Unit– II

Force, Pressure Measurement

2.1 Definition: force, pressure, weight and its units
2.2 Types of pressure
2.3 Different types of pressure and force measuring gauges.
  2.3.1 Manometer- U-tube, Inclined, well type
  2.3.2 Bellows, diaphragm , bourdon tube, bimetallic strip
2.4 Force meter :
  2.4.1 Pneumatic Force meter
  2.4.2 Hydraulic Force meter
  2.4.3 strain gauge load cell
  2.4.4 Piezoelectric Load cell
  2.4.5 Pressductor load cell
2.4 Specifications of electric transducers used for force and pressure measurement.

Define Force

Definition: Force may be defined as a cause that produces or tends to produce resistance or obstruction to any moving body or changes in the motion of the body.

Formula of force:

F = M x A,

Where, F = Force
M = Mass (in Kg)
A = Acceleration (in Kg/m2)

Units of Force:
1. Newton
2. Dyne
3. Kg m/s2

Define Weight

The weight of an object is defined as the force of gravity on the object and may be calculated as the mass times the acceleration of gravity

w = mg

Since the weight is a force, its SI unit is the newton.

1N = 1kg m/s2

Define PRESSURE:

Pressure is defined as the amount of force applied to a surface or distributed over it & is measured as force per unit area.

The force used to calculate the pressure must act at a right angle to the surface.

$$P = \frac{F}{A}$$

Where, P is the pressure, F is the normal force, A is the area of the surface on contact.

Different units of pressure.

1. Pascal (Pa).
2. Pounds per square inch (psi)
3. Pounds per Square inch absolute (Psia)
4. Pound per Square inch gauge (Psig)
5. Kilogram per square of centimeter (Kg/cm^2).
6. Newton's per square meter (N/m2).
7. Liquid columns: mmHg (Millimeter of Mercury column) or mmWc (Millimeter of Water Column).
8. Bar
9. Torr

Units of High Pressure:

1 N/m2 = one Pascal (1 Pa)

1 atm (atmospheric)=1 kg/cm2 = 14.696 psi = 101.325 kPa

Units of Low Pressure:

1 millibar =100dyne/cm2=14.5X10-3 psi

1 micron = 10-6 m Hg=19.34X10-6 psi

1 torr = 1 mm Hg=1000 microns=19.34X10-3 psi

Convert 280 mm of Hg pressure level into bars, psia, kilopascal and microns.

- 1psi= 51.71484 mm of Hg,
  Or, 1 mmHg = 0.019336 psi
  Therefore, 280 mm of Hg = 5.414 psi

- 1 bar = 750.063mm of Hg
  Or, 1 mmHg = 0.0013332 bar
  Therefore, 280 mm of Hg =0 .3733 bar

- 1 mmHg=0.133322387415 kilopascals
  Therefore, 280 mmHg = 37.33 kilopascals

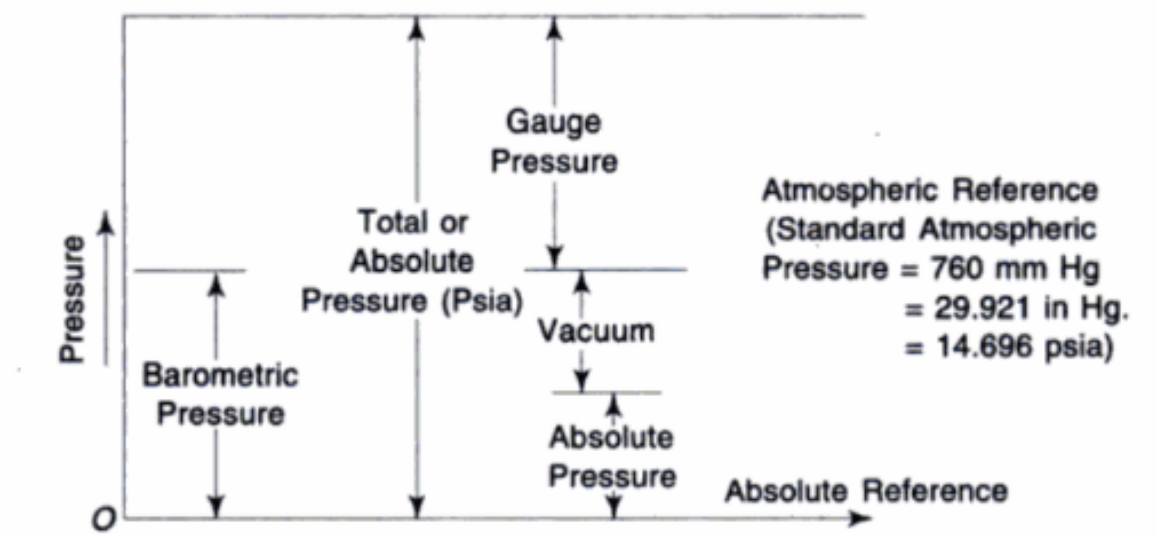
- 1mmHg = 1000 microns,
  Therefore, 280 mmHg = 2,80,000 microns

Convert 520 mm of Hg into bar, psi.

- 1psi= 51.71484 mm of Hg
  Therefore, 520 mm of Hg=10. 050psi
- 1 bar = 750.063mm of Hg
  Therefore, 520 mm of Hg =0 .69328bar.

Types of pressure:

The various types of pressure are Absolute, Gauge, Vacuum and Atmospheric.



Relationship between Absolute, Gauge and Barometric Pressures.

A) ABSOLUTE PRESSURE (psia)

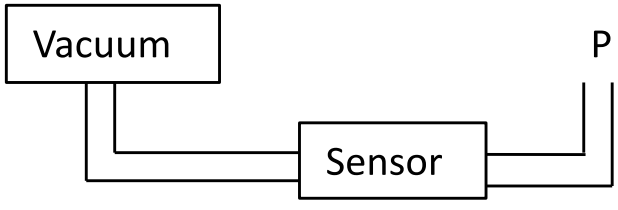
When pressure is measured relative to a perfect vacuum (where pressure is zero),it is called absolute pressure (psia).

For absolute pressure, the perfect vacuum is chosen as the reference point. Therefore, it is defined as the pressure difference between the point of measurement and a perfect vacuum.

Absolute Pressure is the actual total pressure including atmospheric pressure acting on a surface.

Absolute Pressure = Gauge Pressure + Atmospheric Pressure

Absolute Pressure = Actual Pressure + Atmospheric Pressure

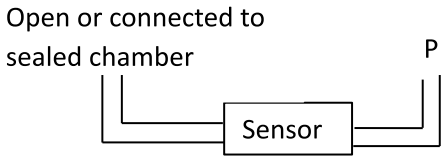


B) GAUGE PRESSURE

Gauge pressure (or relative pressure) is defined as the pressure difference between the point of measurement (actual pressure) and the ambient (atmospheric) pressure.

(i.e. one end is kept open or connected to sealed chamber)

Gauge Pressure =Absolute Pressure –Atmospheric Pressure



- ❖ For gauge pressure, the reference point (or zero point) is atmospheric pressure.; therefore, gauge pressure indicates a pressure of zero psi at the surface of a liquid even though the pressure is 14.7psi.
- ❖ Gauge pressure can assume both positive and negative values. It is referred to as "positive pressure" when it is above atmospheric pressure, and "negative pressure" when it is below atmospheric pressure.

C) ATMOSPHERIC PRESSURE

It is defined as the height of the barometric column at 0^0C at sea level.

Atmospheric pressure = 76 cm of Hg (ρ= 13.59 g/cm^3)

1Atmosphere = 76 cm of Hg

= 14.696 psia

= 1.013X10^5 N/m^2 (Pa)

= 1.013 bar

- Atmospheric pressure (or barometric pressure) is the pressure of the air at the surface of the earth with the reference point as sea level.
- It is caused by the weight of all the molecules in the atmosphere. The accumulation of molecules in the air ensures that the highest pressure occurs at the bottom of the atmosphere.

