ASHRAE India Chapter

ASHRAE INDIA CHAPTER BULLETIN

For the HVAC&R Industry

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Presidential Message

K.K. MITRA
President, ASHRAE India Chapter

We are now completing another year of Ashrae India Chapter service to the Industry. The present BOG completes its 1 year term on 30th June. The installation of the next BOG would take place on 14th July. The new BOG will be headed by Mr. Priyank Garg – President. During the last 3 months, one of our major activity was steering the preparations for the 2nd Developing Economies conference to be held at New Delhi on 10th – 11th November, 2017 at Hotel Le Meridian under the guidance of Mr. Ashish Rakheja, who chairs the Steering Committee. This event is jointly being done along with Delhi Chapter of ISHRAE. This is a two days event with technical lectures under the topics Building Energy Quotient (BEQ), Building Information Management (BIM) , Internet of Things (IoT) , Energy-Water Nexus , Smart Cities , UNEP , Indoor Air Quality (IAQ) and Tall Buildings

There will be DLs from ASHRAE HO as well as local eminent speakers. The target expectation is 200+ delegates. The event is well supported by the sponsors Blue Star Limited, Johnson Controls- Hitachi Air Conditioning India Limited, Kirloskar Brothers Ltd., Daikin Airconditioning India Pvt. Ltd., Desiccant Rotors International Pvt. Ltd., Tristar Global, Edgetech Air Systems Pvt. Ltd., Advance Valves Pvt. Ltd., Zamil Air Conditioners India Private Limited, Anilesh Enterprises Pvt. Ltd., Gripple Hanger & Joiner Systems (India) Pvt Ltd and Lloyd Insulations India Limited.

A Solar Cold Store which was installed at Village – Bachela (near Agra) in the month of January, 2017 was officially inaugurated on 4th June in the presence of Village Sarpanch and the villagers. The cold storage was on trial operation for 3 months. The Cold storage is now open for the usage of villagers. Further this project has been well appreciated and accepted by ASHRAE HO with a grant of 4000 US$. We also had another project titled Performance analysis of solar operated milk refrigerator using hybrid nanomaterials proposed by our Student Chapter – Poornima Engineering College at Jaipur and 5000 US$ has been sanctioned by ASHRAE HO. Three new student chapters were installed viz, SRCEM, Palwal, Pusa Institute Of Technology, Pusa and YMCA Faridabad. The coordination meeting of all ASHRAE Chapters was held at IIT Chennai on 6th May whereby we discussed regarding the various ASHRAE Chapters working and necessary preparations to be taken up in future and the break up of RAL. A briefing was also done on the ARVCS meeting / Training Program held at Sri Lanka on 5th May. The next coordination meeting is planned on 23rd July at Hyderabad primarily to discuss on the preparations for the CRC meeting in September at Sharml El Sheikh, Egypt.

K.K. MITRA
President - ASHRAE India Chapter

Chapter Activities

Pracruti Tech-2017

Full Day Technical Seminar Pracruti Tech-2017 with theme –' Smart Utilities for HVAC System' was held on on 23rd Feb., 2017 at ACREX India 2017. The event was inaugurated by ASHRAE President Timothy G. Wentz. The presentation by Dr. Om Taneja on Challenges of Smart Infrastructure Development For HVAC Design of Smart , Sustainable Cities, Dr. Rajinder Singh on Use of Green Secondary Refrigerant (Ice Slurry) for Refrigeration & Air-Conditioning and by Mr. Rajesh K Jain & Team, DMRC on Insights into Metro Station Design was appreciated by participants.

New Student Chapter

Mr. K K Mitra inaugurated the new student chapter of ASHRAE at PUSA INSTITUTE OF TECHNOLOGY on 9th May, 2017.

AIC Sustainability Activity

The solar cold storage developed by ASHRAE India Chapter under its CSR activity was handed over to the village pradhan Mr. Javar Singh on 4th June, 2017 for use by the people of village Bachela-Bachele, Sirsaganj, Distt Firozabad UP. The cold storage will be used by the villagers to preserve their vegetables and milk produce before sending to market.

Expert Talk

Ashrae DL talk on 'Introduction to Achieving a Green Data Center & Introduction to Building Automation System Master Planning' by Mr. Jim Vallort and presentation on 'Importance to Integrative Design Solutions on Integrative Design and Energy Conservation Building Code 'by Mr. Kanagaraj G was held at ASHRAE Chapter at Amity University on April 3rd, 2017. The event was followed by meeting with ASHRAE student chapter advisor and student.

Mr. Jim Vallort also gave a talk on "Primary Heating/Cooling Plant Strategies" on April 04, 2017 at ASHRAE student chapter, Poornima College of Engineering, Jaipur.

