

PRESSURE MEASUREMENTS FOR OPERATORS

By

Eng. AHMED SABRY

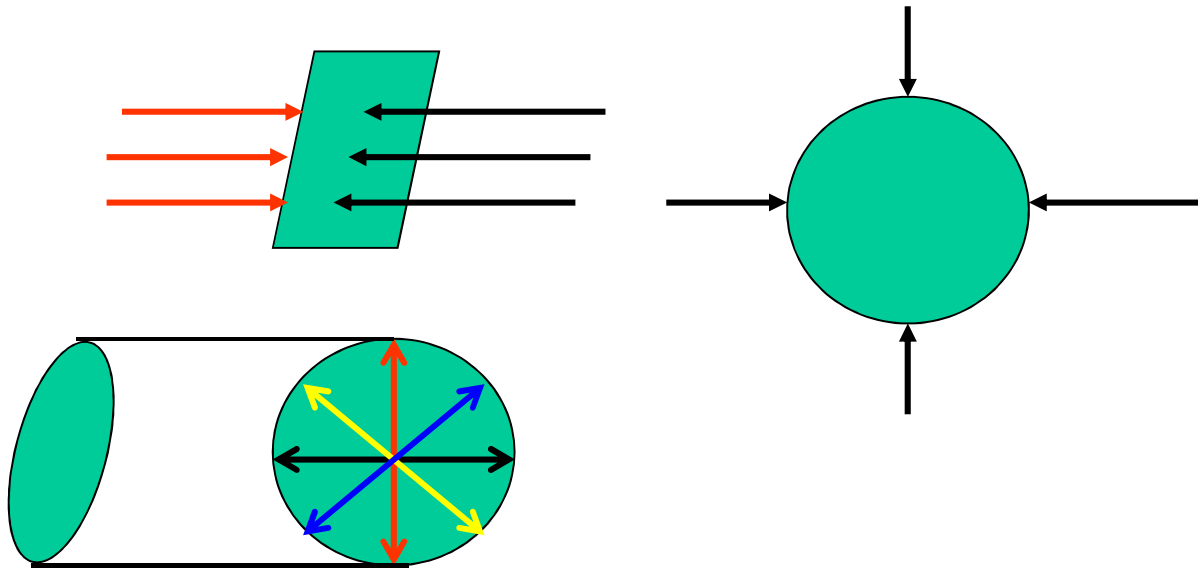
WHAT IS THE PRESSURE?

- Pressure “P” is defined as the **force** acting on the **unit area**
- Therefore: If we have a Force “F” acting on an Area “A”, then:

$$P = F / A \quad \text{and the Dimensional Formula is : } (M \times LT^{-2}) / L^2$$