D) VACUUM =

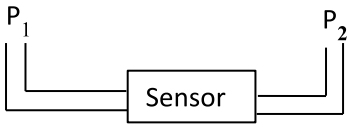
It is the negative gauge pressure. Vacuum is generated when the absolute pressure is less than atmospheric pressure.

- A perfect vacuum corresponds to absolute zero pressure.
- When the local atmospheric pressure is greater than the pressure in the system, the term vacuum pressure is used.

➢ (**Extra**: Vacuum is a space where the absolute pressure is zero. This can only be achieved if all particles are removed from that space. In other words, the space is really empty. The perfect vacuum is only theoretically possible. It will never be technically possible to remove all the particles in a closed volume. A vacuum doesn't need to be perfect to be called a vacuum. In practice, a vacuum will only be partially achieved. It is therefore also referred to as a partial vacuum. In general, we speak about a vacuum when the pressure is lower than the atmospheric pressure.)

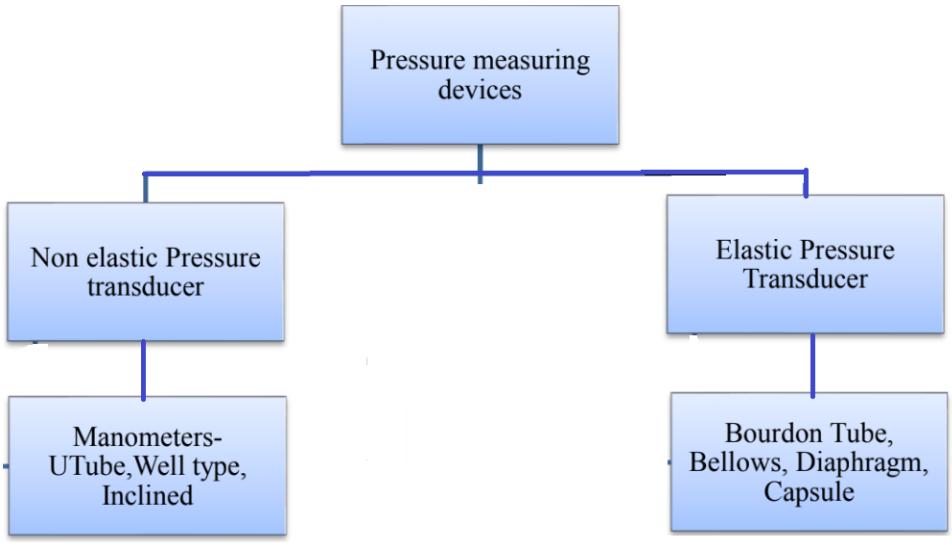
(EXTRA)

- **Differential Pressure**: - It is the pressure difference between two points, one of which is chosen to be the reference.



Different types of pressure measuring gauges.

1. Manometer- U-tube, Inclined, well type
2. Bellows, diaphragm , bourdon tube



MANOMETER- U TUBE, INCLINED TUBE, WELL TYPE MANOMETER

MANOMETER:

- Manometer is a device to measure gauge pressures (low range pressure) by balancing the pressure against the weight of a column of liquid. The action of a manometer depends on the effect of pressure exerted by a fluid at a depth. It uses liquid columns in vertical or inclined tubes.

- Manometer fluids/liquids: The most common fluids for the manometer are water and mercury. For low pressure, water is used and for high pressure, mercury is used. Typically, the liquid is mercury because of its high density. Mercury is 14 times heavier than water. Water or mercury are used because their specific weights for various temperatures are known exactly and they do not stick to the tube.

Advantages:

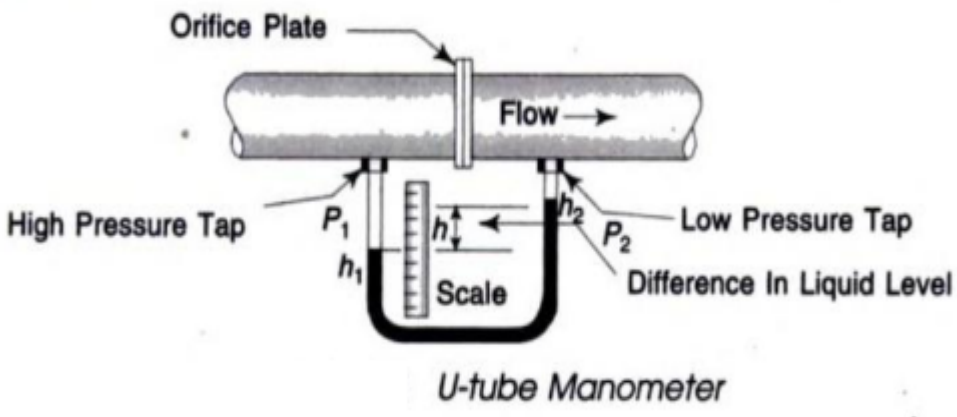
1. Simple to use
2. High accuracy and sensitivity
3. Suitable for low pressure and low differential pressure applications
4. Cost is reasonable
5. Availability of wide range of filling fluids

Disadvantages:

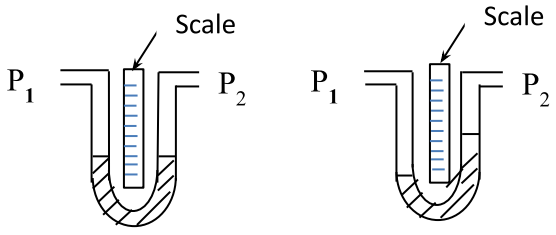
1. Large and bulky
2. Not portable
3. Need leveling
4. No over range protection
5. Measured fluid must be compatible with manometer fluid
6. Condensation of the liquid creates problems

The different types of manometers are given below

i) U TUBE MANOMETER :



This manometer consists of a transparent (glass) tube constructed in the form of U shape and is partially filled with a liquid, most commonly water or mercury. Water or mercury are used because their specific weights for various temperatures are known exactly and they do not stick to the tube.one end of the tube is connected to one pressure tap and other end is connected to the other pressure tap or it may be left open to the atmosphere.



Working:

If a U-tube is filled with a liquid, it will naturally adopt the same height in both the tubes (figure a). If unknown pressure is applied in the one arm of the tube (figure b) , the liquid level will fall on the high pressure side and rises on the low pressure side to give height difference h

The height of the liquid is measured and noted.

The head pressure of a column of liquid is given by

$$P = \rho g h$$

Where, P= pressure(Pa)

ρ=density

g=acceleration due to gravity. (9.8 m/s^2)

h= Column height in meters

In figure b, the pressures in both the tubes must be balanced, so

$$P_1 = P_2 + \rho g h$$

$$h = \frac{P_1 - P_2}{\rho g}$$

i.e. The difference in column height is proportional to the differential pressure.

• Advantages of U-tube manometer:

1. Simple to use
2. For differential pressure measurement

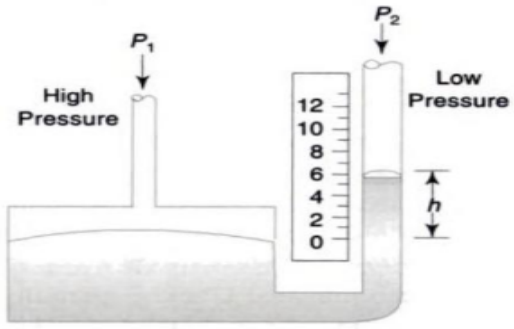
• Disadvantages of U-tube manometer:

1. No fixed reference
2. Measurement of the height is difficult if fixed level has to be maintained

• Applications of U-tube manometer:

1. For Differential pressure measurement
2. In flow measurement

ii) **WELL TYPE MANOMETER**:



Well-type Manometer

The well type manometer is widely used because of convenience;the reading of only a single leg is require in it

It consists of a very large diameter vessel (well) connected on one side to a very small sized tube. Thus the zero level moves very little when pressure is applied. Even this small error is compensated by suitably distorting the length of scale. However such an arrangement is sensitive to non-uniformity of the tube cross sectional area & thus considered somewhat less accurate.

