba in Madhya Pradesh.

177. **Specific Fuel Consumption (S.F.C.)**

It is the ratio of amount of fuel used by the engine per hour to the horse power produced or delivered by the engine.

$$\text{S.F.C.} = \frac{S}{\text{H.P.}}$$

where

S = Amount of fuel used by the engine (kg/hr.)

H.P. = Horse power produced.

It is one of the most important parameters used in comparison of engines. when SFC is based on I.H.P. (Indicated Horse Power) produced it is termed as Indicated Specific Fuel Consumption (ISFC) and when S.F.C. is based on B.H.P. delivered it is called Brake specific fuel consumption (BSFC).

178. (b)
179. (i) The best sites for WECS are found off shore and the sea coast.
 (ii) The second best site are in mountains.
- 180. Advantages:**
- (i) It is a renewable source of energy
 (ii) It is non-polluting
 (iii) Low cost.
- Disadvantages:**
- (i) It is dilute and fluctuating in nature.
 (ii) It is noisy in operation.
 (iii) Large areas are needed.
181. (a) 182. Air, fuel and water
183. (b)
184. (i) Pulverised fuel firing method can handle successfully high ash coals which can not be fired easily by conventional burning methods.
 (ii) High temperature is the furnace can be achieved.
185. (a) 186. (b) 187. (c)
188. (b)
189. (i) Dolomite (ii) Fused alumina (iii) Zirconia
190. (i) True (ii) True (iii) True.
191. (i) (e) (ii) (a) (iii) (d) (iv) (b) (v) (f) (vi) (c)
192. (a) 5 (b) 1.3 (c) Peak load plant (d) 800-900°C
194. (a) True (b) True
195. (i) Pressure filters (ii) Gravity filters
196. (a).

Appendix A CONVERSION TABLES

(i) Length :

$$1 \text{ inch} = 2.54 \text{ cm}$$

$$1 \text{ foot} = 30.48 \text{ cm}$$

$$1 \text{ yard} = 0.9143 \text{ metre}$$

$$1 \text{ metre} = 3.28 \text{ feet} = 39.37 \text{ inches}$$

$$1 \mu(\text{micron}) = 3.281 \times 10^{-6} \text{ ft}$$
$$= 0.001 \text{ mm}$$

(ii) Area :

$$1 \text{ m}^2 = 10.7639 \text{ ft}^2$$

$$1 \text{ inch}^2 = 6.4516 \text{ cm}^2$$

(iii) Weight :

$$1 \text{ ton} = 1.016 \text{ tonnes}$$

$$1 \text{ kg} = 2.204 \text{ lb}$$

$$1 \text{ lb} = 453.6 \text{ gm}$$

1 Imperial gallon of water weights 10 lb

(iv) Volume :

$$1 \text{ cu. ft.} = 0.0283 \text{ cu. m.}$$

$$1 \text{ cu. in.} = 16.39 \text{ cu. cm.}$$

1 Imperial gallon = 4.543 litres.

(v) Density :

$$1 \text{ kg/m}^3 = 0.062 \text{ lb/ft}^3$$

$$1 \text{ lb/ft}^3 = 16.02 \text{ kg/m}^3$$

(vi) Energy :

$$1 \text{ ft. lb} = 0.13825 \text{ kg-m}$$

1 kcal (kilocalories) = 3.961 B.T.U.

1 H.P. (F.P.S. units) = 746 watts

1 metric H.P. = 735.5 watts = 0.7355 kW

1 H.P. = 2544 B.T.U. per hour

1 kcal/kg = 1.8 B.T.U./lb

1 metric H.P. = 4500 kg-m/minute

= 10.54 kcal per minute

1 British H.P. = 550 ft. lb per second

1 kWh (kilowatt-hour) = 3413 B.T.U.

$$= 860 \text{ kcal.}$$

$$1 \text{ erg} = 2.78 \times 10^{-13} \text{ kWh}$$

$$1 \text{ joule} = 10^7 \text{ ergs}$$

$$1 \text{ kg-m} = 2.34 \times 10^{-3} \text{ kcal}$$

$$1 \text{ kW} = 1 \text{ kJ/sec.}$$

$$1 \text{ eV} = 1.6 \times 10^{-12} \text{ erg} = 1.6 \times 10^{-10} \text{ joules.}$$

