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# Air Conditioning
# 2-THERMODYNAMICS

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**Thermodynamics** is the science devoted to the study of energy, its transformations, and its relation to status of matter. Since every engineering operation involves an interaction between energy and materials, the principles of thermodynamics can be found in all engineering activities.

**Properties and State**

A property of a system is any observable characteristic of the system. The more common thermodynamic properties are **temperature**, **pressure**, **specific volume or density**, **internal energy**, **enthalpy, and entropy**.

**Processes and Cycles**

A process is a change in state which can be defined as any change in the properties of a system.

The following terms define special processes:

**isobaric** or constant pressure—process wherein the pressure does not change.

**Isothermal**: process that occurs at constant temperature.

**Isometric**: process with constant volume.

**Adiabatic**: process in which no heat is transferred to or from the system.

**Isentropic**: process with no change in entropy.

A **cycle** is a process, or more frequently, a series of processes wherein the initial and final states of the system are identical. Therefore, at the conclusion of a cycle, all the properties have the same value they had at the beginning.

## Properties of a Substance

### Specific Volume and Density

The specific volume of a substance v is the volume per unit mass. The density of a substance d is the mass per unit volume, and is therefore the reciprocal of the specific volume. Specific volume and density are intensive properties in that they are independent of the size of the system. v= $m^3/kg$ d= $kg/m^3$

$$PV = mRT\big|_{air}, \quad PV = mRT\big|_{vapor}$$

$$R(air) = 287\,J/kg.K$$

$$R(vapor) = 461\,J/kg.K$$

**Pressure**

When dealing with liquids and gases, we ordinarily speak of pressure; in solids we speak of stresses. The pressure in a fluid at rest at a given point is the same in all directions. Pressure is defined as the normal component of force per unit area.

Absolute pressure is the quantity of interest in most thermodynamic investigations. Most pressure and vacuum gages, however, read the difference between absolute pressure and the atmospheric pressure existing at the gage .

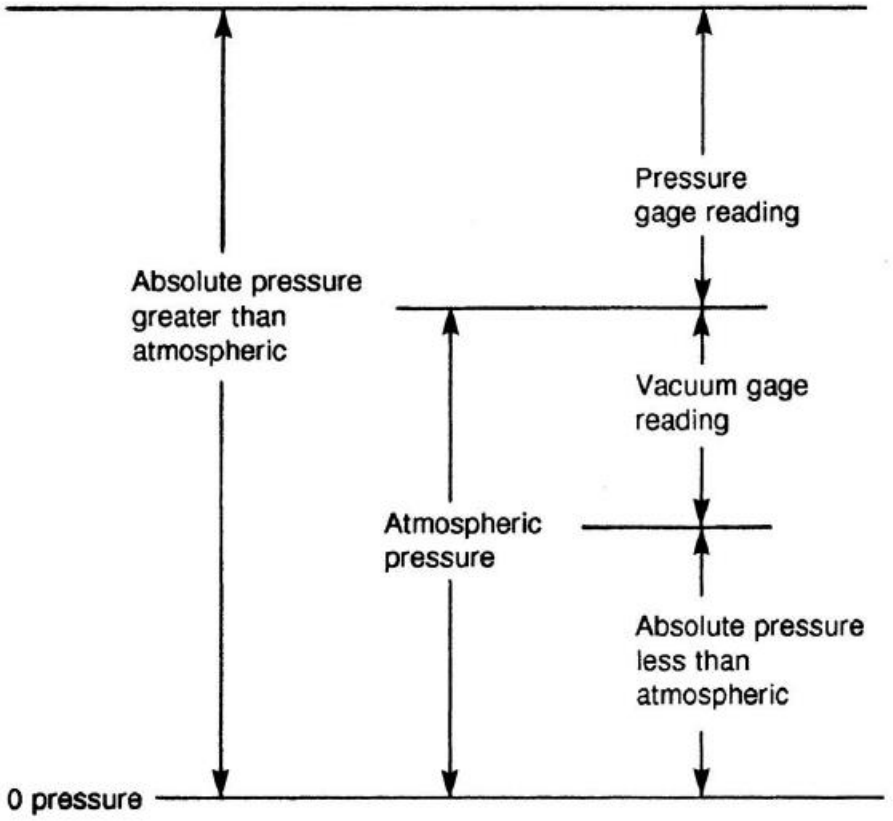



*Fig. 2-1 Terms Used in Pressure Measurement*

**Dalton's law:**

Dalton's law shows that for a mixture of gases occupying a given volume at a certain temperature, the total pressure of mixture is equal to the sum of the partial pressure of the constituents of the mixture.

$$P_B = P_a + P$$

$P_B$= barometric pressure of moist air

$P_a$= partial pressure of air in moist air

P=partial pressure of water vapor in moist air

P can be obtained from water tables or from formulas in appendix.

Pressure = force/area = $N/m^2$

is called pascal, abbreviated Pa.

1 kPa = 1000 Pa and

1 bar = 100000 Pa = 100000 N/ m2 = 10 $N/cm^2$

1 mm of water = ρgh = 1000 ($kg/m^3$) × 9.80665 ($m/s^2$) × 0.001 (m)

= 9.80665 Pa ≈ 9.81 Pa

Standard atmospheric pressure = 1.01325 bar

**Temperature**

Because temperature is difficult to define, equality of temperature is defined instead. Two bodies have equality of temperature if no change in any observable property occurs when they are in thermal communication.

**Fahrenheit** and **Celsius** are two commonly used temperature measuring scales. The Celsius scale was formerly called the Centigrade scale. The **absolute** scale related to the Celsius scale is referred to as the Kelvin scale and is designated K.

$$t_C = (t_F - 32)\ (100/180) = (t_F - 32)\ (5/9)$$

$$T_F = t_F + 459.69 \approx t_F + 460$$

$$T_C = t_C + 273.16 \approx t_C + 273$$

**Internal Energy**

Internal energy refers to the energy possessed by a material due to the motion and/or position of the molecules. This form of energy may be divided into two parts:

(1) **kinetic** internal energy, which is due to the velocity of the molecules.

(2) **potential** internal energy, which is due to the attractive forces existing between molecules.

**Enthalpy**

In analyzing specific types of processes, certain combinations of thermodynamic properties, which are therefore also properties of the substance undergoing the change of state, are frequently encountered. One such combination is U + PV. It is convenient to define a new extensive property, called enthalpy:

$$H = U + PV$$

**Entropy**

Entropy S is a measure of the molecular disorder or of the probability of a given state. The more disordered a system, the greater is its entropy; conversely, an orderly or unmixed configuration is one of low entropy.

**Specific Heats**

The constant-volume specific heat and the constant-pressure specific heat are useful functions for thermodynamic calculations- particularly for gases.

The constant-volume specific heat cv is defined by the relation

$$c_v = (\partial u / \partial T)_v$$

constant-pressure specific heat cp is defined by the relation

$$c_p = (\partial h / \partial T)_p$$

Note that each of these quantities is defined in terms of properties.

## Reference:

**Principles of heating ventilating and air conditioning a textbook with design data based on the 2017 ASHRAE handbook fundamentals by Sauer, Harry J. Howell, Ronald Hunter Coad, William**

*Thank you very much*