In the SI system : **Pressure units is: kg_f/m^2 OR kg_f/cm^2**

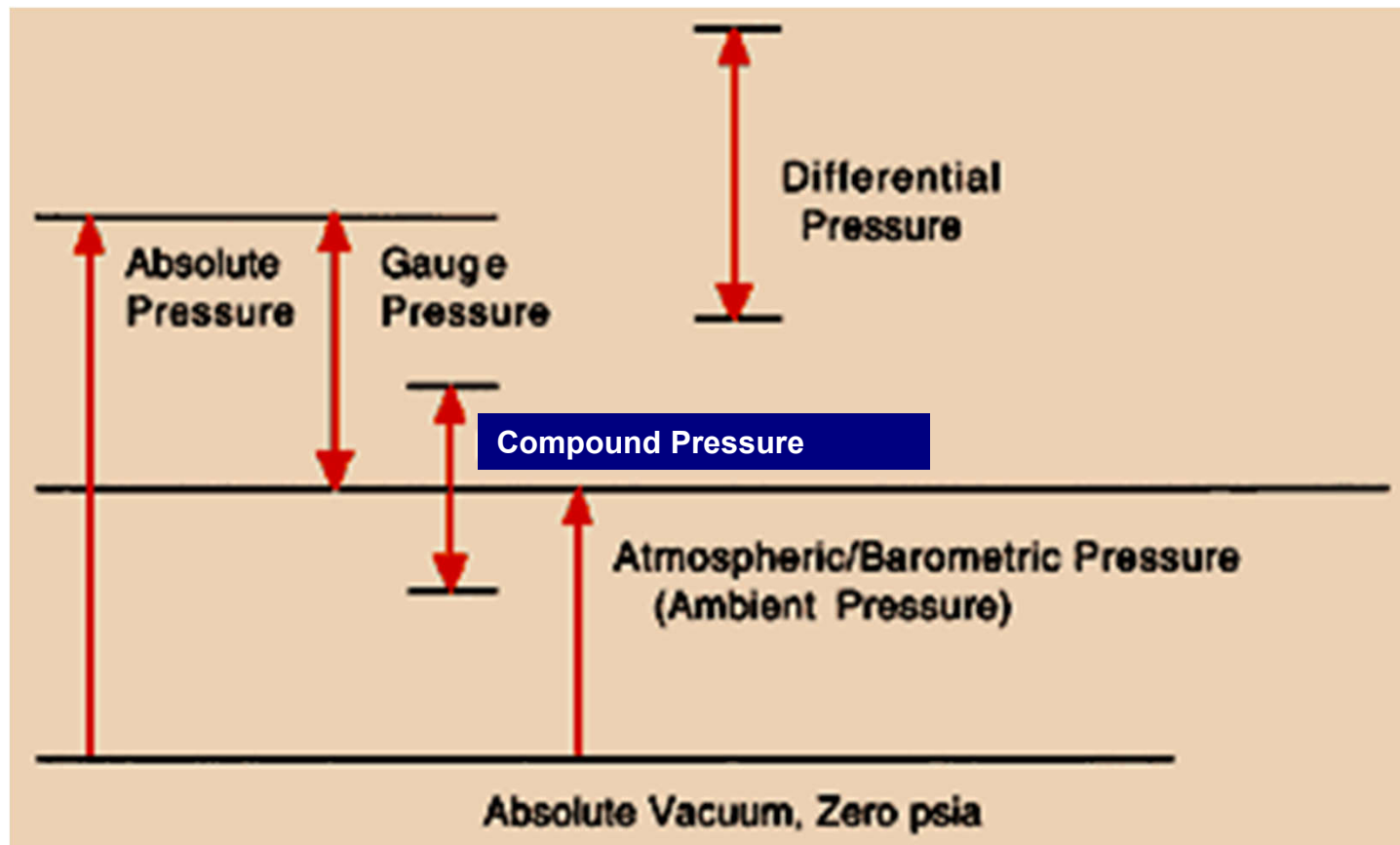
- Pressure acts on bodies and surfaces on **ALL directions**



