Fundamentals of Refrigeration and Air Conditioning

المرحلة الثانية

محاضرة رقم (3)

المخطط المرصدي وراحة الانسان

Psychrometric Chart and Human Comfort

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Department of Mechanical Power Engineering
Class (2nd)
Subject (**Fundamentals of Refrigeration and Air Conditioning**)

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2nd term – Lect. (**Psychrometric Chart and Human Comfort)**

Fundamentals of Refrigeration and Air Conditioning

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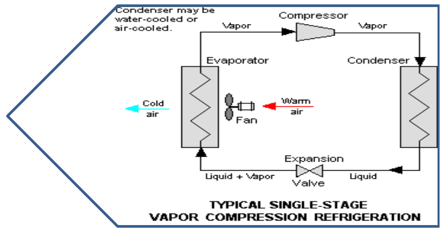

Lecture 3
Psychrometric Chart and Human Comfort

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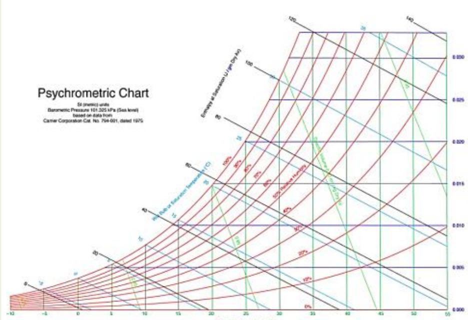
Lecture3. Psychrometric Chart

3-1 THE PSYCHROMETRIC CHART

- A psychrometric chart graphically represents the thermodynamic properties of moist air, as shown in Figure.
- It is very useful in presenting the air conditioning processes.

The psychrometric chart is bounded by two perpendicular axes and a curved line:

- 1) The horizontal ordinate axis represents the dry bulb temperature line t , in°C ;
- 2) The vertical ordinate axis represents the humidity ratio line *w* , in $kg_w/kg_{dry.air}$
- 3) The curved line shows the saturated air, it is corresponding to the relative humidity *Φ=100%* .



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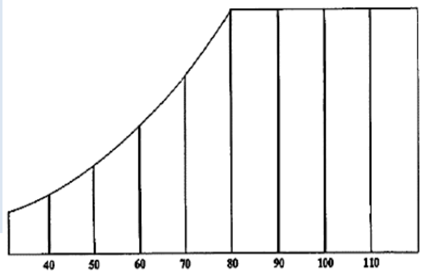
The psychrometric chart incorporates seven parameters and properties.

They are:

- dry bulb temperature t_{DB}
- relative humidity Φ
- wet bulb temperature t_{WB}
- dew point temperature t_{DP}
- specific volume v
- humidity ratio w
- enthalpy h.

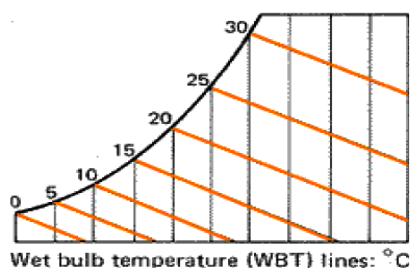
1. Dry-bulb temperature t_{DB} is shown along the bottom axis of the psychrometric chart.
- The vertical lines extending upward from this axis are constant-temperature lines.



Dry bulb temperature lines

2) Wet-bulb temperature t_{WB} : On the chart, the constant wet-bulb lines slope a little upward to the left, and the wet bulb temperature is read following a constant wet-bulb line from the state-point to the saturation line

Intersection of DBT and WBT provides the status point.



Wet Bulb Temperature Lines

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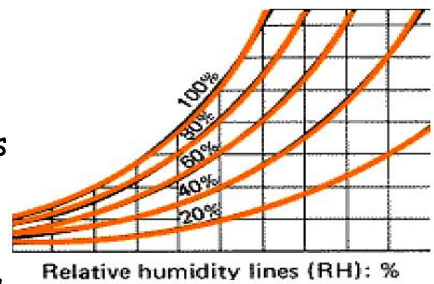
3) Relative humidity lines Φ are shown on the chart as curved lines that move upward to the left in 10% increments.

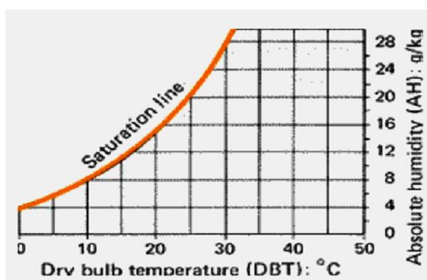
- The line representing saturated air (Φ= 100%) is the uppermost curved line on the chart.
- And the line of Φ = 0% is a horizontal ordinate axis itself.



