BABA BANDA SINGH BAHADUR ENGINEERING COLLEGE FGS

DEPARTMENT OF MECHANICAL ENGINEERING

QUESTION BANK

REFRIGERATION & AIR-CONDITIONING

Practice Set- 1

Q.1 Which of the following can be called as a refrigeration process?

a) Cooling of hot ingot from 1000^{o}C to room temperature
b) Cooling of a pot of water by mixing it with a large block of ice
c) Cooling of human beings using a ceiling fan
d) Cooling of a hot cup of coffee by leaving it on a table
e) Cooling of hot water by mixing it with tap water
f) Cooling of water by creating vacuum over it.

Q.2 In an air cycle refrigeration system, low temperatures are produced due to:

a) Evaporation of liquid air
b) Throttling of air
c) Expansion of air in turbine
d) None of the above

Q.3 Air cycle refrigeration systems are most commonly used in:

a) Domestic refrigerators
b) Aircraft air conditioning systems
c) Cold storages
d) Car air conditioning systems

Q.4 Food products can be preserved for a longer time at low temperatures because:

a) At low temperatures the bacterial activity is reduced
b) Enzymatic activity is reduced at low temperatures
c) Quality of food products improves at low temperatures
d) All of the above

Q.5 Cold storages can be used for storing:

a) Live products such as fruits, vegetables only
b) Dead products such as meat, fish only
c) Both live and dead products
d) None of the above

Q.6 A Carnot cycle refrigerator operates between 250K and 300 K. Its coefficient of performance is:

(a) 6.0 (b) 5.0 (c) 1.2 (d) 0.8

Q.7 What is refrigeration? How does it differ from cooling?

Q.8 State the assumptions made in the analyses of air cycle systems.

Q.9 Why air cycle refrigeration is found to be most suitable for aircraft refrigeration systems?

Q.10 Define one tonne of refrigeration.

Q.11 Draw p-v and T-S graphs for reversed Carnot cycle and Bell Coleman cycle.

Q.12 A Carnot refrigerator extracts 150 kJ of heat per minute from a space which is maintained at -20°C and is discharged to atmosphere at 45°C. Find the work required to run the unit.

Q.13 An industrial heat pump operates between the temperatures of 27°C and 13°C. The rate of heat addition and heat rejection are 750 W and 1000 W respectively. The COP of heat pump is

a) 7.5 **b) 6.5** **c) 4.0** **d) 3.0**

Q.14 A refrigerator working on Bell-Coleman cycle (Reverse Brayton cycle) operates between 1 bar and 10 bar. Air is drawn from cold chamber at -10ºC. Air coming out of compressor is cooled to 50ºC before entering the expansion cylinder. Polytropic law $P.V^{1.3}$ = constant is followed during expansion and compression. Find theoretical C.O.P of the origin. Take γ=1.4 and C_p = 1.00 kJ/kg $^{\circ}$C for air.

Q.15 An air refrigerator working on the principle of Bell-Coleman cycle. The air into the compressor is at 1 bar at -10ºC. It is compressed to 10 bar and cooled to 40ºC at the same pressure. It is then expanded to 1 bar and discharged to take cooling load. The air circulation is 1 kg/s.

The isentropic efficiency of the compressor = 80%

The isentropic efficiency of the expander = 90%

Find the following:

i) Refrigeration capacity of the system

ii) C.O.P of the system

Take $\gamma = 1.4$, $C_p = 1.00$ kJ/kg ºC

Q.16 A refrigerator storage is supplied with 3600 kg of fish at a temperature of 27°C. The fish has to be cooled to –23°C for preserving it for a long period without deterioration. The cooling takes place in 10 hours. The specific heat of fish is 2·0 kJ/kgK above freezing point of fish and 0·5 kJ/kgK below freezing point of fish, which is –3°C. The latent heat of freezing is 230 kJ/kg. What is the power to drive the plant if the actual COP is half that of the ideal COP?