In a single leg instrument, high accuracy is achieved by setting the zero level of the well at the zero level of the scale before each reading is taken.

• Advantages of well type manometer:

1. Reading of only a single leg is required

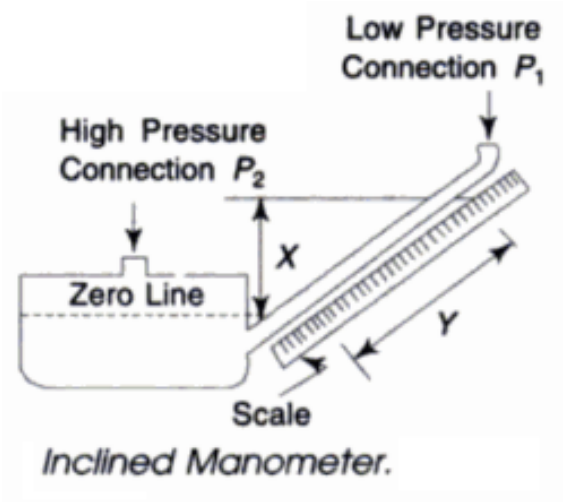
• Disadvantages of well type manometer:

1. Large and bulky
2. It is less accurate

Applications of well type manometer:

1. It is used to measure very small pressure differences.
2. It is used in flow, pressure and force measurement systems.

iii) INCLINED TUBE MANOMETER:



Inclined Manometer.

The inclined tube manometer or slant manometer is an enlarged leg manometer with its measuring leg inclined to the vertical axis by some angle.The angle of inclination is of the order of 10^0. The inclination is done to expand the scale & thereby to increase the sensitivity.

It is used to measure very small pressure difference.The liquid moves a longer distance through the tube as it rises.

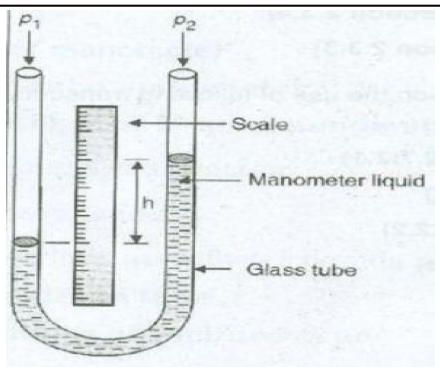
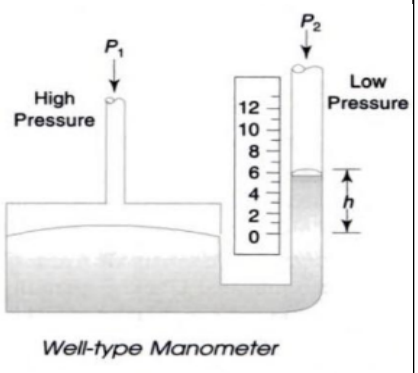
Advantages of inclined manometer:

1. High sensitivity and accuracy
2. Used to measure very small pressure differences.

Disadvantage of inclined manometer:

1. Large and bulky
2. No over range protection
3. Need of leveling

❖ **Compare between U tube and well type manometer.**

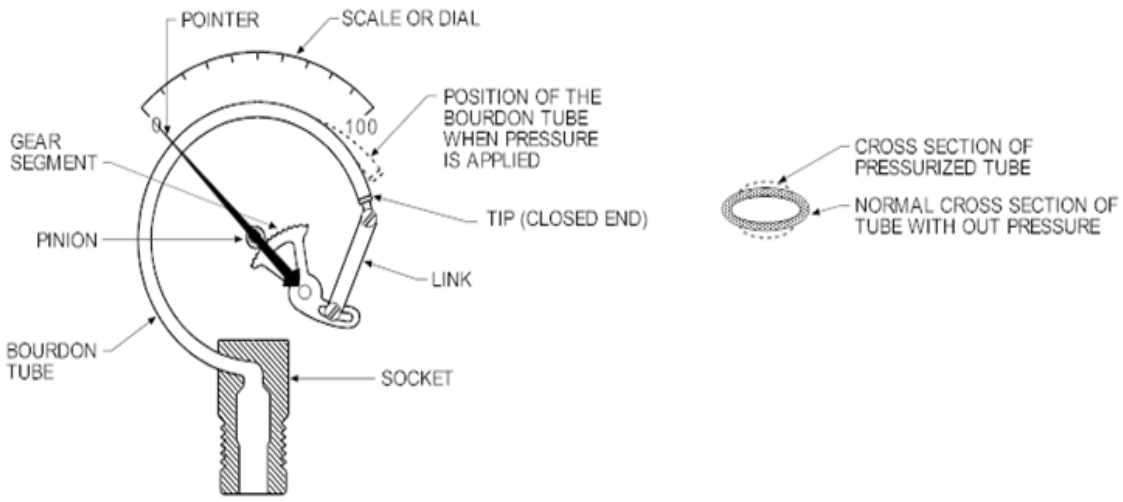
Sr. No	U tube manometer	Well type manometer
1	 Fig: U- Tube manometer P1 = High pressure P2= Low pressure h= Difference in liquid level	 Fig: Well- type manometer P1 = High pressure P2= Low pressure h= Difference in liquid level. A1 and A2 are the areas of the well and the capillary
2	U shape tube	Well shape with small capillary
3	It has two limbs	It has only one limb
4	$P_1 - P_2 = \rho gh$	$P_1 - P_2 = \rho gh(1 + \frac{A_2}{A_1})$
5	U tube manometer is for differential pressure measurement	Well type manometer is for Direct pressure Measurement

ELASTIC PRESSURE TRANSDUCER:

Elastic pressure transducers are the pressure measuring devices that use elastic members for sensing pressure at the primary stage. These elastic members are of many types & convert the pressure into mechanical displacement which is later converted into an electrical form using a secondary transducer.

Elastic pressure transducers are Bourdon Tube, Bellows, Diaphragm and Capsule

BOURDON TUBE: Construction and working



Working:

- C type bourdon tube is made up of an elliptically flattened tube bent in such a way as to produce the C shape as shown in the fig. (Tube is bent over an angle of generally 270°). The free end of this tube is closed or sealed and the other end (fixed end) is opened for the pressure to enter.
- The free end is connected to the pointer with the help of geared sector and pinion. Calibrated scale and pointer is provided to indicate the pressure.
- The pressure which is to be measured is applied to the bourdon tube through open end.When this pressure enters the tube, the tube tends to straighten out proportional to applied pressure.
- This causes the movement of the free end and the displacement of this end is given to the pointer through mechanical linkage i.e. geared sector and pinion.
- The pointer moves on the calibrated scale in terms of pressure. The relationship between the displacement of the free end and the applied pressure is nonlinear.