Relative Humidity Lines

4) Humidity ratio w: it is indicated along the right-hand axis of the chart.

5) Dew point temperature t_{DP} : This temperature is read by following a horizontal line from the state-point to the saturation line.



Saturation Line, Absolute Humidity and Dry bulb temperature lines

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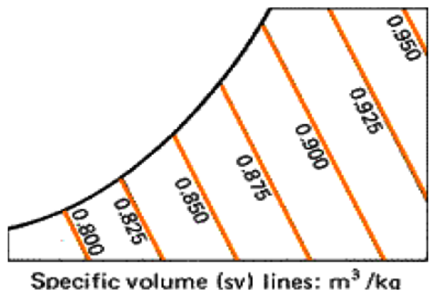
6) Specific volume υ .
indicates the space occupied by air.

- It is shown from the constant-volume lines slanting upward to the left.
- This is useful in converting volumetric flow to mass-flow rate calculation.

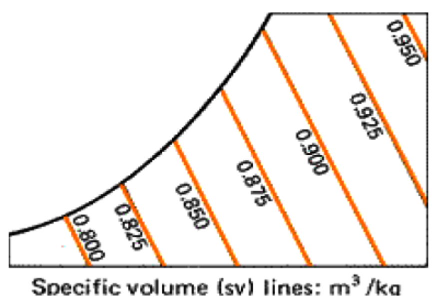


Specific Volume Lines

Lecture3. Psychrometric Chart

7) Enthalpy *h*: It is read from where the constant enthalpy line crosses the diagonal scale above the saturation curve. The constant enthalpy lines, being slanted lines, are almost coincidental as the constant wet-bulb temperature lines.

- Only two properties are needed to characterize the moist air because the point of intersection of any two properties lines defines the state-point of air on a psychrometric chart.
- Once this point is located on the chart, the other air properties can be read directly.



Specific Volume Lines

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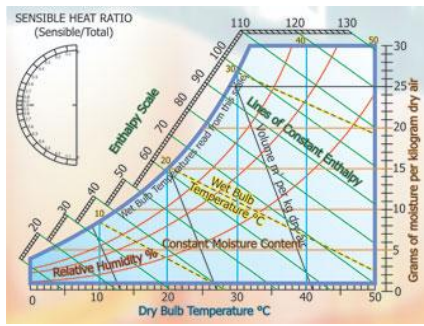

EXAMPLE 1 The Use of the Psychrometric Chart

Consider a room that contains air at 1 atm, 35°C, and 40 percent relative humidity. Using the psychrometric chart, determine (*a*) the specific humidity, (*b*) the enthalpy, (*c*) the wet-bulb temperature, (*d*) the dew-point temperature, and (*e*) the specific volume of the air.

Solution

At a given total pressure, the state of atmospheric air is completely specified by two independent properties such as the dry-bulb temperature and the relative humidity. Other properties are determined by directly reading their values at the specified state as shown in the Psychrometric chart.

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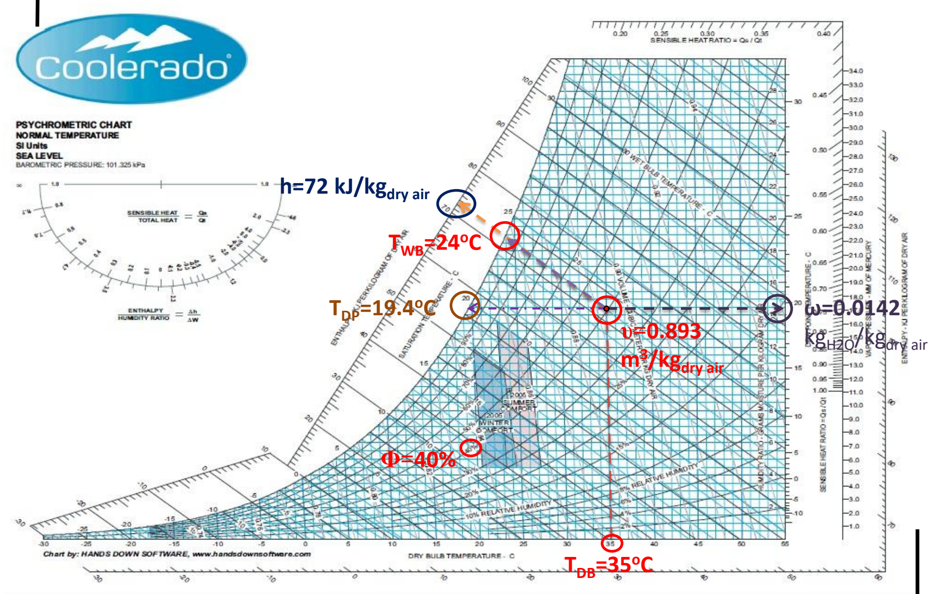

3-2 HUMAN COMFORT AND AIR-CONDITIONING

Human beings have an inherent weakness—they want to feel comfortable. They want to live in an environment that is neither hot nor cold, neither humid nor dry. However, comfort does not come easily since the desires of the human body and the weather usually are not quite compatible.

