Pressure Measurements
A “transducer” is a device that converts some mechanical quantity into some measurable electrical quantity.

Through a calibration procedure, the “sensitivity” of the transducer can be obtained.

**INPUT**

- **Physical Phenomenon**
  - Pressure, Temperature, Strain, Displacement, Velocity, Acceleration, etc.

**OUTPUT**

- **Electrical Signal related to Physical Phenomenon**
  - DC voltage, AC voltage, current, resistance, etc.

- **Volts per Engineering Unit**
  - V/EU
There are a wide variety of devices used to measure pressure

**Direct (Non-Electric) Methods**

- Manometer
- Bourdon Tube
- Dead Weight Tester

**Pressure Transducers**

**Vacuum Measuring Devices**

Several will be considered here
Pressure can be measured three ways

Absolute pressure used to determine the thermodynamic state of a substance

Gage pressure is always relative to local ambient pressure

Differential pressure is used for the description of pressure between two points

\[ P_{\text{ABS}} = P_{\text{GAGE}} + P_{\text{AMBIENT}} \]

English (lbs/sq.in) PSIA, PSIG, PSID
SI (Pascal or Kilopascal) 1 Pascal = 1 newton/sq. meter
Traditional (non-electrical) Pressure Devices

**Manometer**

\[
\Delta P = P_1 - P_2 = \Delta h g (\rho_m - \rho_s)
\]

- \(\Delta h\) – height
- \(g\) – gravity acceleration
- \(\rho_m\) – manometer density
- \(\rho_s\) – sensed fluid density

*Most laboratories contain a barometer for determining absolute atmospheric pressure*
Traditional (non-electrical) Pressure Devices

Bourdon Tube

The basic principle of operation is that a curved, flattened tube will attempt to straighten out when subjected to internal pressure.

The deflection is typically measured with an LVDT or potentiometer.

Fig 9.5
Traditional (non-electrical) Pressure Devices

Dead Weight Tester

The fluid pressure is the weight of the piston divided by the piston area.

This is a very accurate measuring device since the piston area and weight can be measured very accurately.

Dead weight testers are typically used to calibrate other pressure measuring devices.

Fig 9.6
Pressure Transducers - Strain Gage Style

A common design uses a diaphragm instrumented with strain gages.

Test pressure is on one side of the diaphragm and reference pressure on the other (which is often atmospheric pressure which implies that the transducer measures gage pressure).

Typically metal foil gages are used but semiconductor gages are also available (semiconductor have high gage factors).

A Wheatstone bridge uses all four legs to provide high sensitivity and temperature compensation.
Pressure Transducers - Piezoelectric Style

For higher fluctuating pressure events, typically piezoelectric pressure transducers are used.

Piezoelectric elements are much stiffer and have high natural frequencies. This enables a very accurate measurement to be made to relatively high frequencies (up to 30 KHz).

The geometric configuration usually uses a flush mount design.

Fig 9.10
Vacuum Measurementing Devices

McLeod gage - The idea is to compress a large volume of low-pressure gas into a much smaller volume to determine the vacuum pressure.

**Fig 9.11**

Thermal Conductivity Sensors relate the conductivity at low pressure which is a function of pressure.

Ionized Vacuum Gages use energized electrons passing through a gas - these gas molecules ionize and depend on the density of the gas which in turn can be related to the pressure.