(a) 30 kW **(b) 15 kW** **(c) 12 kW** **(d) 6 kW**

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DEPARTMENT OF MECHANICAL ENGINEERING

REFRIGERATION & AIR-CONDITIONING

Practice Set- 2

Q.1 Evaporative cooling systems are ideal for:

a) Hot and dry conditions
b) Hot and humid conditions
c) Cold and humid conditions
d) Moderately hot but humid conditions

Q.2 The useful storage life of food products depends on:

a) Storage temperature
b) Moisture content in the storage
c) Condition of food products at the time of storage
d) All of the above

Q.3 DART is the temperature of the air at the exit of the cooling turbine. (True/False)

Q.4 It is possible to produce cooling by addition of sodium chloride in water. (True/False)

Q.5 A refrigerator based on reversed Carnot cycle works between two such temperatures that the ratio between the low and high temperature is 0.8. If a heat pump is operated between same temperature range, then what would be its COP?

(a) 2 (b) 3 (c) 4 (d) 5

Q.6 A refrigerator working on a reversed Carnot cycle has a C.O.P. of 4. If it works as a heat pump and consumes 1 kW, the heating effect will be:

(a) 1 KW (b) 4 KW (c) 5 KW (d) 6 KW

Q.7 Assertion (A): An air-conditioner operating as a heat pump is superior to an electric resistance heater for winter heating.

Reason (R): A heat pump rejects more heat than the heat equivalent of the heat absorbed.

(a)Both A and R are individually true and R is the correct explanation of A.
(b)Both A and R are individually true but R is not the correct explanation of A.
(c)A is true but R is false.
(d)A is false but R is true.

Q.8. A refrigerator works on reversed Carnot cycle producing a temperature of –40°C. Work done per TR is 700 kJ per ten minutes. What is the value of its COP?

(a) 3 (b) 4.5 (c) 5.8 (d) 7.0

Q.9 A refrigerating machine working on reversed Carnot cycle takes out 2 kW of heat from the ystem at 200 K while working between temperature limits of 300 K and 200 K. C.O.P. and power consumed by the cycle will, respectively, be:

(a) 1 and 1 kW (b) 1 and 2 kW (c) 2 and 1 kW (d) 2 and 2 kW

Q.10 A Carnot refrigerator requires 1.5 kW/ton of refrigeration to maintain a region at a temperature of – 30°C. The COP of the Carnot refrigerator is:

(a) 1.42 (b) 2.33 (c) 2.87 (d) 3.26

Q.11 When you add sufficient amount of glucose to a glass of water, the water becomes cold. Is it an example of refrigeration, if it is, can this method be used for devising a refrigeration system?

Q.12 How do you specify a 'Domestic Refrigerator' and 'Air conditioner'?

Q.13 Why aircraft cooling systems are required, even though the outside temperatures are very low at high altitudes?

Q.14 Compare the various air-refrigeration systems used for aircrafts.

Q.15 A cold storage plant is required to store 50 tons of fish.

The temperature at which fish was supplied = 35°C

Storage temperature of fish = -10°C

Cp of fish above freezing point = 2.94kJ/kg°C

Cp of fish below freezing point = 1.26 kJ/kg°C

Freezing point of fish = -5°C

Latent heat of fish = 250 kJ/kg

If the cooling is achieved within half of a day, find:

a) Capacity of the refrigerating plant

b) Carnot COP

c) If actual COP = Carnot COP2.5

Find the power required to run the plant.

Q.16 A boot strap cooling system of 10 tons is used in an aeroplane. The temperature and pressure conditions of atmosphere are 20°C and 0.9 atm. The pressure of air is increased from 0.9 atm to 1.1 atm due to ramming. The pressures of air leaving the main and auxiliary compressor are 3 atm and 4 atm respectively. Isentropic efficiency of compressors and turbine are 0.85 and 0.8 respectively. 50% of the total heat of air leaving the main compressor is removed in the first heat exchanger and 30% of theirtotal heat of air leaving the auxiliary compressor is removed in the second heat exchanger using removed air.

Find:

a) Power required to take cabin load

b) COP of the system

The cabin pressure is 1.02 atm and temperature of air leaving the cabin should be greater than 25°C. Assume ramming action to be isentropic.