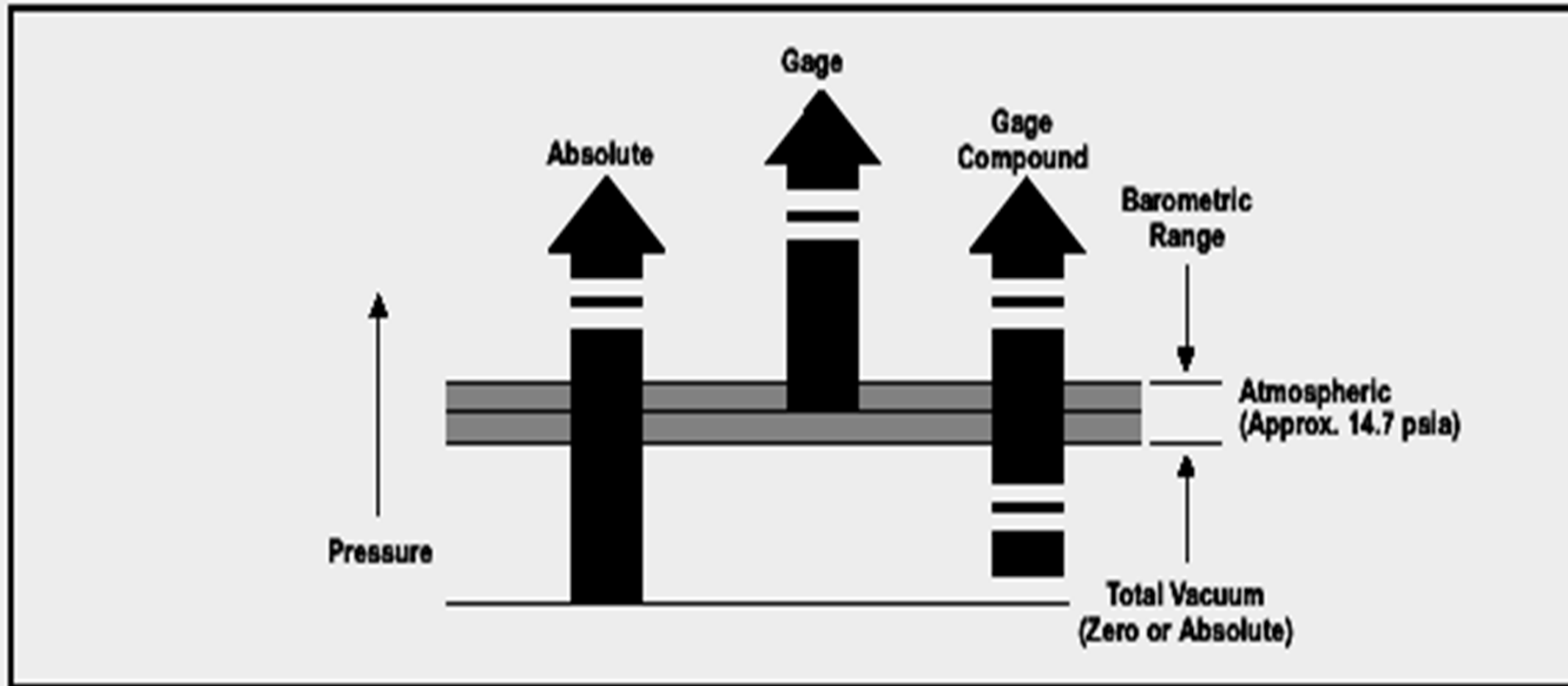
PRESSURE DEFINITIONS

- ❑ Pressure is always measured with respect to a datum or reference.
- ❑ The **reference pressure** may be either one of the following:
 - **Full Vacuum** —————→ **Absolute Pressure**
 - **Atmospheric pressure** —————→ **Gauge Pressure**
 - **Another pressure** with the same reference → **Differential Pressure**
- ❑ **Atmospheric Pressure** is measured with reference to full vacuum.
- ❑ **Compound pressure** contains two parts : one above the atmospheric & the other below the atmospheric. Both parts are referenced to the atmospheric.