Presentation on 'Scope of Refrigeration & Air-Conditioning in India, Innovation in Refrigeration & Air-Conditioning Field and Energy Savings in HVAC Systems' by Dr. Rajinder Singh and Mr. U.S.Jadon in SRCEM was held on 14.02.2017 and appreciated by Students and Faculty Members.

कसेरा को एशरे से 5 हजार डॉलर की ग्रांट

डेली न्यूज, mix रिपोर्टर, जयपुर। अमेरिकन सोसायटी ऑफ हीटिंग रेफ्रिजरेटिंग एंड एयर कंडीशनिंग इंजीनियर्स (एशरे) की ओर से जयपुर के शैलेंद्र कसेरा के प्रोग्राम को पांच हजार डॉलर की ग्रांट मंजूर की गई है। शैलेंद्र को यह ग्रांट उनके प्रोजेक्ट 'परफॉर्मेंस एनालिसिस ऑफ सोलर ऑपरेटेड मिल्क रेफ्रिजरेटर यूजिंग हाइब्रिड नैनोमेटेरियल्स' के लिए दी गई है। शैलेन्द्र पूर्णिमा कॉलेज ऑफ इंजीनियरिंग के मैकेनिकल इंजीनियरिंग डिपार्टमेंट के एचओडी है। एशरे की ओर से अंडरग्रेजुएट प्रोग्राम इक्विपमेंट ग्रांट के तहत यह ग्रांट अप्रूव्ड की गई है। कसेरा ने बताया कि सोलर डीसी पावर से मिल्क रेफ्रिजरेटर को चलाना और हाइब्रिड नैनोमेटेरियल्स का उपयोग करते हुए रेफ्रिजरेटर की परफॉर्मेंस पैरामीटर्स को कैलकुलेट करना इस प्रोजेक्ट का प्रमुख उद्देश्य है। इससे बिजली की अनुपलब्धता वाले क्षेत्रों में भी सोलर एनर्जी के जरिए मिल्क कूलिंग की जा सकेगी और यह सिस्टम एनर्जी एफिशिएंट भी होगा।

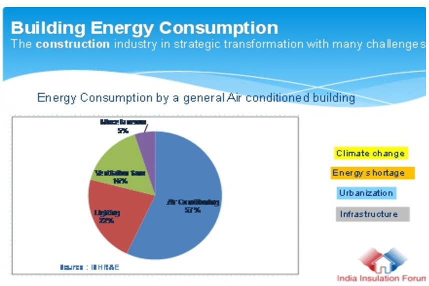
Upcoming Events

- ASHRAE India Chapter Annual General Meeting and installation ceremony of the new BOG (2017-2018)- 14th July, 2017, Magnolia, India Habitat Centre, Lodhi Road, New Delhi
- ASHRAE's Conference on Developing Economies : November 10 - 11, 2017, Hotel Le Méridien, New Delhi
- AIC TECH International conference- 20th January 2018 at the Gulmohar, India Habitat Centre, Lodhi Road, New Delhi

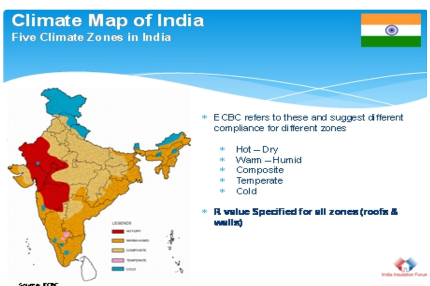
The roles of Thermal insulation in the energy performance of the Wall & Roof

By Dr. Sunil Bajaj
ISOFOAM -INDIA
AIC BOG MEMBER

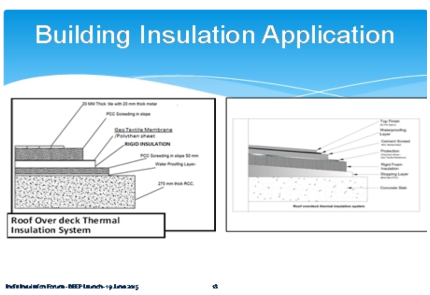
The demand for energy in India is steadily increasing as a result of rapid growth in population and economic development. Due to high industrialization for the past two decades, India is facing an increasing deficit in power supply to meet its normal requirements as well as its peak load demand. The total national energy consumption accounts to 3.4% of global energy consumption and is divided among four main sectors such as industrial, building (residential/commercial), transportation and agriculture. Building sector is the third largest consumer of energy and its share is 30% of total national energy consumption. This increases at a rate of 4.3% exceeding the population growth rate of 1.3%. The distribution of energy use pattern in Air conditioned building is shown in Figure below



The energy required for HVAC is highest share of all utilities and it is ever increasing due to improvement in life standards and growth in IT sector. On the basis of metrological data ,the country is divided into five climatic zones as shown in Figure .