Q.17 A simple air cooled system is used for an aeroplane to take a load of 10 tons. Atmospheric temperature and pressure is 25°C and 0.9 atm respectively. Due to ramming the pressure of air is increased from 0.9 atm, to 1 atm. The pressure of air leaving the main compressor is 3.5 atm and its 50% heat is removed in the air-cooled heat exchanger and then it is passed through a evaporator for future cooling. The temperature of air is reduced by 10°C in the evaporator. Lastly the air is passed through cooling turbine and is supplied to the cooling cabin where the pressure is 1.03 atm. Assuming isentropic efficiency of the compressor and turbine are 75% and 70%, find

a) Power required to take the load in the cooling cabin

b) COP of the system.

The temperature of air leaving the cabin should not exceed 25°C.

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REFRIGERATION & AIR-CONDITIONING

Practice Set- 3

Sem: 7th/8th

1. **Draw the following vapor compression refrigeration cycles on P.H diagram:**
   a) cycle with dry saturated vapor after compression
   b) cycle with wet vapor after compression
   c) cycle with superheated vapor after compression
   d) cycle with superheated vapor before compression.
   e) Cycle with under cooling/ subcooling of refrigerant.

2. **In a refrigeration plant, if the condenser temperature increases, the power input to the compressor will**
   (a) Increase (b) Decrease (c) Remain the same (d) Be unpredictable

3. **Which one of the following statements is correct?**
   In a domestic refrigerator periodic defrosting is required because frosting
   (a) Causes corrosion of materials
   (b) Reduces heat extraction
   (c) Overcools food stuff
   (d) Partially blocks refrigerant flow

4. **A standard vapour compression refrigeration cycle consists of the following 4 thermodynamic processes in sequence:**
   (a) Isothermal expansion, isentropic compression, isothermal compression and isentropic expansion
   (b) Constant pressure heat addition, isentropic compression, constant pressure heat rejection and isentropic expansion
   (c) Constant pressure heat addition, isentropic compression, constant pressure heat rejection and isentropic expansion
   (d) Isothermal expansion, constant pressure heat addition, isothermal

compression and constant pressure heat rejection

5. **In a vapour compression cycle, the refrigerant, immediately after expansion value is:**
   (a) Saturated liquid
   (b) Subcooled liquid
   (c) Dry vapour
   (d) Wet vapour

6. **In conventional refrigerants what is the element responsible for ozone depletion?**
   (a) Chlorine (b) Fluorine (c) Carbon (d) Hydrogen

7. **The leakage in a Freon-based refrigeration system can be detected by using a/an**
   (a) Oxy-acetylene torch (b) Halide torch
   (c) Sulphur torch (d) Blue litmus paper

8. **The pipes and fitting in an ammonia refrigeration system should be made of:**
   (a)Cast steel or wrought iron (b) Aluminium
   (c)Naval brass (d) Copper

9. **The refrigerant used for absorption refrigerators working heat from solar collectors is a mixture of water and**
   (a) Carbon dioxide (b) Sulphur dioxide
   (c) Lithium bromide (d) Freon 12

10. **Waste heat can be effectively used in which one of the following refrigeration systems?**
    (a) Vapour compression cycle (b) Vapour absorption cycle
    (c) Air refrigeration cycle (d) Vortex refrigeration system

11. **What are the advantages and disadvantages of Vapor Compression Refrigeration System over Absorption Refrigeration System?**

12. What is purpose of “Flash Chamber” in simple vapor compression refrigeration system?

13. Explain simple vapor compression refrigeration cycle with “sub-cooling of liquid refrigerant by vapor refrigerant”.

14. Find the chemical formula and names of the refrigerants R-22 and R-114.

15. In a one ton capacity water cooler, water enters at 30°C at the rate of 200 litres per hour. The outlet temperature of water will be (sp. heat of water = 4.18 kJ/kg K)
    (a) 3.5°C (b) 6.3°C (c) 23.7 °C (d) 15°C

16. The efficiency of a Carnot engine is given as 0·75. If the cycle direction is reversed, what will be the value of COP for the Carnot refrigerator?
    (a) 0·27 (b) 0·33 (c) 1·27 (d) 2·33

17. For simple vapour compression cycle, enthalpy at suction = 1600 kJ/kg, enthalpy at discharge from the compressor = 1800 kJ/kg, enthalpy at exit from condenser = 600 kJ/kg. What is the COP for this refrigeration cycle?
    (a) 3·3 (b) 5·0 (c) 4 (d) 4·5

18. An ideal refrigeration cycle operates with R134a as the working fluid. The temperature of refrigerant in the condenser and evaporator are 40ºC and -20ºC respectively. The mass flow rate of refrigerant is 0.1 kg/s. Determine the cooling capacity and COP of the plant.