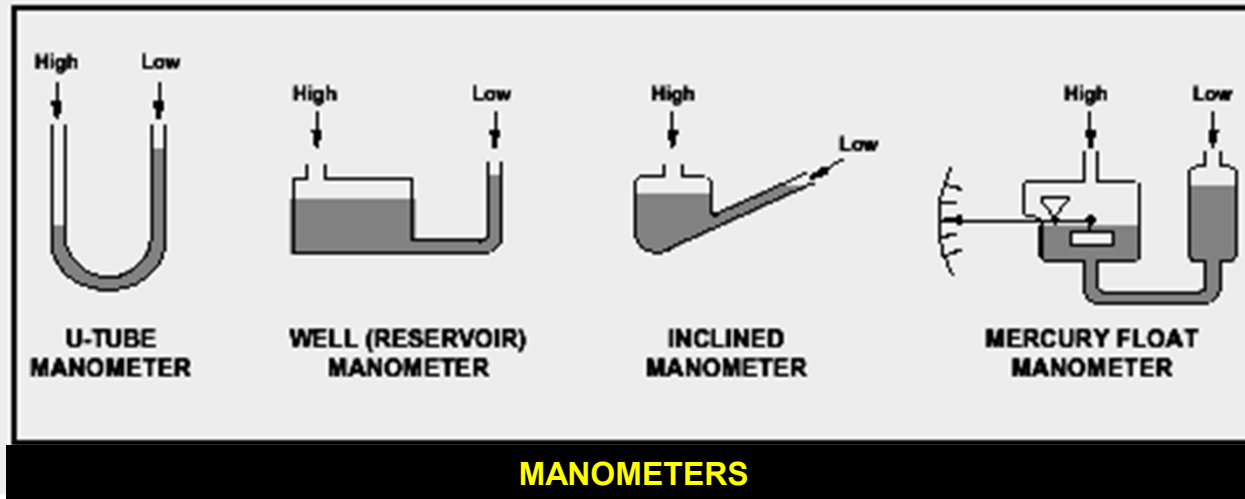
PRESSURE DEFINITIONS



PRESSURE DEFINITIONS



PRESSURE MEASUREMENTS

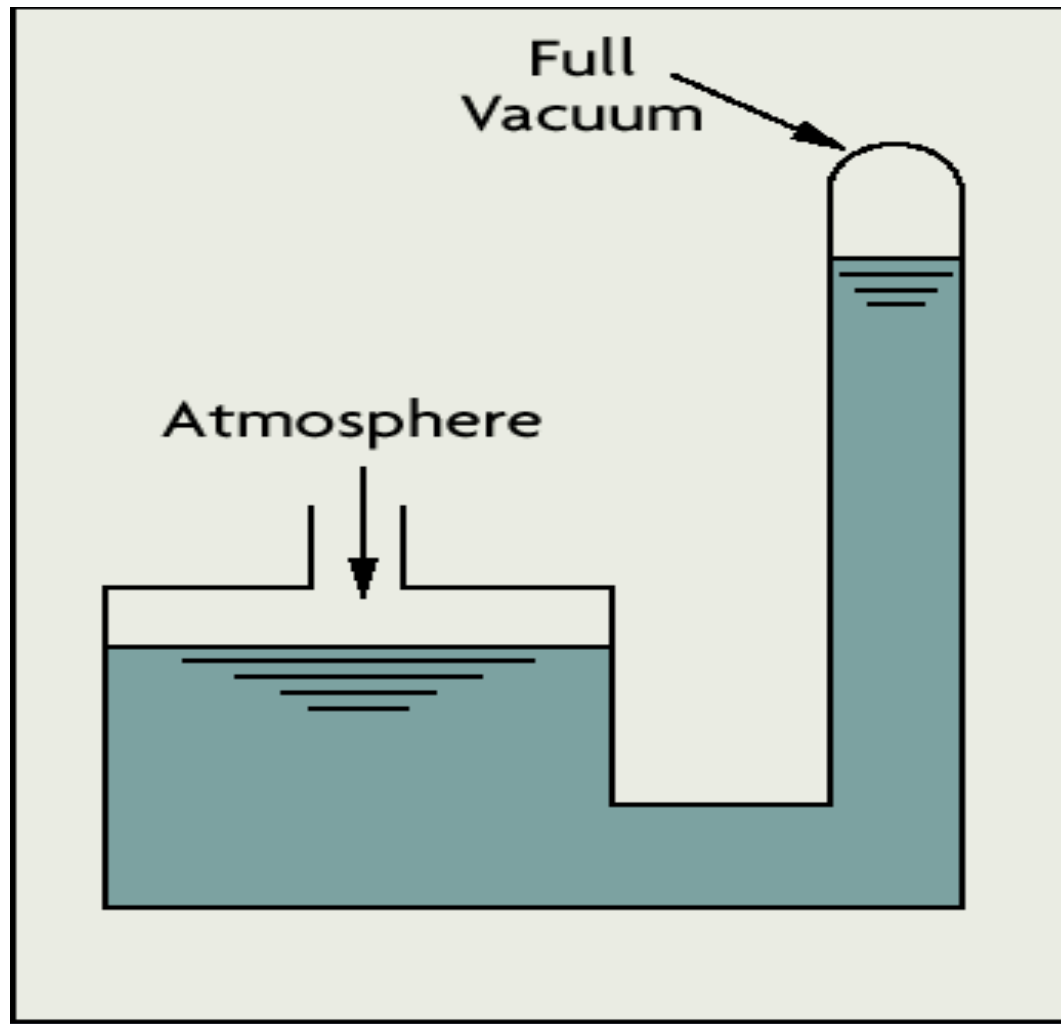


The Low Pressure may be :