The human body can be viewed as a heat engine whose energy input is food. As with any other heat engine, the human body generates waste heat that must be rejected to the environment if the body is to continue operating.

The rate of heat generation depends on the level of the activity. For an average adult male, it is about 87 W when sleeping, 115 W when resting or doing office work, 230 W when bowling, and 440 W when doing heavy physical work.

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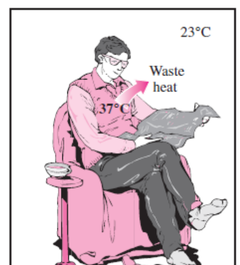
The corresponding numbers for an adult female are about 15 percent less. (This difference is due to the body size, not the body temperature. The deep-body temperature of a healthy person is maintained constant at about 37°C.)

A body will feel comfortable in environments in which it can dissipate this waste heat comfortably .



Heat transfer is proportional to the temperature difference. Therefore in cold environments, a body loses more heat than it normally generates, which results in a feeling of discomfort.

The body tries to minimize the energy deficit by cutting down the blood circulation near the skin (causing a pale look). This lowers the skin temperature, which is about 34°C for an average person, and thus the heat transfer rate.

A low skin temperature causes discomfort. The hands, for example, feel painfully cold when the skin temperature reaches 10°C (50°F).

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We can also reduce the heat loss from the body either by putting barriers (additional clothes, blankets, etc.) in the path of heat.

Or by increasing the rate of heat generation within the body by exercising.

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Lecture3. Psychrometric Chart

In hot environments, we have the opposite problem—we do not seem to be dissipating enough heat from our bodies, and we feel as if we are going to burst.

We dress lightly to make it easier for heat to get away from our bodies, and we reduce the level of activity to minimize the rate of waste heat generation in the body.

We also turn on the fan to continuously replace the warmer air layer that forms around our bodies as a result of body heat by the cooler air in other parts of the room.

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When doing light work or walking slowly, about half of the rejected body heat is dissipated through perspiration as *latent heat* while the other half is dissipated through convection and radiation as *sensible heat*.

When resting or doing office work, most of the heat (about 70 percent) is dissipated in the form of sensible heat whereas when doing heavy physical work, most of the heat (about 60 percent) is dissipated in the form of latent heat.

The body helps out by perspiring or sweating more. As this sweat evaporates, it absorbs latent heat from the body and cools it.

Perspiration is not much help, however, if the relative humidity of the environment is close to 100 percent.

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Lecture3. Psychrometric Chart

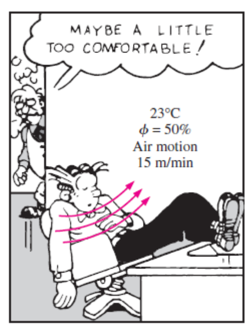
Another important factor that affects human comfort is heat transfer by radiation between the body and the surrounding surfaces such as walls and windows.

The comfort of the human body depends primarily on three factors: the (dry-bulb) temperature, relative humidity, and air motion.

Most people feel comfortable when the environment temperature is between 22 and 27°C (72 and 80°F).

The relative humidity also has a considerable effect on comfort since it affects the amount of heat a body can dissipate through evaporation.

Most people prefer a relative humidity of 40 to 60 percent.



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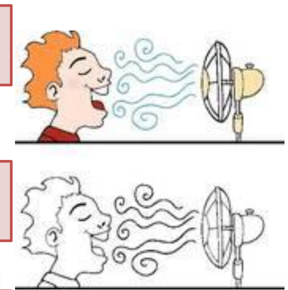
Air motion also plays an important role in human comfort. It removes the warm, moist air that builds up around the body and replaces it with fresh air. Therefore, air motion improves heat rejection by both convection and evaporation.

Air motion should be strong enough to remove heat and moisture from the vicinity of the body, but gentle enough to be unnoticed.



Most people feel comfortable at an air speed of about **15 m/min**.

Other factors that affect comfort are air cleanliness, odor, noise, and radiation effect.

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