(vii) Pressure :

$$1 \text{ standard atmosphere} = 14.696 \text{ p.s.i.}$$

$$= 1.033 \text{ kg/cm}^2$$

$$= 29.92 \text{ inches of mercury}$$

$$= 760 \text{ mm of mercury}$$

$$= 10.332 \text{ m H}_2\text{O}$$

$$= 33.8985 \text{ feet H}_2\text{O}$$

$$1 \text{ cm of Hg} = 0.01359 \text{ kg/cm}^3$$

$$1 \text{ p.s.i.} = 0.0703 \text{ kg/cm}^2$$

$$1 \text{ kg/cm}^3 = 1 \text{ ata} = 754.6 \text{ mmHg.}$$

$$1 \text{ mm of water} = 1 \text{ kg/m}^2$$

(viii) Temperature :

$$^\circ\text{K} = 273 + ^\circ\text{C}$$

$$^\circ\text{R} = 460 + ^\circ\text{F}$$

where

$$^\circ\text{K} = \text{Degree Kelvin}$$

$$^\circ\text{R} = \text{Degree Rankine}$$

$$^\circ\text{C} = \text{Degree Centigrade.}$$

Appendix B

Properties of Dry Saturated Steam

Pressure <i>p</i> kg/sq cm	Satura- tion tempera- ture <i>T</i> (°C)	Sensible heat <i>h_w</i> kcal/kg	Latent heat <i>L</i> kcal/kg	Total heat <i>H</i> kcal/kg	Specific volume <i>V_s</i> m ³ /kg	Entropy	
						Liquid ϕ_l kcal/kg °K	Vapour ϕ_s kcal/kg °K
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
0.02	17.1	17.1	585.8	602.2	68.27	0.0609	2.0803
0.04	28.6	28.6	580.3	680.9	35.46	0.0936	2.0219
0.06	35.8	35.8	575.7	611.4	24.19	0.1232	1.9880
0.08	41.1	41.1	572.9	614.0	18.45	0.1407	1.9642
0.10	45.4	45.4	570.5	615.9	14.96	0.1539	1.9458
0.12	49.0	49.0	568.6	617.6	12.60	0.1652	1.9308
0.13	59.6	53.6	566.0	619.6	10.22	0.1892	1.9126
0.20	59.7	59.7	563.6	622.3	7.797	0.2976	1.8892
0.25	64.6	64.6	559.6	624.5	6.325	0.2124	1.8712
0.30	68.7	68.7	557.9	626.3	5.331	0.2242	1.8562
0.35	72.3	72.3	555.5	627.8	4.614	0.2348	1.8444
0.40	75.4	75.4	553.8	629.2	5.082	0.2439	1.8334
0.50	80.9	80.9	550.6	631.5	3.304	0.2593	1.8156
0.60	85.5	85.5	547.0	633.4	2.785	0.2724	1.8019
0.70	89.3	89.3	545.8	635.1	2.411	0.2832	1.7889
0.80	93.0	93.0	543.5	636.2	2.128	0.2931	1.7789
0.90	96.2	96.2	541.4	637.8	1.806	0.3018	1.7693
1.0	99.1	99.1	536.8	639.0	1.727	0.3056	1.7600
1.2	104.1	104.1	536.9	641.0	1.457	0.3235	1.7467
1.4	118.7	108.9	533.9	642.8	1.261	0.3354	1.7344
1.6	112.7	112.9	531.4	644.3	1.113	0.3460	1.7283
1.8	116.3	116.5	529.1	645.7	0.996	0.3554	1.7148
2.0	119.6	119.9	527.0	646.9	0.903	0.3639	1.7066
2.5	126.8	127.2	522.0	649.5	0.7341	0.3823	1.6888
3.0	132.2	133.4	518.2	651.6	0.6180	0.3977	1.6748
3.5	138.2	138.9	514.5	653.4	0.5352	0.4110	1.6625
4.0	142.9	143.7	511.2	654.9	0.4418	0.4227	1.6515
4.5	147.2	148.1	508.1	656.2	0.4224	0.4333	1.6425
5.0	151.1	152.2	505.1	657.3	2.3825	0.4428	1.6341
5.5	154.7	155.9	502.5	658.4	0.3489	0.4515	1.6295
6.0	158.1	159.4	499.9	659.3	0.3222	0.4596	1.6165
6.5	161.2	162.7	497.5	660.2	0.2987	0.4671	1.6125
7.0	164.2	165.7	495.2	660.9	0.2785	0.4742	1.6075
7.5	167.0	168.7	493.0	661.7	0.2609	0.4808	1.6015
8.0	169.6	171.4	430.9	662.3	0.2411	0.4870	1.5962