Materials used for Bourdon tube and pressure range :

1. Beryllium copper- Range 10000 psi
2. Phosphor Bronze -Range 600 psi
3. Stainless steel or Alloy steel -Range above 10000psi

• Advantages of Bourdon Tubes

1. Cost is low
2. Simple construction
3. Rugged construction
4. Time-tested in application

5. Available in wide variety of ranges of pressure including very high ranges
6. Adaptable to transducer designs for electronic instruments.
7. High accuracy

• Disadvantages of Bourdon Tubes

1. Low spring gradient
2. Susceptible to shock and vibration
3. Susceptible to hysteresis

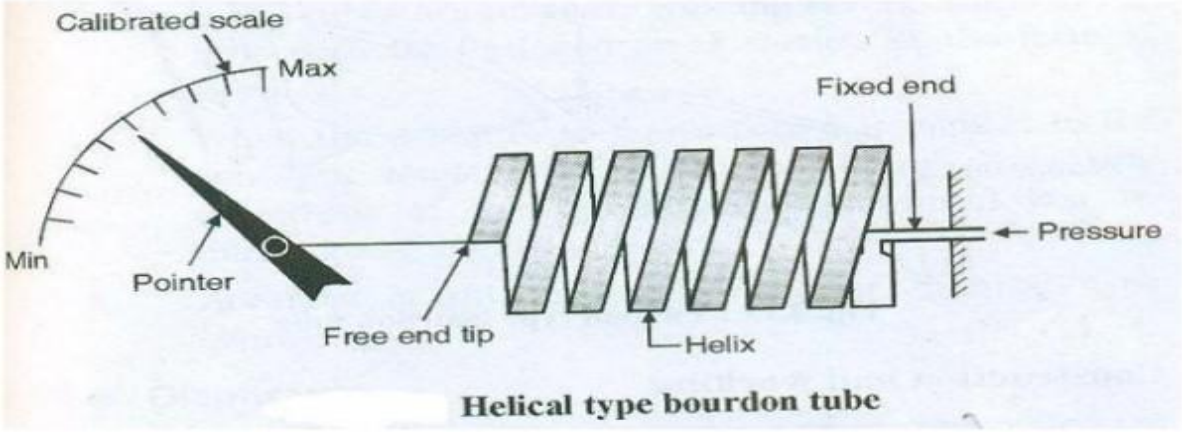
• Applications of Bourdon Tubes

1. Refineries and petrochemical processing
2. Hydraulic and pneumatic installations
3. Energy industries
4. Power stations
5. Wastewater operations

Types of bourdon tube other than C-type:

Other than C-type, bourdon gauges can also be constructed in the form of spiral type and helical type , twisted type.

Helical Bourdon Tube

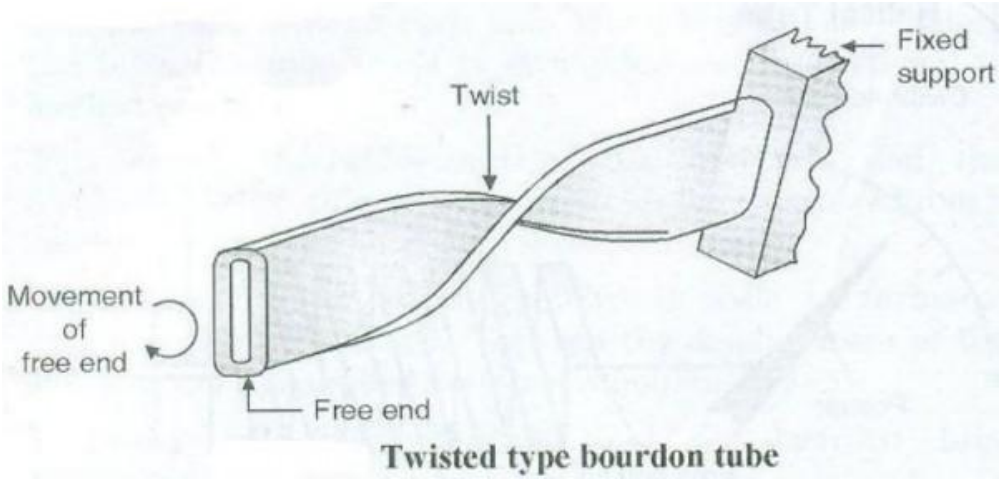


Helical type bourdon tube

Construction and working:

It is similar to spiral element, except it is wound in the form of helix. The displacement of the tip of a helical element is larger than the spiral element. Central shaft is installed (not shown in fig.) within a helical element and the pointer is driven by this shaft using connecting links. This mechanism transmits only the circular motion of the tip to the pointer which is directly proportional to the applied pressure.

Twisted BourdonTube

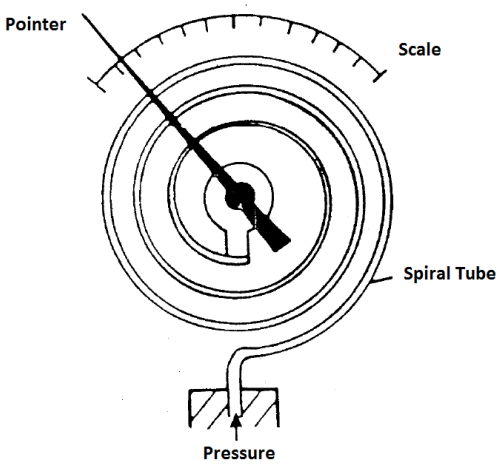


Twisted type bourdon tube

Construction and working:

Twisted bourdon tube element is as shown in figure. One end of the tube is fixed and the other end is free for application of the twist. As we apply the pressure at the free end, it gives rotation or creates the twist at that end. As we remove the pressure the free end tries to retain its original position.

Spiral Bourdon Tube



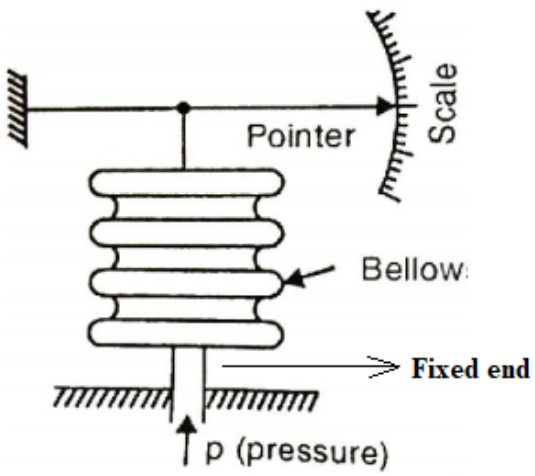
Construction and working:

Spiral type bourdon tube is as shown in figure. Spiral tubes are made by winding several turns of the tube with its flattened cross section in the form of spiral. When the pressure to be measured is applied to the spiral, it tends to uncoil, producing relatively long movement of the tip whose displacement can be an indication of applied pressure. Accuracy of this element is higher than the 'C' type element.

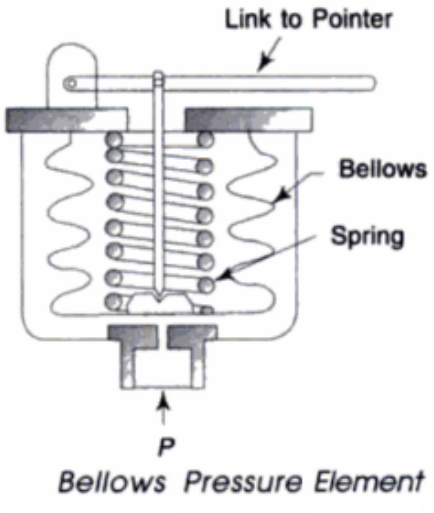
BELLOWS:

- Bellows are thin-walled metallic units made of single sheet, with deep folds, of which one end is sealed and the other end remains open.
- The closed end can move freely while the open end is fixed.
- The pressure is applied to the internal volume of the bellows. The applied pressure makes the bellows expand. The expansion causes the bellows to get longer. When pressure is removed, the bellows contract.
- The moving end of the bellows is connected to a mechanical linkage assembly which transmits the movement of the bellows to a pointer. The pointer indicates the pressure applied to the bellows.
- Bellows are more sensitive than bourdon tubes. Bellows can be used to measure pressure which has low range up to 3 psi

Draw Bellows and write application of it:



Spring loaded bellows:



• Advantages of bellows:

1. Moderate cost
2. Can deliver high force
3. Can be used for absolute and differential pressure measurement
4. Can be used for low to medium range pressure measurement