This vast climatic diversity along with different income groups developed different energy use patterns which influence energy consumption. Although the energy consumption in India is much less than the world's average, still due to lack of energy efficient practices, Indian buildings give rise to significant energy wastage. The Vast climatic diversity has resulted in different energy use patterns which influence energy consumption. The air conditioning systems installed both in commercial and residential establishments consume more energy due to lack of awareness on energy conservation needs and poor buying capacity of the people for their homes. Government of India has setup Bureau of Energy Efficiency, which has brought out energy conservation building code to promote good practices for energy conservation. BEE has made it mandatory for manufacturers to label their consumer goods which include air conditioners to rises information regarding energy consumption and efficiency of the system. The best way to conserve energy in buildings is to use to energy efficient devices and to avoid heat gain in buildings. Heat gain in buildings can be avoided by insulating walls and roof. Energy performance index for buildings as per energy conservation building code regulated by Bureau of Indian Standard (BIS) and Bureau of Energy Efficiency (BEE) is high as 200 to 400 kWh/m2 /year. This clearly demands for energy conscious building design. Thermal insulation to avoid heat gain from the surrounding is one of the simplest methods to conserve energy. Thermal insulation of buildings can reduce electricity consumption up to 40%. The selection of insulation material is based on its thermal conductivity and price. A tradeoff between insulation thickness and reduction in energy consumption is required as insulation thickness increases the insulation cost. There must be an optimum insulation thickness which reduces the investment cost and energy cost required for space cooling over the life-time of the building. The heat gain through roof conduction is significant which has to be avoided by incorporating proper roof insulation. The roof over deck Thermal Insulation System is as shown

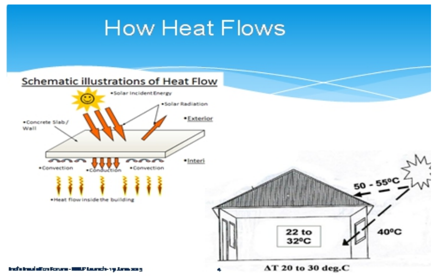


Optimum insulation thickness of walls for energy-saving in hot regions of India

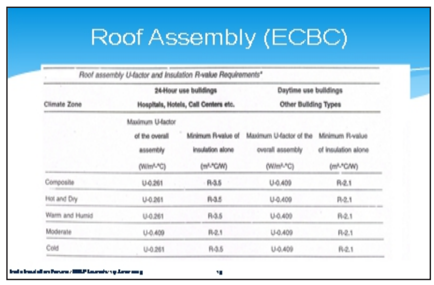
Effective thermal insulation of building walls is one of the most effective energy conservation measures for heating, ventilation, and air conditioning applications in buildings The thermo economic optimization of insulation thickness on walls of buildings is analysed based on degree days. Thermo- economic parameters such as optimum insulation thickness, annual electrical energy consumption, annual energy cost and payback period can be determined by using insulation materials for the cities located in India.

Thermal insulation for roofing is one of the best practices to reduce heat energy consumption for space cooling and heating. The roof insulation avoids retention heat into the room. The selection of optimum insulation material and optimum insulation thickness plays a vital role.

The roof is affected by three modes of heat transfer mechanisms: Conduction, convection and radiation. The roof surface exposed to atmosphere absorbs solar radiation and transmits it into the inner surface through conduction.

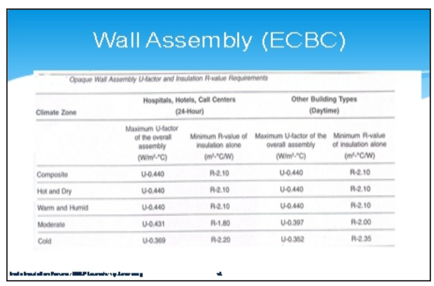


Determination of optimum thickness of insulation for Roof and External walls can be found in BEE



Roof assembly U-factor and Insulation R-value Requirements*

Climate Zone	24-Hour use buildings Hospitals, Hotels, Call Centers etc.		Daytime use buildings Other Building Types	
	Maximum U-factor of the overall assembly (W/m²-°C)	Minimum R-value of insulation alone (m²-°C/W)	Maximum U-factor of the overall assembly (W/m²-°C)	Minimum R-value of insulation alone (m²-°C/W)
Composite	U-0.261	R-3.5	U-0.409	R-2.1
Hot and Dry	U-0.261	R-3.5	U-0.409	R-2.1
Warm and Humid	U-0.261	R-3.5	U-0.409	R-2.1
Moderate	U-0.409	R-2.1	U-0.409	R-2.1
Cold	U-0.261	R-3.5	U-0.409	R-2.1



Opaque Wall Assembly U-factor and Insulation R-value Requirements

Climate Zone	Hospitals, Hotels, Call Centers (24-Hour)		Other Building Types (Daytime)	
	Maximum U-factor of the overall assembly (W/m²-°C)	Minimum R-value of insulation alone (m²-°C/W)	Maximum U-factor of the overall assembly (W/m²-°C)	Minimum R-value of insulation alone (m²-°C/W)
Composite	U-0.440	R-2.10	U-0.440	R-2.10
Hot and Dry	U-0.440	R-2.10	U-0.440	R-2.10
Warm and Humid	U-0.440	R-2.10	U-0.440	R-2.10
Moderate	U-0.431	R-1.80	U-0.397	R-2.00
Cold	U-0.369	R-2.20	U-0.352	R-2.35

However the impacts of heat insulation used for reduction of heat loses in buildings have reported a cut down in CO2 emission by 50% for optimum insulation thickness and other energy saving methods. with a payback period of 3.11 years.