19. A NH3 refrigerator produces 100 tons of ice from water at 0ºC in a day. The cycle operates between 25ºC and -15ºC . The vapor is dry saturated at the end of compression. If the COP is 50% of theoretical COP, calculate the power required to drive the compressor.

20. A food storage locker requires a refrigeration capacity of 50kW. It works between condenser and evaporator temperature of 35ºC & -10ºC. The refrigerant is NH3. It is sub

cooled by 5ºC assuming a single cylinder, single acting compressor operating at 1000rpm with stroke equal to 1.2 times the bore. Determine a) the power required b) The cylinder dimensions. Take Cp (liquid NH3) = 4.556 kj/kgk and Cp (superheatedNH3) = 2.9 kj/kgK. Use refrigerant Table.

21. An R-12 plant has to produce 10 tons of refrigeration. The condenser and evaporator temperatures are 40ºC and -10ºC respectively. Determine
    a. Refrigerant flow rate
    b. Volume flow rate of the compressor
    c. Operating pressure ratio
    d. Power required to drive the compressor
    e. COP

22. In a refrigerator the power rating impressed on the compressor is 1.2 kW. The circulating wire in evaporator is 5 kW and the cooling water took away 10 kW from condenser coil. The operating temperatures range is 18ºC and 0ºC and their corresponding latent heats are 170 kJ/kg and 230 kJ/kg and the difference between the liquid energy is 35 kJ/kg. Find the actual COP of the system (2) relative COP, assuming the vapour is just dry and saturated at the end of the compression.

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DEPARTMENT OF MECHANICAL ENGINEERING

REFRIGERATION & AIR-CONDITIONING

Practice Set- 4

Sem: 7th/8th

1. **Assertion (A):** If a domestic refrigerator works inside an adiabatic room with its door open, the room temperature gradually decreases.

   Reason (R): Vapour compression refrigeration cycles have high COP compared to air refrigeration cycles.

   (a)Both A and R are individually true and R is the correct explanation of A.

   (b)Both A and R are individually true but R is not the correct explanation of A.

   (c)A is true but R is false.

   (d)A is false but R is true.

2. **When the lower temperature is fixed, COP of a refrigerating machine can be improved by:**

   (a) Operating the machine at higher speeds

   (b) Operating the machine at lower speeds

   (c) Raising the higher temperature

   (d) Lowering the higher temperature

3. **A single-stage vapour compression refrigeration system cannot be used to produce ultralow temperatures because**

   (a)Refrigerants for ultra-low temperatures are not available

   (b)Lubricants for ultra-low temperatures are not available

   (c)Volumetric efficiency will decrease considerably

   (d)Heat leakage into the system will be excessive

4. **In a vapour compression refrigeration system, a throttle valve is used in place of an expander because**

   (a)It considerably reduces the system weight

   (b)It improves the COP, as the condenser is small

(c)The positive work in isentropic expansion of liquid is very small.

(d)It leads to significant cost reduction.

5. **The desirable combination of properties for a refrigerant include**

   (a)High specific heat and low specific volume

   (b)High heat transfer coefficient and low latent heat

   (c)High thermal conductivity and low freezing point

   (d) High specific heat and high bailing point

6. **In milk chilling plants, the usual secondary refrigerant is:**

   (a)Ammonia solution (b)Sodium silicate (c)Propylene glycol (d)Brine

7. **Which one of the following statements regarding ammonia absorption system is correct?**

   The solubility of ammonia in water is:

   (a) A function of the temperature and pressure of the solution

   (b) A function of the pressure of the solution irrespective of the temperature

   (c) A function of the temperature of the solution alone

   (d) Independent of the temperature and pressure of the solution

8. **Hydrogen is essential in an Electrolux refrigeration system, because**

   (a) It acts as a catalyst in the evaporator

   (b) The reaction between hydrogen and ammonia is endothermic in evaporator and exothermic in absorber

   (c) The cooled hydrogen leaving the heat exchanger cools the refrigerant entering the evaporator