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
8.5	172.1	184.0	488.9	662.9	9.2217	0.4929	1.5013
9.0	174.5	176.0	486.0	663.4	0.2195	0.4985	1.5862
10	179.0	181.3	483.1	664.4	0.1985	0.5090	1.5775
11	183.2	185.7	479.5	665.2	0.1813	0.5186	1.5698
12	187.1	189.9	470.1	665.9	9.1668	0.5335	1.5628
13	190.7	193.9	473.0	666.6	0.1445	0.5358	1.5556
14	194.8	197.3	469.4	667.0	0.1488	0.5436	1.5493
15	197.4	200.7	466.7	667.4	0.1346	0.5508	1.5432
16	200.4	204.0	463.4	667.8	0.1164	0.5577	1.5375
17	203.4	207.1	461.1	668.2	0.1192	0.5643	1.5321
18	206.2	210.1	458.2	668.3	0.1128	0.5705	1.5270
19	208.8	213.0	455.5	668.5	0.1070	0.5764	1.5220
20	211.4	215.8	452.9	668.7	0.1027	9.5821	1.5173
22	216.2	221.0	447.9	668.9	0.0927	0.5924	1.5084
24	220.8	226.0	443.0	669.0	0.0350	0.6026	1.5504
26	225.0	230.6	438.4		0.0785	0.6110	1.4921
28	829.0	235.0	433.8	668.8	0.0725	0.6205	1.4850
30	232.8	231.1	429.5	668.6	0.06802	0.6287	1.4780
32	236.4	243.1	425.2	668.4	0.06372	0.6364	1.4813
34	239.8	246.9	421.1	668.5	0.05991	0.6437	1.4650
36	243.1	250.1	417.1	667.7	0.05651	0.6507	1.4589
38	245.2	254.1	413.0	667.1	0.05365	9.6573	1.4530
40	249.2	257.4	409.2	666.6	0.05169	0.6637	1.4474
42	252.1	260.7	405.2	666.5	0.04817	0.6698	1.4478
44	254.5	263.9	401.6	666.5	0.04588	0.6757	1.4365
46	257.6	266.9	397.9	664.8	0.04378	0.6813	1.4314
48	260.2	269.8	394.2	664.1	0.04185	0.6868	1.4215
50	262.7	272.7	390.7	663.4	0.04007	0.6921	1.4215
55	268.7	279.6	381.9	661.5	0.03616	0.7046	1.4098
60	274.3	286.1	373.4	659.5	0.03289	0.7162	1.3987
65	279.6	292.2	365.3	657.5	0.03009	0.7270	1.3822
70	284.5	299.0	359.3	657.3	0.02469	0.7371	1.3781
80	293.6	308.8	341.8	650.6	0.02374	0.7557	1.3591
90	301.1	319.0	326.6	645.6	0.02064	0.7731	1.3413
100	309.5	328.7	318.8	640.5	0.01815	0.7893	1.3245
150	340.5	374.1	338.8	612.9	0.01044	3.8622	1.2514
200	364.2	425.6	147.2	572.8	0.00614	0.9404	1.1715
250	374.0	501.1		501.1	0.00310	0.0558	1.0558

Properties of Superheated Steam

Pressure <i>P</i> kcal/cm	Total heat <i>H</i> kcal/kg											
	<i>T</i> ₀	50	100	150	200	250	300	350	400	450	500	550
0.01	600	619.5	642	664.5	687.5	710.5	734	758	782.0	807	822.5	858.5
0.05	611.5	619.5	642	664.5	687.5	710.5	734	758	782.0	807	832.5	858.5
0.10	617	619	642	664.5	687.5	710.1	734	758	782.0	807	832.5	854.3
0.50	631.5	—	641	664	687	710	734	757.5	782	807	832.5	858.5
1.00	639.5	—	632	663	686.3	710	733.5	757.5	782	806.5	832	858
5.00	657.3	—	—	—	682	701	731	757.5	780.5	805.5	831	857.5
10.00	664.4	—	—	—	676	702.8	728.1	753.3	778.4	804	830.5	856
15.00	667.4	—	—	—	608.5	698.6	725	751	776.5	802.5	825.8	855
20.00	658.5	—	—	—	—	694	721.9	748.5	774.5	801	827.5	854
25.60	669.0	—	—	—	—	689	718.5	746	772.5	799.5	826	853
30.00	668.6	—	—	—	—	683.5	715	743.5	771	797.5	824.5	853
40.00	666.6	—	—	—	—	667.5	708	738.5	767	794.5	822.0	849.5
50.00	663.4	—	—	—	—	—	669.5	343	763	791.5	819.6	847.6