• Disadvantages of Bellows

1. Unsuitable for high pressure
2. Needs ambient temperature compensation
3. Unsuitable for zero reading

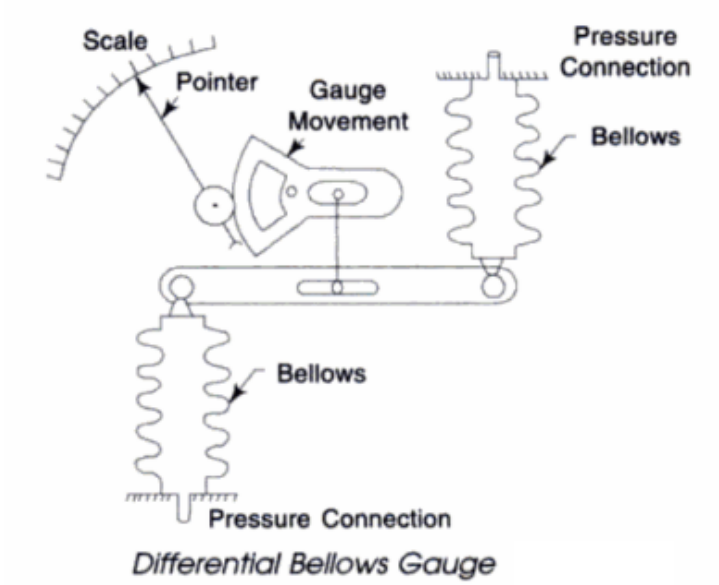
• Applications of Bellows

1. It is used for differential pressure measurement.
2. It is used in large indicating gauges recorders where space is not a problem. .
3. It is useful in pneumatic controllers.

Material for Bellows and pressure range :

1. Brass 100 psi
2. Bronze 1000psi
3. Beryllium Copper 10000 psi
4. Steel above 10000 psi

Differential pressure measurement using bellows

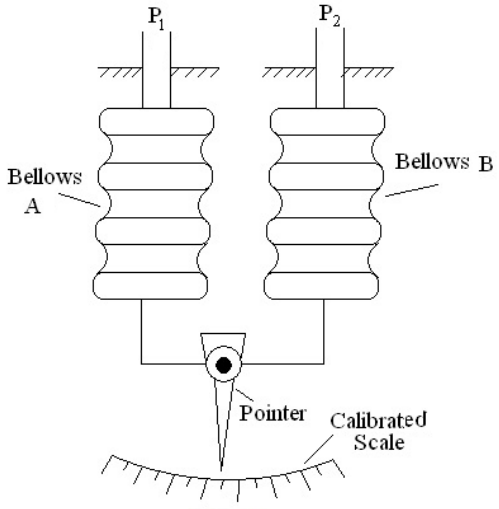


Differential Bellows Gauge

One pressure is applied to the inside of one sealed bellow while the other pressure is applied to the inside of another sealed bellow as shown in the figure.

By suitable linkage and calibration of the scale, the pressure difference is indicated by a pointer on the scale.

Differential pressure measurement using bellows



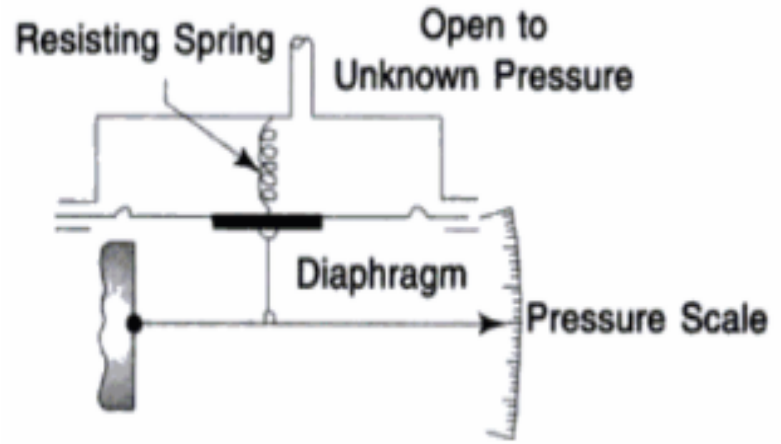
There are two bellows A & B.The pressure applied to bellow A is P_1 and that to bellow B is P_2.

In this arrangement three different types of reading can be taken.

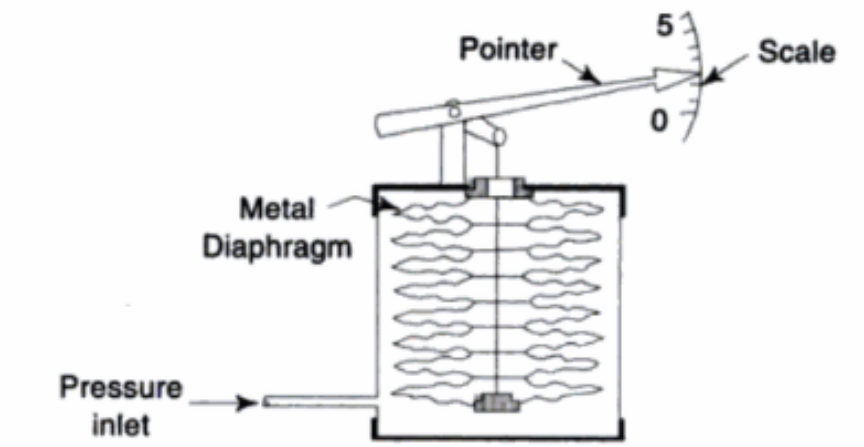
1) One pressure is applied to one sealed bellow A while the other pressure is applied to another sealed bellow B as shown in the figure.
   By suitable linkage and calibration of the scale, the pressure difference is indicated by a pointer on the scale.
   $P= P_1- P_2$
2) To measure absolute pressure, bellow B is evacuated and the resultant pressure P_1 is the absolute pressure.
3) When measurement of gauge pressure is desired , bellows B is opened up to atmosphere with pressure P_2 is equal to the atmospheric pressure and therefore the reading of the gauge is gauge pressure.

DIAPHRAGM:

- The diaphragm pressure gauge consists of a thin flexible circular membrane, made from sheet metal of precise dimensions, or non-metallic materials, which can either be flat or corrugated. It is clamped or welded between two flanges.
- The unknown pressure is applied to one side of a diaphragm. It causes a deflection on account of the applied pressure.
- The edge of the diaphragm is rigidly fixed.
- A pointer is attached to the diaphragm.
- The diaphragm is mechanically connected to the transmission mechanism which will amplify the small deflections of the diaphragm and transfer them to the pointer.
- Two types of diaphragms are 1. Metallic Diaphragm Gauge. 2. Slack Diaphragm Gauge.

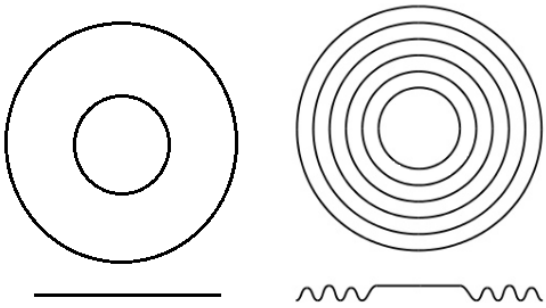


Slack Diaphragm Gauge.

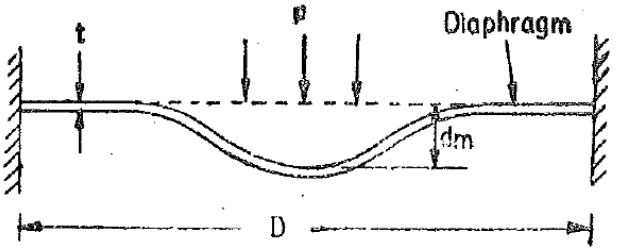


Metallic Diaphragm.