   (d) It helps in maintaining a low partial pressure for the evaporating ammonia

9. **In the absorption refrigeration cycle, the compressor of the vapour compression refrigeration cycle is replaced by:**

   (a) Liquid pump (b) Generator

   (c) Absorber and generator (d) Absorber, liquid pump and generator

10. **Assertion (A):** In a practical vapour compression refrigerator, the vapour should leave the evaporator with a definite amount of superheat.
    Reason (R): It reduces the work done by the compressor.
    (a) Both A and R are individually true and R is the correct explanation of A
    (b) Both A and R are individually true but R is not the correct explanation of A
    (c) A is true but R is false
    (d) A is false but R is true

11. **An R-12 plant has to produce 10 tons of refrigeration. The condenser and evaporator temperatures are 40ºC and -10ºC respectively. Determine**
    a. Refrigerant flow rate
    b. Volume flow rate of the compressor
    c. Operating pressure ratio
    d. Power required to drive the compressor
    e. COP

12. Draw and explain Actual Vapor Compression Cycle on P-H and T-S diagram.

13. What is the effect of suction pressure, discharge pressure, sub cooling, superheating before compression on the performance of simple vapor compression refrigeration cycle.

14. What is the role of H_2 gas in vapour absorption refrigeration system?

15. Explain the importance of refrigerant selection. List the important thermodynamic and environmental properties influencing refrigerant selection.

16. A refrigerating machine having coefficient of performance equal to 2 is used to remove heat at the rate of 1200 kJ/min. What is the power required for this machine?
    (a) 80 kW (b) 60 kW (c) 20 kW (d) 10 kW

17. The values of enthalpy at the beginning of compression, at the end of compression and at the end of condensation are 185 kJ/kg, 210 kJ/kg and 85 kJ/kg respectively. What is the value of the COP of the vapour compression refrigeration system?
    (a) 0·25 (b) 5·4 (c) 4 (d) 1·35

18. In a vapour compression refrigeration plant, the refrigerant leaves the evaporator at 195 kJ/kg and the condenser at 65 kJ/kg. For 1 kg/s of refrigerant, what is the refrigeration effect?

(a) 70 KW (b) 100 KW (c) 130 KW (d) 160 KW

19. For a heat pump working on vapour compression cycle, enthalpy values of the working fluid at the end of heat addition process, at the end of compression process, at the end of heat rejection process, and at the end of isenthalpic expansion process are 195 kJ/kg, 210 kJ/kg, and 90 kJ/kg respectively. The mass flow rate is 0.5 kg/s. Then the heating capacity of heat pump is, nearly

(a) 7.5 kW (b) 45 kW (c) 52.2 kW (d) 60 kW

20. Sub-cooling with regenerative heat exchanger is used in a refrigeration cycle. The enthalpies at condenser outlet and evaporator outlet are 78 and 182 kJ/kg respectively. The enthalpy at outlet of isentropic compressor is 230 kJ/kg and enthalpy of subcooled liquid is 68 kJ/kg. The COP of the cycle is:

(a) 3.25 (b) 2.16 (c) 3.0 (d) 3.5

21. A "R-12" refrigerating machine works on vapor-compression cycle. The temperature of refrigerant in evaporator is -20ºC. The vapor is dry saturated when it enters the compressor. The condenser temp is 30ºC assuming specific heat at constant pressure for R-12 in the superheated condition as 1.884kj /kgk,determine;a) condition of vapor at the entrance to the evaporator b) C.O.P of the machine

Temperature	Enthalpy, kj/kg		Entropy, kj/kg K	
	Liquid	vapor	Liquid	Vapor
-20°C	17.82	178.73	0.0731	0.7087
30	64.59	199.62	0.2400	0.6843

22. In a refrigerator the power rating impressed on the compressor is 1.2 kW. The circulating wire in evaporator is 5 kW and the cooling water took away 10 kW from condenser coil. The operating temperatures range is 18ºC and 0ºC and their corresponding latent heats are 170 kJ/kg and 230 kJ/kg and the difference between the liquid energy is 35 kJ/kg. Find the actual COP of the system (2) relative COP, assuming the vapour is just dry and saturated at the end of the compression.