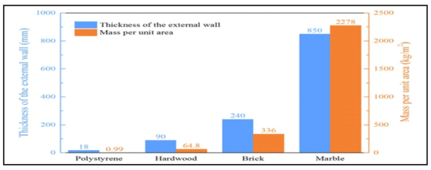
DETERMINATION OF DEGREE DAYS The use of proper insulation is the effective way to conserve energy in building applications. Energy requirement for heating-cooling is required to determine suitable insulation material and to optimize its thickness. The annual energy consumption for heating-cooling can be determined by using the degree-days method.

OPTIMUM THICKNESS OF INSULATION The heat gain in the building envelope occurs due to heat transmission forms ambient to the room through walls, ceiling, windows and basements and by infiltration. Due to absorption of radiant heat, roof retains heat and transmits inside room to increase in temperature. The radiant portion introduces a time lag and also a decrement factor depending upon the dynamic characteristics of the surfaces. Due to this time lag, the effect of radiation will be felt even when the source of radiation is not present due to sunset. Therefore the insulation plays a vital role in minimizing the heat gain in building envelope.

A high-performance envelope is the prerequisite and foundation to a zero energy building. The thermal conductivity and volumetric heat capacity of a wall are two thermophysical properties that strongly influence the energy performance.

The energy performance illustrates the comparisons of thickness and mass for some typical materials, whose cooling energy performances approximate that of a 240mm brick wall. The thickness of the polystyrene is just 2% of the marble and 7.5% of the brick. Furthermore, the mass per unit wall area of the polystyrene wall is much smaller than those of the other materials due to a low density of the polystyrene. A small mass per unit area means a lower construction cost, and a smaller thickness results in larger net area. Therefore, an external wall made of light insulation materials, like polystyrene, will be recommendable in buildings following an improvement in mechanical strength.

Figure : Comparisons in thickness and mass per unit wall area of typical materials.



The energy performances of an external wall made of different materials are close to that of 240mm-thickness bricks. For example, the cooling energy consumption of a room with an 850mm-thickness-marble external wall is approximately equal to that with a 240mm-thickness-brick external wall.

Fire at Grenfell Tower Fire at West London

The fire at Grenfell Tower in West London has posed a huge challenge to the building designers in India also as lots of buildings have similar type of aluminium composite panel exterior cladding. This cladding enhances the aesthetic look of a building and also insulate the interior from the environment factors. However the air gap between the cladding and the building wall can act as a chimney sending the flames up through these gaps. In the event of a fire, the cavity acts as a chimney drawing hot air and driving the fire spread throughout the building. The spread becomes very fast and can enter through the windows left open. Though stone is also another option but aluminium being lighter is considered a better option. The sealant used between the panels to stop water seepage can also be fire hazardous, if not selected properly. One of the possible remedial measure can be filling up of cavity with non-combustible filler materials and also creating barriers at the floor joints to stop the flow of fire and chimney effect as expressed by Mr. Pankaj Dharkar-President FSAI in an interview to The Telegraph. One of the options for filling the cavity can be non-combustible grade insulating boards, which can have a defined fire rating and thus stop the fire propagation. These insulating boards can be of desired thickness filling the gap. Further being an insulation material will also stop heat ingress into the building interior. This viable option can be given further thought and deliberated.

K.K. Mitra

Air-conditioning and Air-conditioning Design

Dr. Rajinder Singh
Senior Faculty, Pusa Institute of Technology,
(Imm. Past President, Chair Sustainability and Chair Student Activities - ASHRAE India Chapter)

1.1 Introduction

Air-Conditioning is a branch of Engineering to control following factors:

(I) Temperature

(ii) Humidity

(iii) Air movement

(iv) Air purity

Air-Conditioning Design is based upon Psychrometry.

Psychrometry is a branch of Air-Conditioning science dealing with moisture present in air (the working substance in air-conditioning). Atmospheric air is a mixture of dry air, water vapour and contaminants (gaseous pollutants, smoke and pollen etc.).

Dry air is atmospheric air without water vapour and contaminants. Its composition is relatively constant, but there is small variations in the amounts of individual constituents occur due to time, altitude and geographical location.