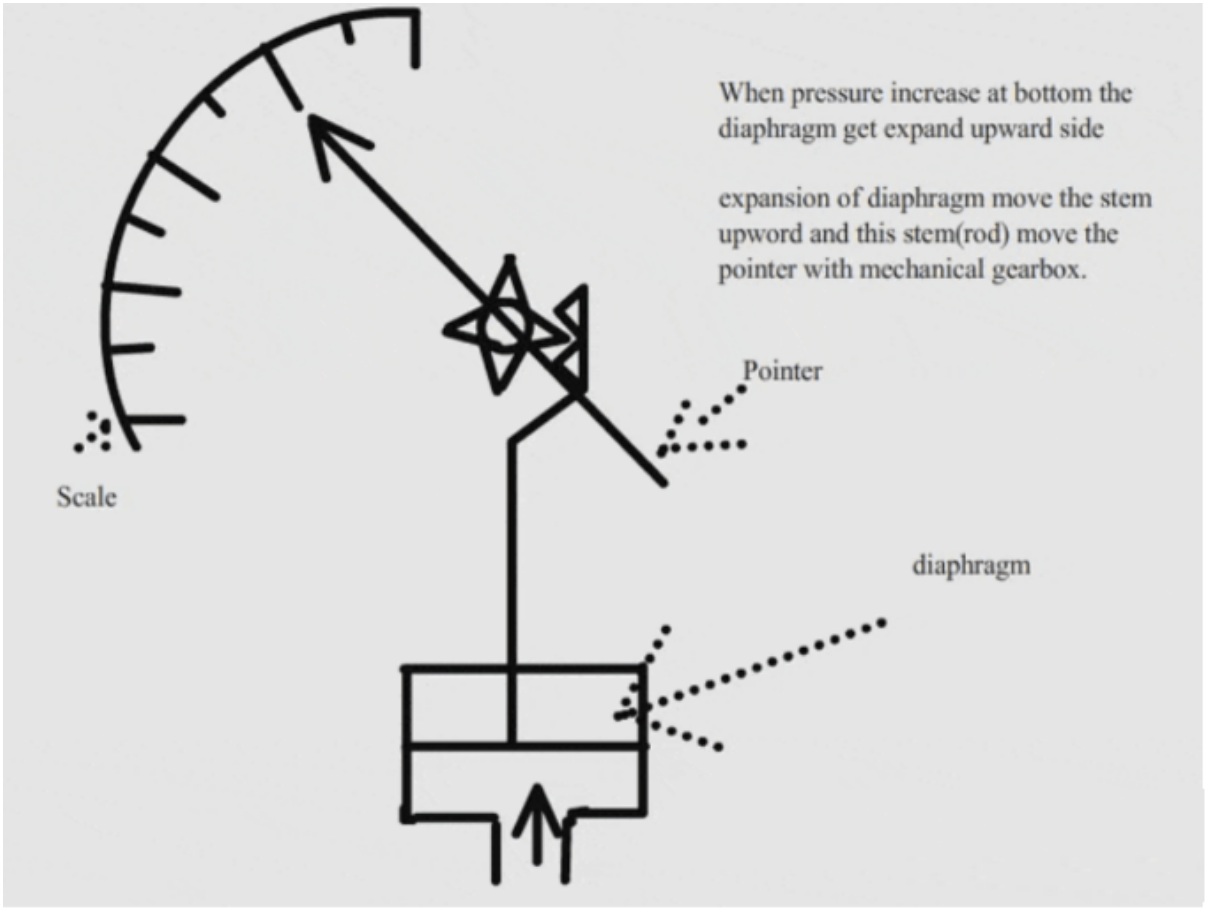
The diaphragms can be in the form of flat, corrugated or dished plates.



a) Flat type b) Corrugated type



Flat diaphragm.



Materials used for Diaphragms are

For metallic Diaphragm, materials used are Phosphor Bronze, stainless steel, beryllium copper, Ni-span C, Inconel, Monel, nickel.
Non-metallic materials are used for some applications. Buna N rubber, Nylon & Teflon are used In environments that corrode metals.

• Advantages of Diaphragms

1. Moderate cost
2. Small size
3. Good linearity
4. High over-range characteristics
5. Adaptable to absolute and differential pressure measurement
6. Can be used for slurry services
7. Available in several materials for good corrosion resistance

• Disadvantages of Diaphragms

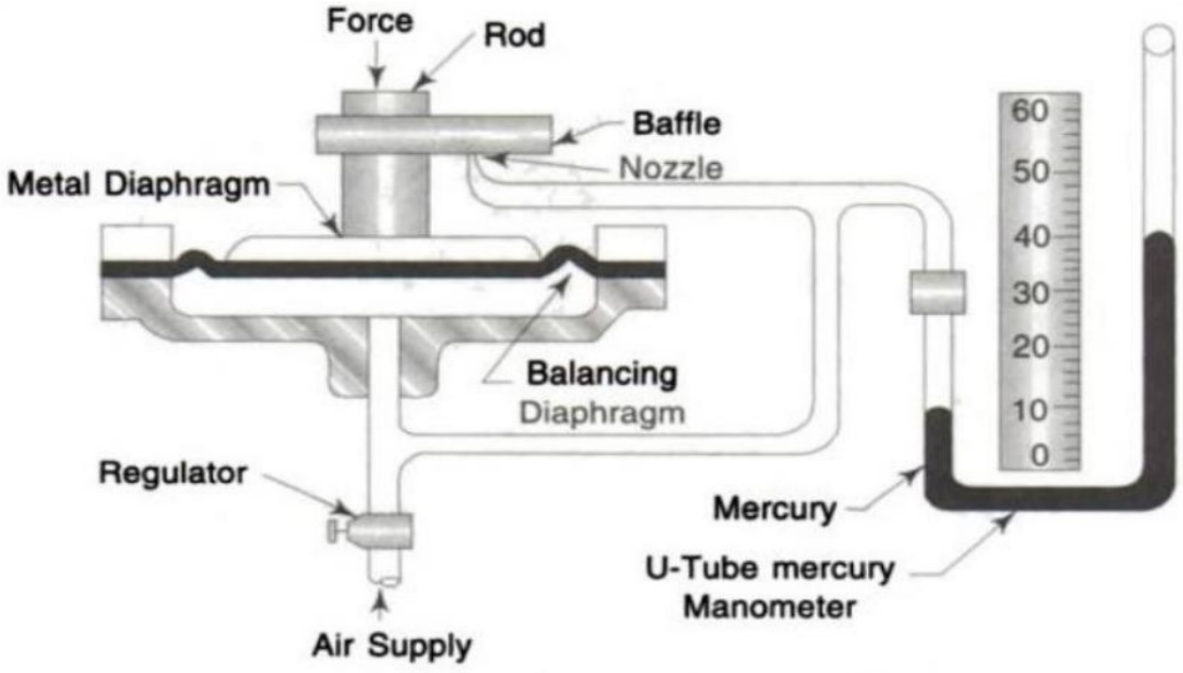
1. Difficult to repair
2. Less resistance to vibration and shock
3. Suitable only for low pressure applications

• Applications of Diaphragms

1. For the measurement of low pressure
2. Protection from over pressure in measuring systems

Force meter :

1. Pneumatic Force meter



Principle of working :

It operates on the force balance principle. If a force is applied to one side of a diaphragm & an air pressure is applied to the other side, some particular value of pressure will be necessary to exactly balance the force. This pressure is proportional to the applied force.

Construction:

It consists of a diaphragm to which the rod and baffle are attached. Just near the baffle, a nozzle is placed which is connected to the air supply and a pressure measuring device such as a manometer, bourdon tube etc.

Operation of Pneumatic load cell

The force to be measured is applied to the top side of the diaphragm rod. Due to this force, the diaphragm moves downwards and the baffle covers the nozzle. Now an air supply is provided at the bottom of the diaphragm. As the baffle closes the nozzle opening, a back pressure results underneath the diaphragm. This back pressure acts on the diaphragm and produces an upward force.
Air pressure is regulated until the diaphragm returns to the pre-loaded position which is indicated by air which comes out of the nozzle. At equilibrium position, the corresponding pressure indicated by the pressure gauge becomes a measure of the applied force when calibrated. The force magnitude is indicated by the height of the mercury column if a manometer is used, or by the indication of a pointer if the Bourdon-tube is used.