23. A refrigerator produces 20 tones of ice per day from and at 0ºC, The condensation and evaporation take place at 20ºC and -20ºC. The temperature of the vapor at the end of isentropic compression is 50ºC and there is no under-cooling of the liquid. Find: a) the rate of NH3 circulation b) the size of single acting- compressor when running at 240rpm assuming L = D and volumetric efficiency of 80 %. Specific heat of superheated vapor = 2.8 kj/kgK. Use refrigerant table.

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REFRIGERATION & AIR-CONDITIONING

Practice Set- 5 **Sem: 7th/8th**

1. What do you understand by the term 'Psychrometry'?
2. Define the following: a) DPT b) Specific humidity c) Absolute humidity d) Relative humidity.
3. Establish the following relation:

   $W = 0.622pv/(pb-pv)$; W= Specific humidity

4. Explain in brief the meaning of 'by-pass factor'.
5. How does fog formation takes place? Show it on psychometric chart.
6. Explain the concept of 'Adiabatic mixing of two air streams'.
7. What do you mean by 'Chemical dehumidification'?
8. What is the use of 'Air washer'?
9. What do you mean by 'Effective Temperature'? Write a short not on Comfort Chart.
10. What are various factors affecting comfort air conditioning?
11. How will you classify Air conditioning systems?
12. Define RSHF, GSHF and ESHF.
13. How will you calculate the cooling load for a building?
14. A sample of moist air has a DBT of 25ºC and a relative humidity of 50%. The barometer reads 740mm of Hg. Calculate: a) partial pressure of water vapor and dry air b) DPT c) specific humidity d) enthalpy of air/kg of dry air.

    [Ans. 0.01583bar, 14ºC,0.0101kg/kg, 50.81kj/kg of dry air]

15. One kg of air at 20ºC DBT and 40%RH is mixed adiabatically with 2kg of air at 40ºC DBT and 40%RH. Find specific humidity and enthalpy of the final condition of air.

    [Ans: 0.0144kj/kg of air, 71.67kj/kg of dry air.]

16. The following data refers for a space to be air conditioned:

Inside design condition = 25ºC DBT, 50% RH

Out door air conditions= 43ºC DBT, 27.5ºC WBT

Room sensible heat gain = 20kW

Room latent heat gain = 5kW

By-pass factor = 0.1

The return air from the space is mixed with the outside air before entering the cooling coilin the ratio of 4:1 by mass. Determine a) ADP b)condition of air entering and leaving the cooling coil c) fresh air mass flow and volume flow rate ; d) total refrigeration load on the air conditioning plant.

[Ans 11.8ºC, 28.6ºC, 13.5ºC, 6265 kg/h; 1253kg/h, 19.2m3/min,40.7kw]

17. An air conditioning plant is to be designed for a small office for winter conditioning;

Out door conditions = 10ºC DBT, 8ºC WBT

Required indoor conditions=20ºC DBT, 60%RH

Amount of air circulation= 0.3m3/min/person

Seating capacity of the office= 50 persons

The required condition is achieved first by heating and then by adiabatic humidifying. Find a) heating capacity of the coil in kw and the surface temperature, if the BPF of the coil is 0.32; and b) capacity of the humidifier. [Ans. 5.5kW, 35.7ºC, 3.3kg/h]

18. The design data for an air conditioning plant of a restaurant is given below:

Outdoor design conditions	= 35ºC DBT, 24ºC WBT
Indoor design conditions	= 27ºC DBT, 55% RH
Seating capacity of the restaurant	= 50
Latent heat gain/person	= 44W
Latent heat gain from meals/person	= 6W
Sensible heat gain/person	=58W
Sensible heat gain/person from meals	= 3.5W
No. of service employees	= 5
Latent heat gain/employee	= 75W
Sensible heat gain/employee	= 58W

Sensible heat gain from outside the restaurant =8.14kw

Sensible heat gain from inside the restaurant = 2.9kw

Latent heat gain from equipment = 0.7kw

Rate of infiltrated air = 400m3/h

Rate of fresh air supply = 1600m3/h

Minimum temp of air supplied to room=17ºC DBT

The fan is situated before the conditioner and has a motor of 11kw.

Calculate

a) Volume of air passing through the room in m^3/h

b) ADP, BPF

c) Cooling capacity.

[Ans. 4747 m^3/h, 68.6%, 14.6ºC, 0.161, 11.9TR]