Table 1. Approximate percentage composition by volume of dry air

Constituents	N_2	O_2	Ar	CO_2	Ne	He	CH_4	SO_2	H_2	$Kr/Xe/O_3$
%age	78.084	20.9476	0.934	0.314	0.001818	0.000524	0.00015	0-0.0001	0.0005	0.0002

Gas constant for dry air = Universal Gas constant/Molecular Mass

= 8.3143 kJ/kg mole K/28.966 kg/ kg mole

= 0.287 kJ / kg K.

Pure dry air is not available in atmosphere; it always contains some moisture/water vapour. The amount of water vapour varies from zero (dry air) to a maximum that depends upon temperature and pressure. If water vapour is added to dry air, a limit will be reached when the air will be saturated and can not hold more water vapour, such air is called as saturated air and it is not visible. But if more water vapour is added to it, the drops of water may remain in suspension and make air misty or foggy such drops are the condensed particles of water vapour and this will happen only beyond saturation.

According to Dalton's Law of Partial Pressure:

$$P_b = P_a + P_v$$

Where P_b = Barometric pressure of mixture.

P_a = Partial Pressure of dry air

P_v = Partial Pressure of vapour

At saturation $P_v = P_s$

Therefore $P_b = P_a + P_s$

Water vapours in atmosphere are always in superheated state.

The gas constant for water vapour = 8.3143 kJ/ kg mole K/ 18.016 kg/ kg mole

= 0.461 kJ / kg K

1.2 Psychrometric Properties of Air

Various psychometric properties of air like Dry Bulb Temperature, Wet Bulb Temperature, Dew Point Temperature, Specific Humidity, Relative Humidity, Degree of Saturation, Enthalpy of moist Air, Adiabatic Saturation Temperature are explained in this chapter.

1.2.1 Dry Bulb Temperature

The temperature recorded by a thermometer whose bulb is having all dry surfaces and unaffected by moisture present in the air is defined as dry bulb temperature It is denoted by 'DBT'.

1.2.2 Wet Bulb Temperature

The temperature recorded by a thermometer whose bulb is covered with a wetted wick or wetted cotton, either rotate the thermometer with an average velocity of 4 to 5 m/s or blow air on it with the same velocity, the moisture present on the wick tends to evaporate and makes the air in close vicinity of wick saturated. The heat required for evaporation is taken that atmosphere itself in the close 100 vicinity of wick thereby reducing the temperature nearby wick. This reduced temperature of surrounding saturated air is defined as wet bulb temperature. It is denoted by 'WBT'.

A very thin film is formed around wick (close vicinity) making air saturated. Air, wick and bulb are in thermal equilibrium with each other. Temperature of this surrounding saturated air is known as wet bulb temperature.

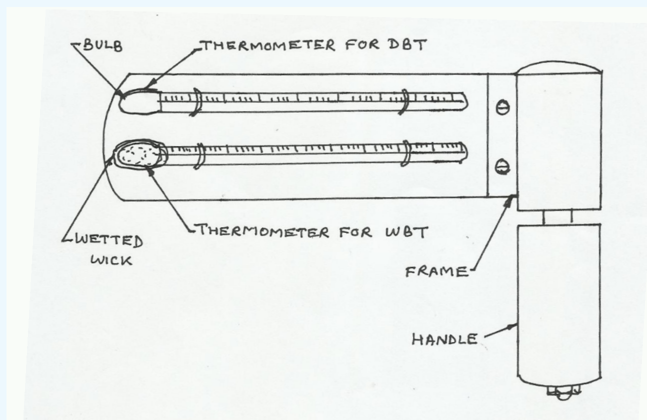


Fig.2.1 Sling Psychrometer which is used to measure DBT and WBT

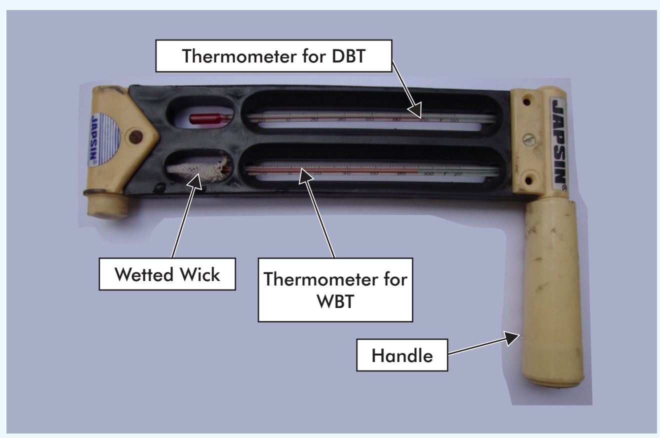
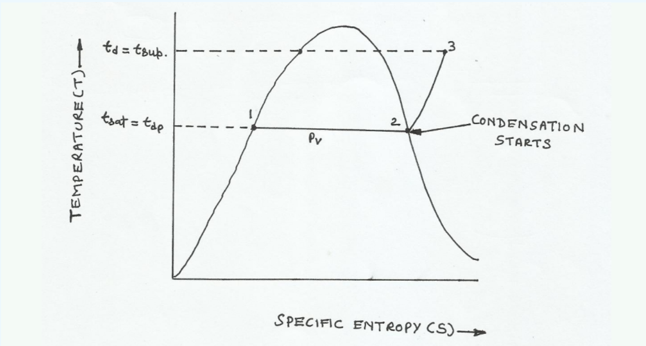


