Refrigeration & Air Conditioning Technology
SIXTH EDITION

Section 1: Theory of Heat
Unit 2: Matter and Energy

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Unit Objectives

After studying this chapter, you should be able to:

- define matter.
- list the three states in which matter is commonly found.
- define density.
- discuss Boyle's Law.
- state Charles' Law.
- discuss Dalton's Law as it relates to the pressure of different gases.

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Unit Objectives

After studying this chapter, you should be able to:

- define specific gravity and specific volume.
- state two forms of energy important to the air conditioning (heating and cooling) and refrigeration industry.
- describe work and state the formula used to determine the amount of work in a given task.
- define horsepower.
- convert horsepower to watts.
- convert watts to British thermal units.

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MATTER

- Described as any substance that occupies space and has mass
- Matter is made up of atoms
- Exists as a solid, liquid or a gas
- The state of matter is determined by heat content of the matter as well as the amount of pressure exerted on the substance

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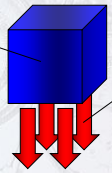
Solids

Molecules in solids have a great attraction for each other and can maintain a definite shape



All of the force exerted by solids is in the downward direction

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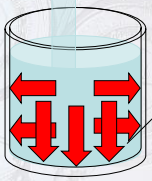
Liquids

The strength of molecular attraction is lower in liquids than in solids

The force of a liquid is exerted outward…

… and downward



Liquids will take the form and shape of the container in which it is placed

Gases

Gases will take the shape of the vessel they are contained in and will completely fill the vessel

The pressure of a gas is exerted outward in all directions

In the case of a toy balloon…

…as it blown up, the pressure causes the balloon to expand or inflate

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IMPORTANT DEFINITIONS

- Mass – Property of matter that responds to gravity
- Weight – Depends on the strength of gravitational attraction (More gravity = More weight)
- Density – Mass to volume relationship (Water has a density of 62.4 lb/ft^3
- Specific Gravity – Density of a substance divided by the density of water
- Specific Volume – Volume of one pound of a gas (Measured in ft^3/lb)

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SPECIFIC GRAVITY EXAMPLE

- Density of water = 62.4 lb/ft^3
- Density of Aluminum = 171 lb/ft^3
- Specific gravity of aluminum = Density of aluminum / Density of water = (171 lb/ft^3)/(62.4 lb/ft^3) = 2.74
- Specific gravity is unitless

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GAS LAWS

- General Law of Perfect Gases – Relates pressure, volume and temperature
- Boyle's Law – Relates pressure and volume
- Charles' Law – Relates volume and temperature
- Dalton's Law – Relates pressures of gases in a mixture
- Always use absolute pressures and temperatures when working with gas laws

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BOYLE'S LAW

$$P_1 \times V_1 = P_2 \times V_2$$

Where P_1 = Initial Pressure

P_2 = Final Pressure

T_1 = Initial Temperature

T_2 = Final Temperature

V_1 = Initial Volume

V_2 = Final Volume

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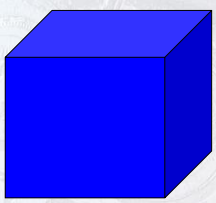
Boyle's Law

Volume = 30 in^3

Pressure = 40 psia



Volume = 24 in^3

Pressure = 50 psia

As the volume decreases, the gas pressure increases

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CHARLES' LAW

$$\frac{V_1}{T_1} = \frac{V_2}{T_2}$$

If $V_1 = 2000\ ft^3$, $T_1 = 535R$ and $T_2 = 590R$, we get:

$V_2 = (V_1 \times T_2) / T_1 = (2000\ ft^3 \times 590\ R) / 535\ R$

$V_2 = 1{,}180{,}000 / 535 = 2205.6\ ft^3$

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Dalton's Law

P = 30 psig P = 70 psig P = 40 psig

Total pressure of a gaseous mixture is the sum of the individual pressures

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ENERGY

- Electrical energy drives motors and pumps in air conditioning systems
- Heat energy provides comfort heating and flows from a warmer substance to a cooler substance
- Energy cannot be created or destroyed, but can be converted from one type to another
- Electrical energy purchased by the kWh, fuel oil by the gallon, natural gas by the cubic foot

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WORK

- Work = Force x Distance
- Force is given in pounds, distance in feet
- The units of work are foot-pounds, ft-lbs

Example: How much work is done to move a 150-pound object 100 feet?

Work = Force x Distance = 150 pounds x 100 feet

Work = 150 x 100 = 15,000 ft-lbs

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POWER

- The rate at which work is done
- Work per unit time, ft-lbs/min
- Rated in horsepower
- 1 hp = 33,000 ft-lbs/min
- Electrical power measured in watts
- 1 hp = 746 watts
- 1 watt = 3.413 btu
- 1 kw = 3,413 btu

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UNIT SUMMARY

- Matter can be in the form of solids, liquids and gases
- Specific gravity compares the density of substances
- Gas laws relate pressure, volume and temperature
- Electrical and heat energy are common in the industry
- Work is defined as FORCE times DISTANCE
- Power = Work per unit time (Horsepower)
- 1 Horsepower = 746 watts
- 1 Watt = 3.413 Btu