Properties of Dry Standard Steam

Saturation Temperature <i>T</i> (°C)	Pressure kg/sq. cm	Specific volume <i>V_s</i> M ³ /kg	Latent heat <i>L</i> Kcal/kg	Total heat <i>H</i> kcal/kg
(1)	(2)	(3)	(4)	(5)
0	0.00623	360.3	597.2	597.2
1	0.00669	192.7	596.6	597.6
2	0.00719	180.0	596.6	598.0
3	0.00772	168.2	595.5	598.5
4	0.00829	157.3	535.0	599.0
5	0.00889	147.2	534.0	599.4
6	0.00953	137.8	593.8	599.8

(1)	(2)	(3)	(4)	(5)
7	0.01020	129.1	593.2	600.2
8	0.01090	121.0	592.0	600.7
9	0.01170	113.4	592.1	600.1
10	0.01251	106.4	591.6	601.6
11	0.01333	90.90	561.0	602.0
12	0.01429	93.90	590.5	602.5
13	0.01556	88.19	589.9	602.9
14	0.0163	82.91	589.4	603.4
15	0.0174	77.90	588.8	603.0
16	0.0185	73.40	588.3	604.3
17	0.0197	69.10	587.7	604.6
18	0.0210	65.10	587.1	605.1
19	0.0224	69.35	586.6	605.0
20	0.0238	57.84	586.0	606.6
21	0.0254	54.56	585.5	606.5
22	0.0274	51.49	544.9	606.0
23	0.0286	48.63	584.3	607.3
24	0.0304	45.94	583.8	607.8
25	0.0323	43.41	583.3	608.2
26	0.0342	41.04	582.6	608.6
27	0.0263	38.82	582.1	609.5
28	0.0386	36.78	581.5	609.5
29	0.0408	34.77	581.0	610.0
30	0.0432	32.93	580.4	610.4
31	0.0458	31.30	579.8	610.8
32	0.0485	29.60	579.3	611.3
33	0.0513	28.05	578.3	611.7
34	0.0542	26.61	578.1	612.1
35	0.0573	25.25	577.5	612.5
36	0.0606	22.57	577.0	613.0
37	0.0640	22.77	576.4	613.4
38	0.0676	21.66	575.9	613.9
39	0.0713	28.56	575.3	614.6
40	0.0752	19.55	574.7	614.3
41	0.0793	18.60	574.1	615.2
42	0.0836	17.70	573.6	615.6
43	0.0881	16.85	573.0	616.0
44	0.0928	16.04	572.4	616.4
45	0.0977	15.28	571.8	616.8
46	0.108	14.56	571.2	617.2
47	0.103	13.48	570.7	617.7
48	0.114	13.23	570.1	618.1
49	0.120	12.63	569.5	618.5

(1)	(2)	(3)	(4)	(5)
50	0.126	12.03	569.0	619.0
51	0.160	9.544	566.1	621.0
52	0.203	7.682	563.3	623.2
53	0.255	6.205	560.3	625.2
54	0.318	5.049	567.7	627.3
75	0.398	4.136	554.4	629.3
80	0.383	3.410	551.3	631.3
85	0.589	2.830	548.2	633.2
90	0.715	2.361	545.1	635.1
95	0.862	1.981	542.0	637.0
100	1.0332	1.673	538.9	638.9
105	1.2318	1.419	535.6	640.5
110	1.4609	1.210	539.4	642.5
115	1.7238	1.036	329.1	644.3
120	2.0245	0.891	525.7	646.0
125	2.3666	0.770	522.4	647.7
130	2.7544	0.668	518.9	649.3
135	2.192	0.582	515.3	650.8
140	3.685	0.508	511.6	652.5
145	4.237	0.446	558.9	654.0
150	4.854	0.392	504.2	655.5
155	5.540	0.3364	500.8	656.5
160	5.302	0.3068	497.0	658.3
165	7.141	0.2724	493.1	659.6
170	8.078	0.2425	489.9	660.9
175	9 101	0.2166	485.2	663.1