Fig.2.2 Photograph of Sling Psychrometer

1.2.3 Dew Point Temperature

The temperature of air at which first particle of water vapour in air is condensed and a dew is formed is known as dew point temperature. This is a function of partial pressure of vapour. It is denoted by 'DPT'.



t_{sat} = saturation temperature

t_{sup} = superheated temperature

t_d = dry bulb temperature

t_{dp} = dew point temperature

Fig.2.3 Temperature-Entropy Diagram

"Saturation temperature corresponding to partial pressure of vapour at which first dew is formed". Water vapour in air is in superheated state. The partial pressure of water vapour is low and its corresponding saturation temperature is also low.

The dry bulb temperature of air is higher than the saturation temperature of water vapour at its partial pressure. Therefore, water vapour is in superheated state as shown by point 3 in Fig.1.3. At point 2 condensation of water vapour starts. The Temperature at point 2 is called Dew Point Temperature.

At Saturation condition	DBT = WBT = DPT
Wet Bulb depression	= DBT – WBT
If dry atmosphere difference	DBT – WBT is more
If moisture more difference	DBT – WBT is less

1.2.4. Specific Humidity or Humidity Ratio

Specific Humidity is the mass in kg of water vapour present in the air-vapour mixture per kg of dry air. It is also known as Humidity Ratio. It is denoted by 'w'.

Specific Humidity = Kgm of vapours present in the air / Kgm of dry air.

Assuming the vapours to behave like a perfect gas.

$$P_v V_v = m_v R_v T_v$$

and for dry air

$$P_a V_a = m_a R_a T_a$$

$$P_v V_v / P_a V_a = m_v R_v T_v / m_a R_a T_a$$

Since $V_v = V_a$ and $T_v = T_a$

$$P_v / P_a = mv\ Rv / m_a R_a$$

Therefore, specific humidity,

$$w = m_v / m_a$$

$$= R_a P_v / R_v P_a$$

$$= 0.287 P_v / 0.461 (P_b - P_v)$$

$$= 0.622 P_v / (P_b - P_v)$$

At saturation $P_a = P_s$

and $w_s = 0.622\ Ps / (P_b - P_s)$

Where P_a, V_a, m_a, T_a and Ra are partial pressure, volume, mass flow rate, temperature and gas constant of dry air and P_v, V_v, m_v, T_v, and R_v are the partial pressure, volume, mass flow rate, temperature and gas constant of vapour.

1.2.5. Relative Humidity

Relative Humidity is the ratio of mass of water vapours present in a given volume of air at a given DBT to the mass of the water vapours present in the same volume of air at same DBT at saturation. It is denoted by 'RH'.

Assuming the vapours and dry air to behave as perfect gases

For vapour $P_v V_v = m_v R_v T_v$

For saturated air $P_s V_s = msRsTs$

Since $Vv = V_s$, $T_v = T_s$ and $R_v = R_s$

$$P_v / P_s = m_v / m_s = RH$$

Thus Relative Humidity may be defined as the ratio of partial pressure P_v of water vapour in humid air to the saturation pressure P_s of the vapour at the same DBT.

For saturated air $P_v = P_s$ and RH = 100 %

1.2.6. Percentage Saturation or Degree of Saturation

Percentage Saturation or Degree of Saturation is defined as the ratio of kg of water vapors present in a given mass of air at a given DBT to Kg of water vapors required to saturate the same mass of air at the same DBT. It is denoted by 'μ'.

μ = kg of water vapors present in a given mass of air at a given DBT / Kg of water vapors required to saturate the same mass of air at the same DBT.

$$\mu = w / w_s$$

$$= 0.622 P_v / (P_b - P_v) / 0.622 P_s (P_b - P_s)$$

Because at saturation $P_v = P_s$

Where P_s = saturation pressure corresponding to dry bulb temperature.

