CHAPTER 1: INSTRUMENTATION EQUIPMENT

MODULE 3: Pressure Instrumentation

MODULE OBJECTIVES:

At the end of this module, you will be able to:

1. Explain the basic operation of a differential pressure transmitter, in respect of how differential pressure can be detected and how the pressure detected can be converted into an electronic signal.

Pressure Unit

Pressure is defined as force exerted on a unit surface area. Mathematically, we have:

$$P = F/A$$

where

$$P = \text{Pressure (Pa)}$$

$$F = \text{Force (N)}$$

$$A = \text{Area (m}^2\text{)}$$

The basic unit of pressure in SI units is the Pascal (Pa).

It is defined as force of 1 Newton (N) per square meter (m2). That is:

$$1 \text{ Pa} = 1 \text{ N/m}^2$$

Since the Pascal (Pa) is a very small unit (1 Pa = 1.45×10^{-4} PSI), it is more common to use units of

kPa (1 kPa = 1000 Pa)   and

MPa (1 MPa = 1000 kPa or 1×10^6 Pa)

Absolute and Gauge Pressures

- Pressure measurements can be stated as either <u>gauge</u>, or absolute.

- Gauge pressure is referenced to atmospheric pressure, and is denoted by a <u>(g)</u>, e.g. kPa(g)

- Absolute pressure includes the effect of atmospheric pressure on gauge pressure, denoted as <u>(a)</u>, e.g. kPa(a)

- The relationship between absolute pressure and gauge pressure is:

  Absolute Pressure = Gauge Pressure + Atmospheric Pressure

- The standard value of atmospheric pressure is the atmospheric pressure at sea level, which is <u>101.3</u> kPa.

- A reading of less than 101.3 kPa(a) indicates a vacuum condition.
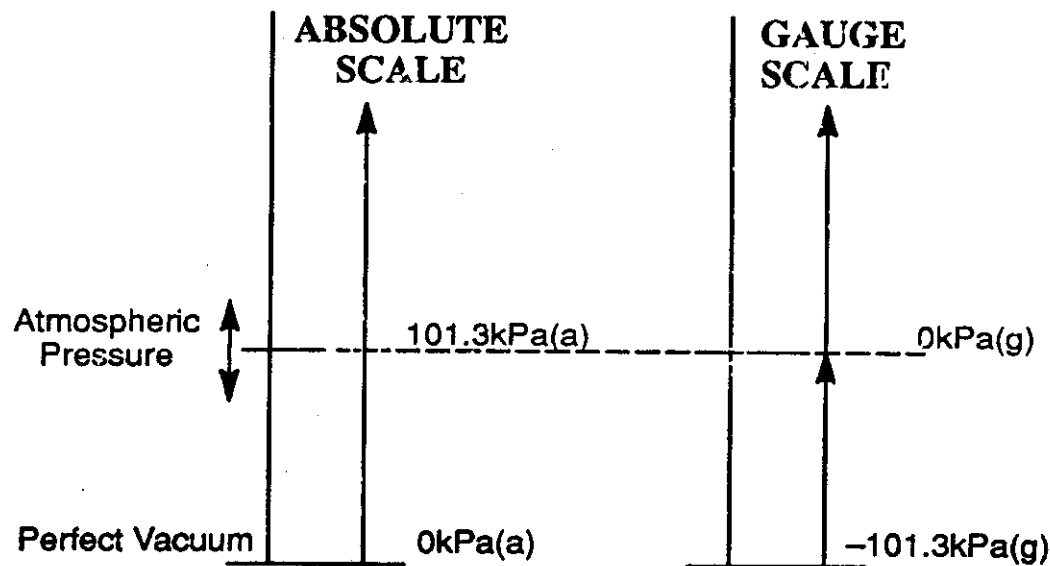
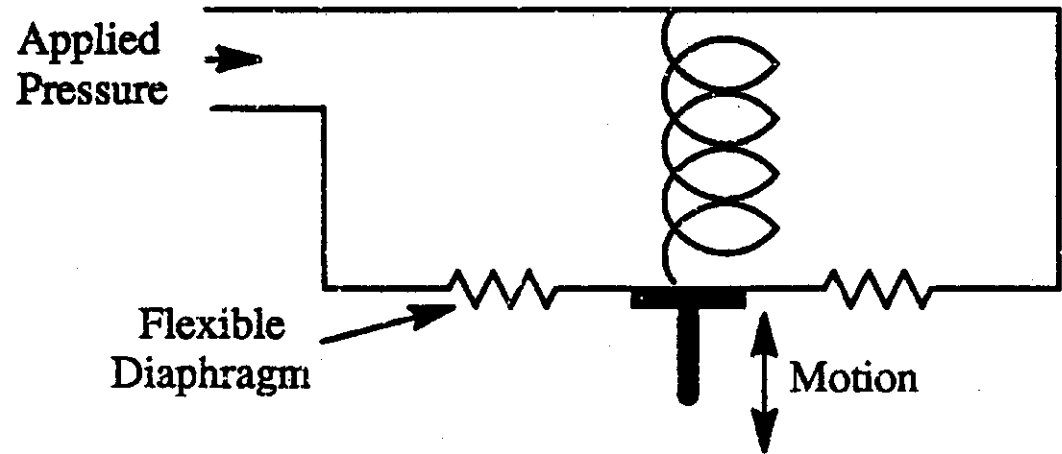|		Example:
		The pressure of the gas in a tank is 1000 kPa(a). What is the pressure in gauge units?
		<u>Solution</u>
		Gauge Pressure = Abs Pressure - Atm Pressure
		Therefore, Gauge Pressure = 1000 kPa(a) - 101.3 kPa = 898.7 kPa(g)