Specifications

1. These types of instruments are available in ranges of 0 to 35 Newtons, 0 to 12250. Newtons with standard 3-15 psig output signal
2. accuracy 0.5% of full scale

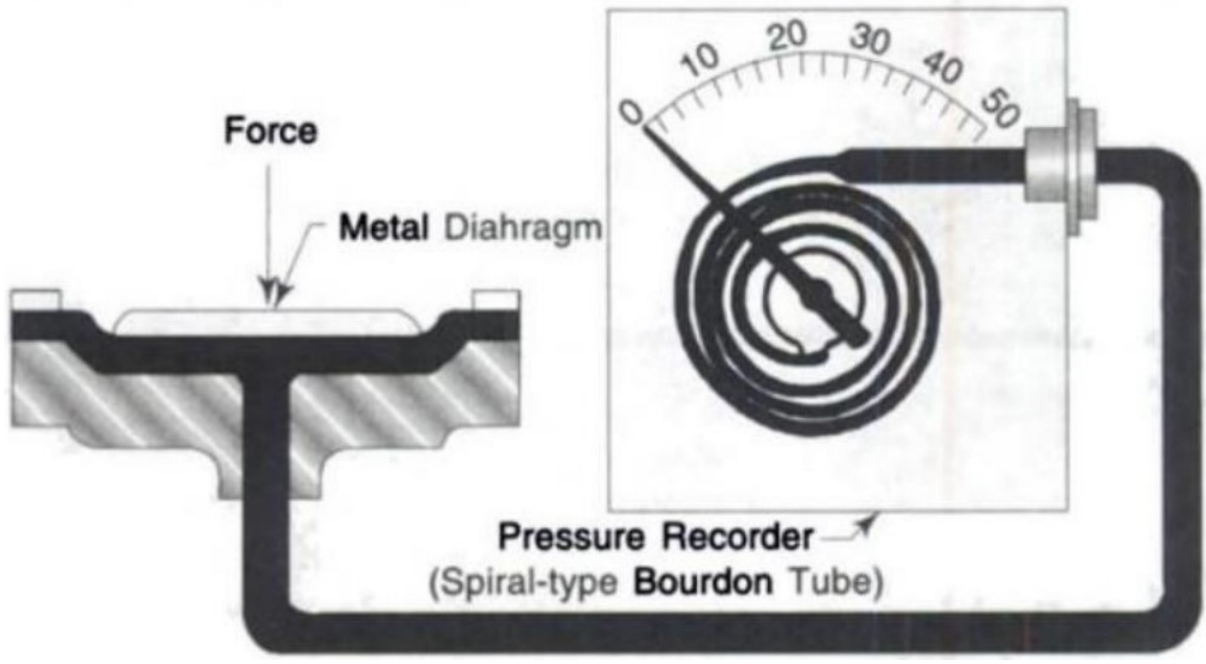
Advantages

1. Suitable in hazardous or explosive areas.
2. Free from temperature related errors.
3. They contain no fluids like other types that might contaminate the process if diaphragm is destroyed.

Disadvantages

1. Respond slowly to sudden load changes.
2. They need clean, dry, regulated air .

2. Hydraulic Force meter



Principle of working:

The hydraulic force meter operates on the principle of a **force counterbalance**. It involves the application of force to a definite area of fluid surface, thus producing hydrostatic pressure in the fluid, which can be measured by a Bourdon tube, manometer or any other type of pressure gauge. The transmitting element between force and pressure may be piston, bellow or diaphragm.

Construction

1. It consists of a metal diaphragm on which the force to be measured is applied.
2. The metal diaphragm is attached to a fluid chamber which is connected to a spiral type Bourdon tube pressure gauge through tubings.
3. A pointer is attached to the bourdon tube with linkages and gearings , which moves on a scale calibrated in units of force.

Working

1. The force to be measured is applied to the piston with a loading platform placed on top of the diaphragm.
2. The applied force moves the piston downwards and deflects the diaphragm and this deflection of the diaphragm increases the pressure in the liquid medium (oil).
3. This increase in pressure of the liquid medium is proportional to the applied force.
4. The increase in pressure is measured by the Bourdon tube which is connected to the liquid medium.
5. The pressure is indicated by the pointer of the bourdon tube on the calibrated scale and gives the value of the applied force.
6. In this , an electrical pressure transducer can also be used to obtain an electrical signal.

Specifications

1. This may be used for measurement of forces in the range of 0 to 30,000 Newtons (0 to 6000 lb) to 0to 5 million Newtons (0 to 1million lb).
2. Accuracy is 0.1% of full scale.
3. Resolution is about 0.02%

Advantages

1. Require no outside force of power for indication.
2. Respond quickly to load changes
3. Insensitive to temperature changes
4. Well suited in hazardous areas since they require no electrical power.
5. Well suited for high impact loads.
6. Can withstand high overloads

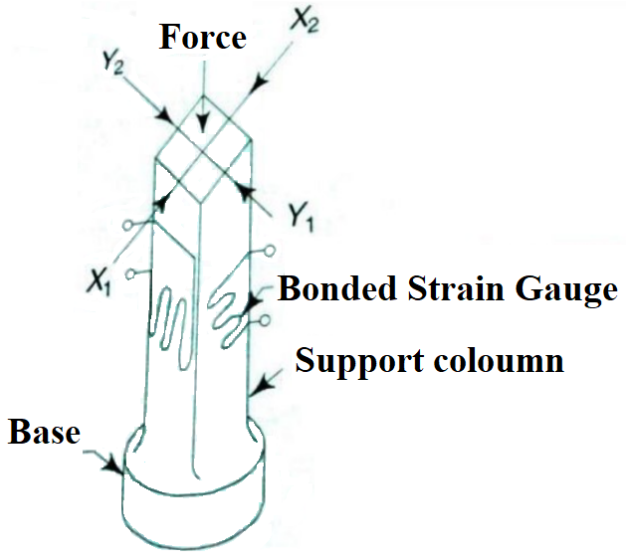
Disadvantages:

1. They are bulky and occupies much space
2. Cost of oil is high
3. Transportation is difficult
4. maintenance is difficult

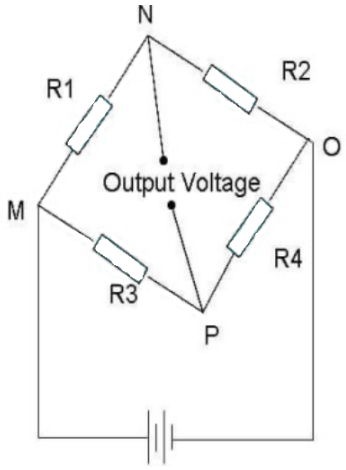
Applications

1. It can be used for occasional force checks, continuous loading, or permanent installation depending on the model.
2. Verifying presses
3. Heavy Industrial Paper Textile Mills (Paper/ Textile Tension)
4. Monitor Drill/ Milling machine loads
5. Aviation (Aircraft Load monitoring)
6. It can be used to monitor pulling loads on Tractors / Trailers

3) Strain gauge load cell



Wheatstone Bridge



Principle

- Strain gauge load cell is also called an electromechanical transducer in which change in applied force is converted into change in voltage.
- The change in voltage is calibrated directly in terms of the force (or load) applied to the cell.
- When the column is subjected to a force, it tends to change in dimension. When the strain gauges bound on the cylinder are stretched or compressed causes a change in strain gauge dimension along length and diameter. If the dimension of strain gauge is changed, its resistance also changes. The change in resistance is a measure of applied force.

Construction

- Wire grids known as strain gauges are bonded to supporting columns.
- These grids are connected electrically to form a balanced wheatstone bridge.