1.2.7. Enthalpy of Moist Air

Enthalpy of moist air is the enthalpy of mixture (1 kg of dry air + w kg of water vapour per kg of dry air). Enthalpy of moist air is given by:

h = Enthalpy of dry air + Enthalpy of water vapour.

$$= h_{dryair} + w.\ h_{vapour}$$

$$= 1.\ h_a + w.h_v$$

$$= Cp_a \cdot t_d + w\,(h_g + Cp_v\,(t_d - t_{dp}))$$

$$= Cp_a \cdot t_d + w(h_f + h_{fg} + Cp_v\,(t_d - t_{dp}))$$

$$= Cp_a \cdot t_d + w\,(Cp_w . t_{dp} + h_{fg} + Cp_v\,(t_d - t_{dp}))$$

$$= (Cp_a + w.Cp_v)\, t_d + w(h_{fg} + (Cp_w - Cp_v)\, t_{dp})$$

$$h = Cp_m . t_d + w\,(h_{fg} + (Cp_w - Cp_v)\, t_{dp})$$

Where, Cp_m = Specific heat of moist air of (1 + w) kg per kg of dry air.

$$= Cp_a + w.Cp_v$$

Cp_a = Specific heat of dry air = 1.006 kJ / kg. K

Cp_w = Specific heat of water = 4.1868 kJ / kg. K

Cp_v = Specific heat of vapour = 1.88 kJ / kg. K

1.2.8. Adiabatic Saturation Temperature or Thermodynamic Wet Bulb Temperature

Adiabatic Saturation Temperature or Thermodynamic Wet Bulb Temperature is the temperature of the saturated air obtained in an adiabatic saturation process i.e. where there is no heat transfer between the given air and surroundings.

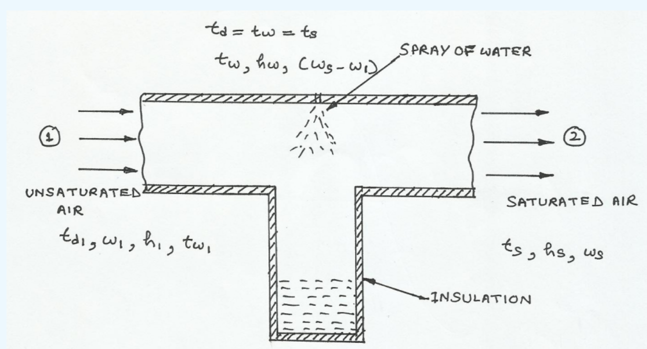


Fig.2.4 Temperature-Entropy Diagram

Let us consider on adiabatic system completely insulated, unsaturated air enters at point (1) and leaves as saturated air at point (2), water at a temperature of tw and enthalpy hw is sprayed in the system. Since the system is adiabatic, therefore, enthalpy balance :

$$h_1 + (w_s - w_s) = h_s$$

The condition at point (2) i.e. t_s, h_s and w_s correspond to thermodynamic wet bulb temperature or adiabatic saturation temperature and this process is called adiabatic saturation process.

$$h_1 + w_s . (h_w - w_1).h_w = h_s$$

or $(h_1 - w_1).h_w = (h_s - w_s).h_w$

= Sigma function

= Constant.

Therefore for a constant thermodynamic wet bulb temperature, sigma function is constant for any value of dry bulb temperature at condition (1). Since $(w_s - w_1)$ is very small quantity and h_w is also small, $(w_s - w_1).h_w$ is negligible small.

Therefore, $h_1 = h_s$

Enthalpy of unsaturated air = Enthalpy of saturated air.

Hence for a given wet bulb temperature, whatever may be the DBT, Enthalpy of the air remains same.

$(w_s - w_1)\ h_w$ = enthalpy deviation

If, $(w_s - w_1)\ h_w = 0$

$w_s = w_1$

Dry bulb tempt (DBT) = Wet Bulb temperature (WBT)

i.e. the entering air is saturated.

Case Study

The humidity ratio or specific humidity of atmospheric air at 27.5 °C is 0.016 kg /kg of dry air.

Determine

(i) The partial pressure of vapour (P_v)

(ii) Relative humidity (RH)

(iii) Dew point temperature (DPT)

Assume standard barometric pressure of 760 mm of Hg.

Solution.

(i) Specific humidity or humidity ratio

$w = 0.622\ (P_{v1} / (P_b\text{-}P_{v1})$

$(0.016 / 0.622) = (P_{v1} / (760\text{-}P_{v1})$

$P_{v1} = 19.05$ mmHg

(ii) Relative humidity, $RH = P_{v1} / P_{s1}$

$= P_{v1} / P_{v3}$

Where P_{s1} is the saturation pressure of vapour corresponding to the saturation temperature equal to 27.5 °C

$RH_1 = P_{v1} / P_{v3}$

$= 19.050 / 27.535 = 0.694$ or 69.40 %

(iii) Dew point temperature (DPT) is the saturation temperature corresponding to vapour pressure of 19.05 mm of Hg, as read from tables.