Figure 1: Relationship Between Absolute and Gauge Pressures.
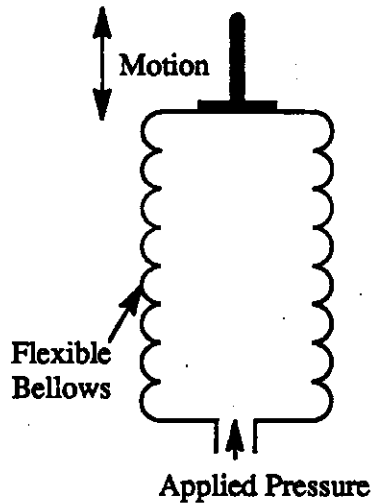
Pressure Measurement

In order to produce a standard (4 - 20 mA) electronic signal which represents the pressure in a process, pressure must be sensed in terms of a physically detectable motion in proportion to the pressure.
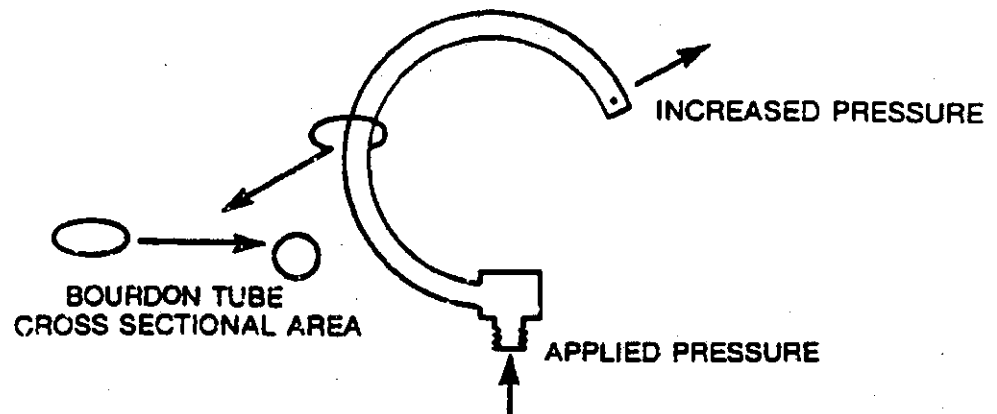
Metal Diaphragm