Operation of strain gauge load cell

Specifications -

1. This may be used for measurement of forces in the range of 1 to 12 million lbs.
2. Accuracy is 0.1% of full scale.

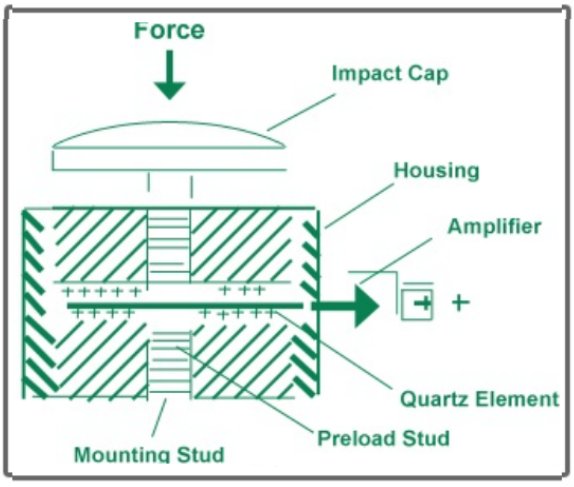
Advantages -

1. Small and compact in size
2. Well suited for measurements when an electric signal output signal is desired.
3. Respond rapidly to load variations.
4. inexpensive
5. relatively maintenance free.

Disadvantages

1. They have to be protected from angular & non-axial loads as they have no way to discriminate between non-axial & axial loads.
2. Overloads greatly in excess of their rating should be avoided.
3. Applications
    - Strain gauge load cells are used when the load is not steady.
    - Strain gauge load cells are used in vehicle weigh bridges.

1) Piezoelectric Load cell



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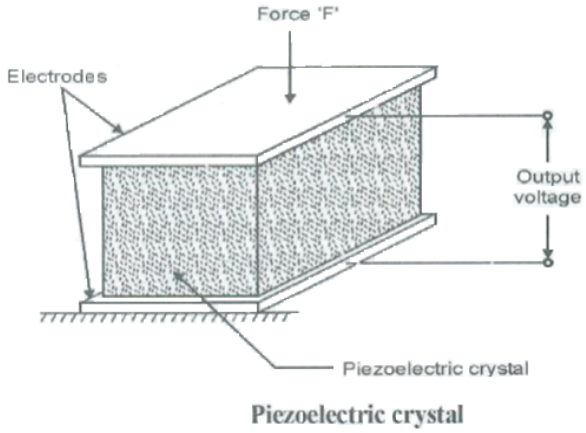


Piezoelectric crystal

Principle:

"If dimension of crystal is altered, an electronic potential appears across a certain surface of crystal material due to displacement of charges that induces an output voltage and induces a voltage proportional to the force applied".

Construction:

Piezoelectric materials used:
Natural Group: Quartz, Rochelle Salt
Artificial or synthetic: Lithium Sulphate, Ethylene tartrate.
In a typical quartz-based force sensor, a charge-collection electrode is sandwiched between quartz-crystal element

Working

- Any force applied to the piezoelectric sensing element produces a separation of charges within the atomic structure of the material, generating an electrostatic output voltage.
- The polarity of the voltage generated depends on the atomic structure of the material and the direction in which the force is applied.
- When a force is applied to the surface of an electrode, the quartz elements generate an output voltage which can be routed directly to a charge amplifier.
- The magnitude and polarity of induced surface charges are proportional to magnitude and direction of applied force.

Advantages

1. Fast response,
2. ruggedness,
3. stiffness comparable to solid steel,
4. extended ranges
5. and the ability to measure quasi-static forces

Disadvantages

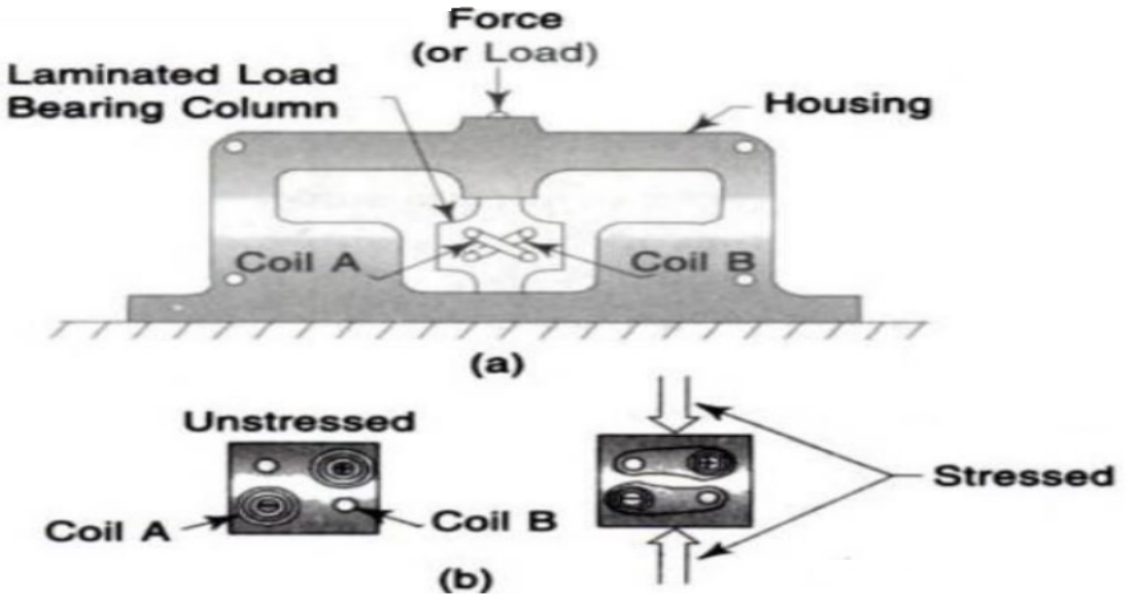
The electrical signal generated by the crystal decays quickly after the application of force so this device is inappropriate for the *detection of static force*.

Applications

Piezoelectric force sensors are mostly used for dynamic- force measurements such as oscillation, impact, or high speed compression or tension.

- The measurement of spring or sliding friction forces,
- Chain tensions,
- Clutch release forces,
- Peel strengths of laminates, labels, and pull tabs

5) Pressductor load cell



MAGNETO-ELASTIC LOAD CELL

Principle

Magneto-elastic load cells work in principle of "Magneto elastic principle" called as Villari effect. "When a ferromagnetic material undergoes mechanical stress, it changes the magnetic permeability of the material. The level of change in permeability property is proportional to applied force / stress." Depends on the permeability property of magnet defined as "The measure of the ability of a material to support formation of magnetic field within itself". Magneto-elastic load cells are also called "Pressductor"

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Construction

It consists of a laminated load-bearing column enclosed in a housing A primary and secondary transformer coil windings are wound on the column through holes in the column. Coil A is excited with an a.c. voltage and coil B provides the output signal voltage.

Operation

1. When the load cell is unloaded (or unstressed), the permeability of the material is uniform throughout the structure.
2. Since the coils are oriented at 90° with respect to each other the magnetic flux lines around the windings do not influence each other.
3. Hence, no output signal is developed.
4. When the column is loaded, the induced mechanical stresses cause the permeability of the column to be non-uniform, resulting in corresponding distortions in the flux pattern within the magnetic material. Now the magnetic line of flux of the two coils cut each other, and thus a voltage proportional to the applied force is induced in the secondary

winding.

5. The pressductor has greater applicability in steel plants for the measurement of roll-forces in rolling mills, strip-tension in trip mills, and in weighing cranes in steel-melting shops.

Specifications

The output Signal levels range from 1 to 20 volt dc with source impedances ranging from 0.5 to 25 ohms

Advantages

1. Produces relatively high output signals
2. It is an extremely robust transducer.
3. It's overload ratings are as high as 1.5 times rated loads.

Disadvantages

1. It has hysteresis errors.
2. The excessive stress & aging may cause permanent change.
3. Zero drift & sensitivity changes due to temperature vibration.

Applications

- used in steel plants for measurement of roll forces in Rolling Mill
  Strip tension in strip mills. In weighing cranes in steel melting shops