Thus $t_{dp1} = 21.34$ °C

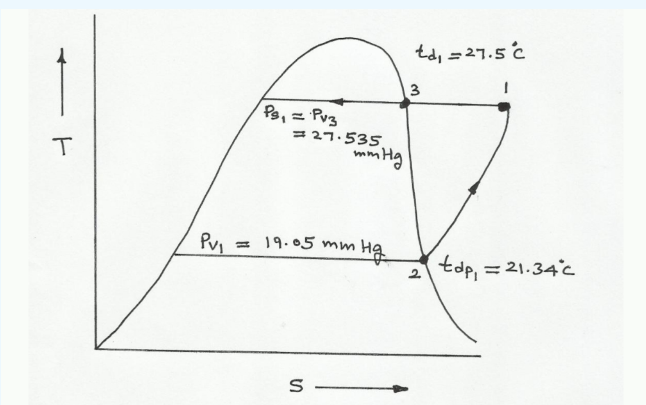


Fig.2.4 Temperature-Entropy Diagram

1.3 Psychrometric Chart

Psychrometric chart is shown below:

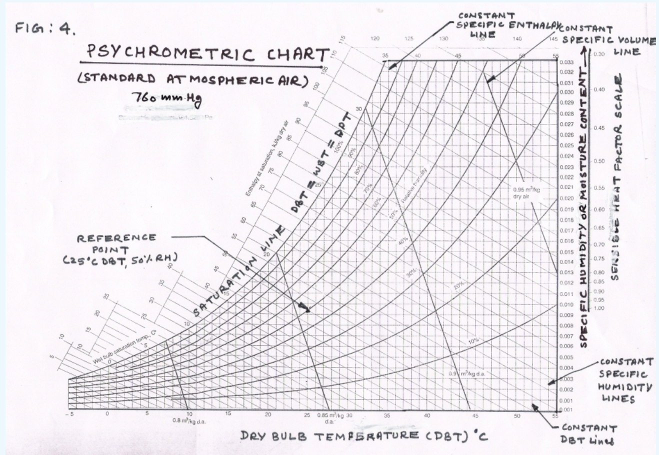


Fig.3.1 Psychrometric Chart

Case Study

Find out w, h, v, DPT, RH or WBT at following conditions using psychrometric chart:

(i) 22 °C DBT and 60 % RH

(ii) 20 °C DBT and 16 °C WBT

(iii) 25 °C DBT and 14 °C DPT.

Solution. (i) 22 °C DBT and 60 % RH

From psychrometric chart

Specific humidity, w = 0.0102 kg / kg of dry air

Specific enthalpy, h = 48.0 KJ / kg of dry air

Specific volume, v = 0.85 m3 / kg of dry air

Dew point temperature, DPT = 14.1 °C

Wet bulb temperature, WBT = 17.0 °C

(ii) 20 °C DBT and 16 °C WBT

From psychrometric chart

Specific humidity, w = 0.0098 kg / kg of dry air

Specific enthalpy, h = 45.0 KJ / kg of dry air

Specific volume, v = 0.842 m3 / kg of dry air

Dew point temperature, DPT = 13.8 °C

Relative humidity, RH = 66 %

(iii) 25 °C DBT and 14 °C DPT

From psychrometric chart

Specific humidity, w = 0.010 kg / kg of dry air

Specific enthalpy, h = 51.2 KJ / kg of dry air

Specific volume, v = 0.86 m3 / kg of dry air

Wet bulb temperature, WBT = 18.0 °C

Relative humidity, RH = 50 %

Second ASHRAE Developing Economies Conference

November 10 -11, 2017
Delhi, India
ashrae.org/Developing2017

In view of the anticipated construction boom in Developing Economies for infrastructure and urbanization, the conference is an ASHRAE initiative to reach out and share its resources.

The conference theme is entitled "Trends, Opportunities and Challenges for the Built Environment in Developing Economies."

This theme is focused on trends that are affecting the built environment in developing economies and the opportunities and challenges presented by these trends. With the benefit of the learnings from developed countries, Developing Economy Countries are in many ways leapfrogging technologies while at the same time handicapped due to inadequate education and regulations.

The Conference attempts to bring together experts from all over the world. A call for conference presenters is now open:

- Technologies that can be a game changer in building design.
- Solutions to challenges, such as outdoor and indoor pollution, refrigerant phasedown, lack of trained manpower and expensive technologies.
- Standards, measurement and rating standards being developed and adopted to bring a common language for built environment evaluation, such as bEQ, well standards, local standards, etc.
- The regulatory changes and direction affecting the building industry, such as energy codes.
- The evolving economic models and their impact on building planning and use.

The presentations and sessions cover aspects of energy efficiency, comfort, indoor air quality, wellness and environmental impact of buildings in developing economy countries as affected by the air-conditioning, heating and ventilating systems for the buildings.

Abstracts (400 or less words in length) are due July 7, 2017.

The conference is being co-organized by ASHRAE, the ASHRAE India Chapter and Delhi Chapter of ISHRAE.

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