Motion

Welded Joint

Applied Pressure

Pressure Capsule

Applied Pressure

Flexible Diaphragm

Motion
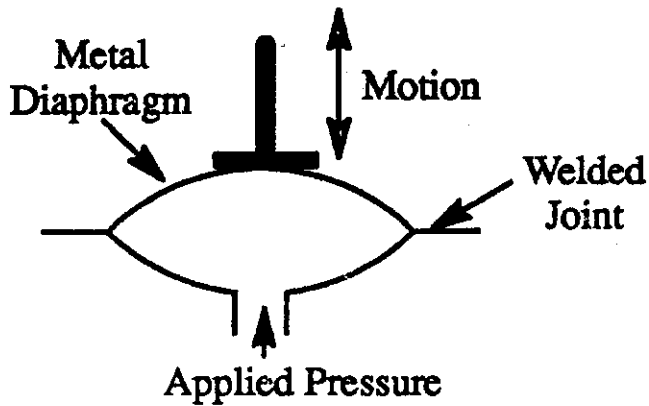
Spring Opposed Diaphragm

Motion

Flexible Bellows

Applied Pressure

Pressure Bellows

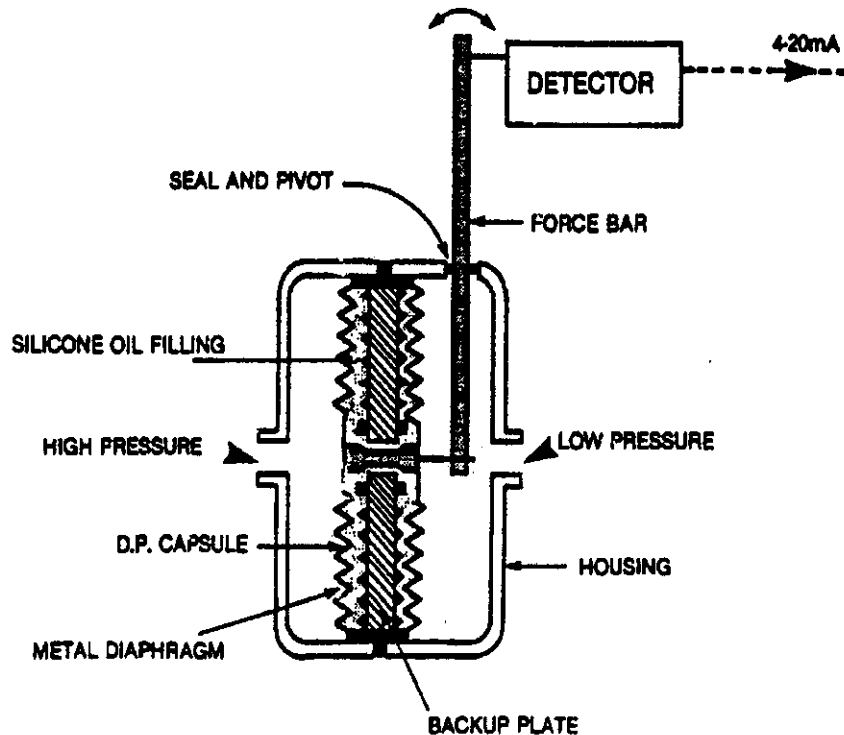INCREASED PRESSURE

BOURDON TUBE CROSS SECTIONAL AREA

APPLIED PRESSURE

Bourdon Tube

DP transmitters or DP cells

Most pressure transmitters are built around the pressure capsule. They are capable of measuring Differential Pressure (that is, the difference between a high pressure input and a low pressure input).

DETECTOR 4-20mA

SEAL AND PIVOT
FORCE BAR
SILICONE OIL FILLING
HIGH PRESSURE
LOW PRESSURE
D.P. CAPSULE
HOUSING
METAL DIAPHRAGM
BACKUP PLATE

Figure 3: A Typical DP Transmitter Construction.