- Full Vacuum
- Atmospheric Pressure
- Any pressure lower than that applied to the “HIGH” pressure side.

A small change in the High pressure side will produce a considerable change in the low pressure side.

BAROMETER OPERATION



STATIC PRESSURE

$$Dg = W/V, W = VDg$$

$$P = W/A = VDg/A = hADg/A = hDg$$

Where:

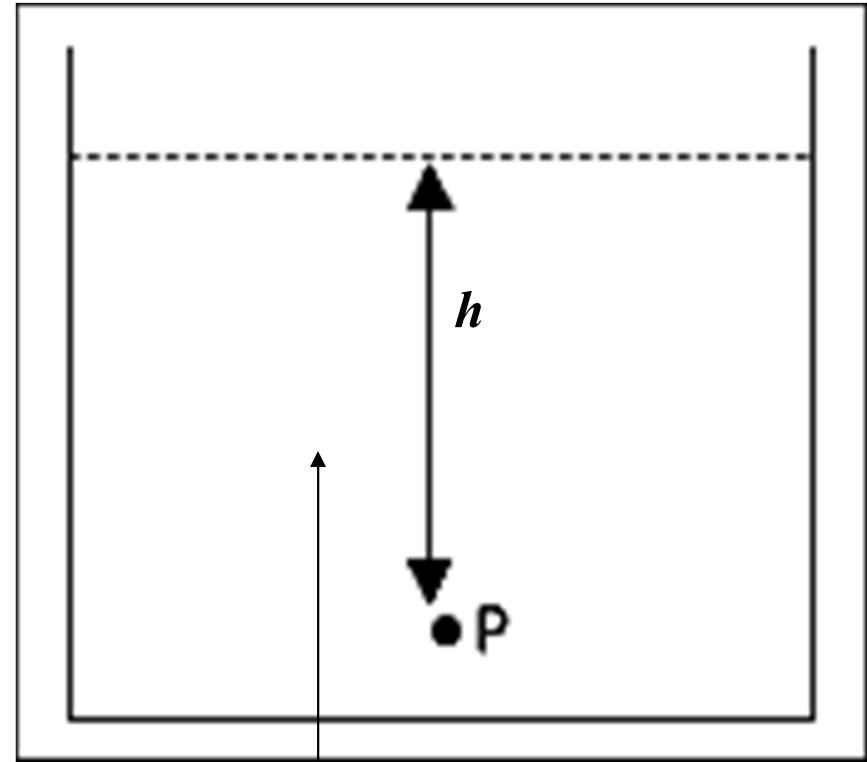
D = Liquid Density

g = gravity acceleration

V = Volume **A** = Area