- A differential pressure capsule is mounted inside a housing.
- One end of a force bar is connected to the capsule assembly.
- A sealing mechanism is used where the force bar penetrates the housing. This seal also acts as the pivot point for the force bar.
- High pressure fluid to be applied on one side of the capsule and low pressure fluid on the other.
- Any difference in pressure will cause the capsule to deflect and create motion in the force bar.
- The top end of the force bar is connected to an electronic motion detector, which via an electronic system, will produce a 4 - 20 mA signal that is proportional to the force bar movement.

Four different kinds of electronic position detectors are currently used by manufacturers. They are:
1. Inductive Detector.
2. Variable Differential Transformer Detector.
3. Capacitive Detector.
4. Resistive (strain gauge) Detector.

Differential Pressure (DP) Capsules

- The DP capsule is formed by welding two metallic (usually stainless steel) diaphragms together.

- Most DP capsules can withstand static pressure of up to 14 MPa (2000 psi) on both sides of the capsule without any damaging effect.

- The sensitive range for most DP capsules is typically in the order of only a few hundred kPa of differential pressure.

DP Transmitter Installation

A DP transmitter is used to measure the gas pressure (in gauge scale) inside a vessel. In this case, the low pressure side of the transmitter is vented to atmosphere, and the high pressure side is connected to the vessel through an isolating valve. The isolating valve facilitates the removal of the transmitter. The output of the DP transmitter is proportional to the gauge pressure of the gas, i.e., 4 mA when pressure is 20 kPa and 20 mA when pressure is 30 kPa.
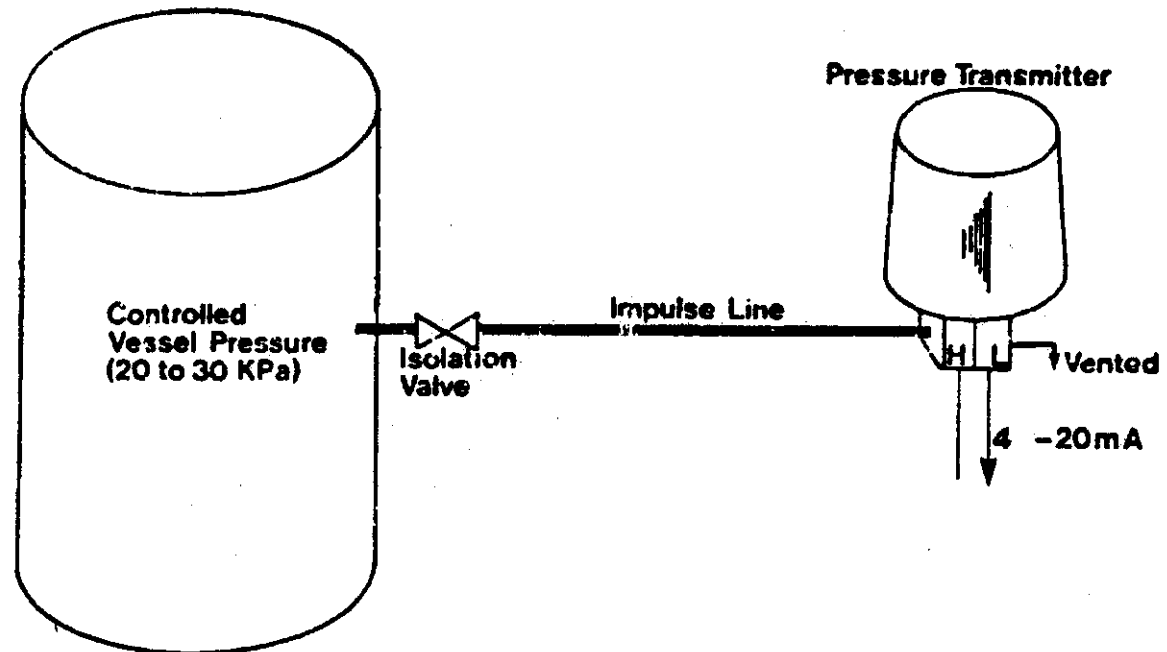

Figure 4: A DP Transmitter Application.