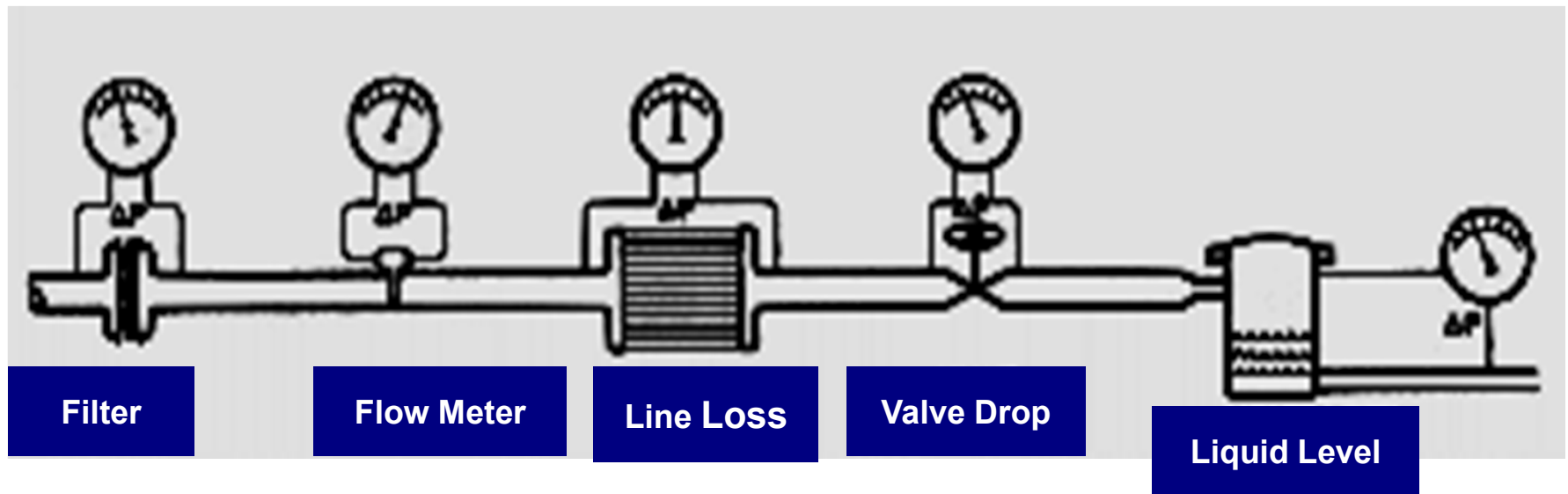
W = Weight **P** = Pressure

h = Liquid head

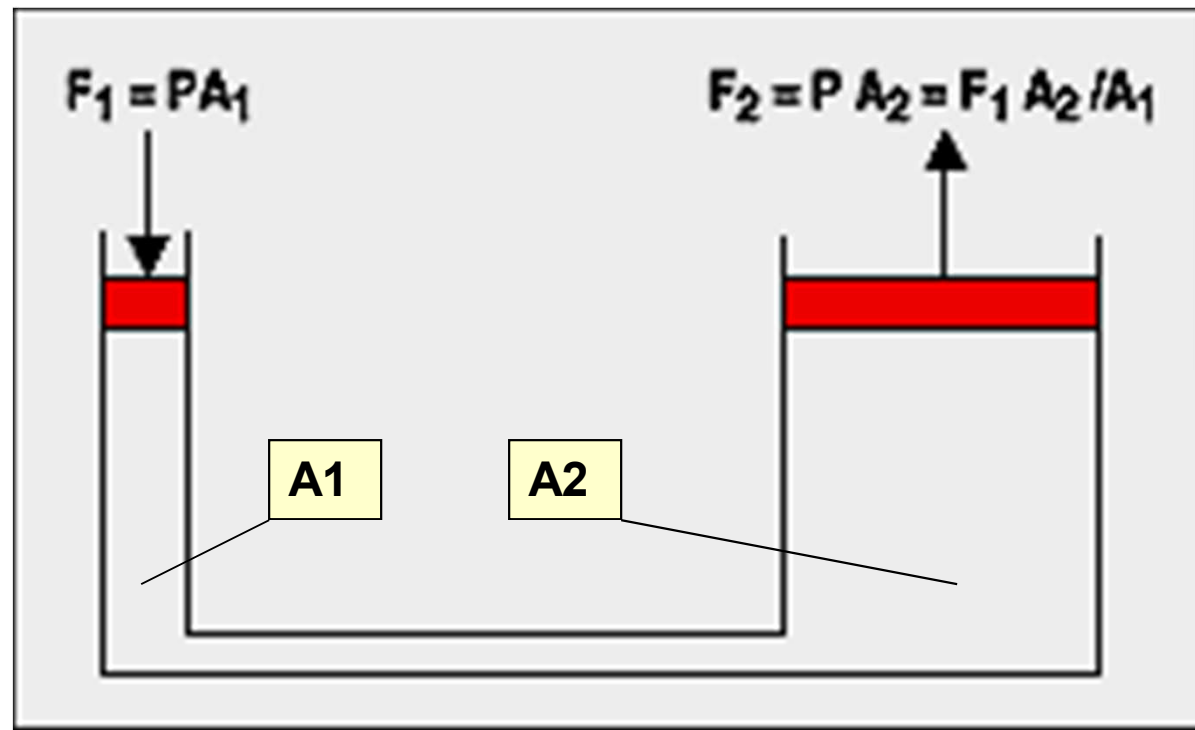


Liquid Density = D

ΔP CELLS APPLICATIONS

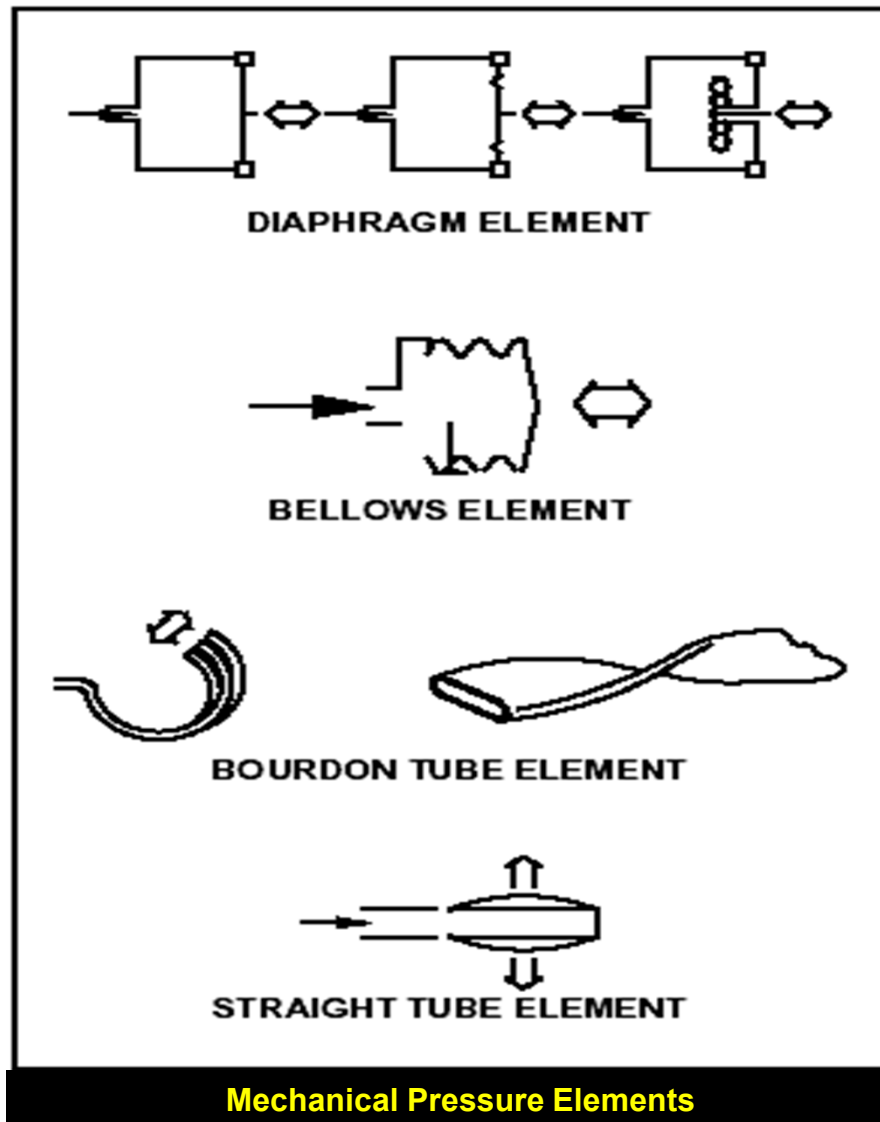


PRESSURE MEASUREMENTS

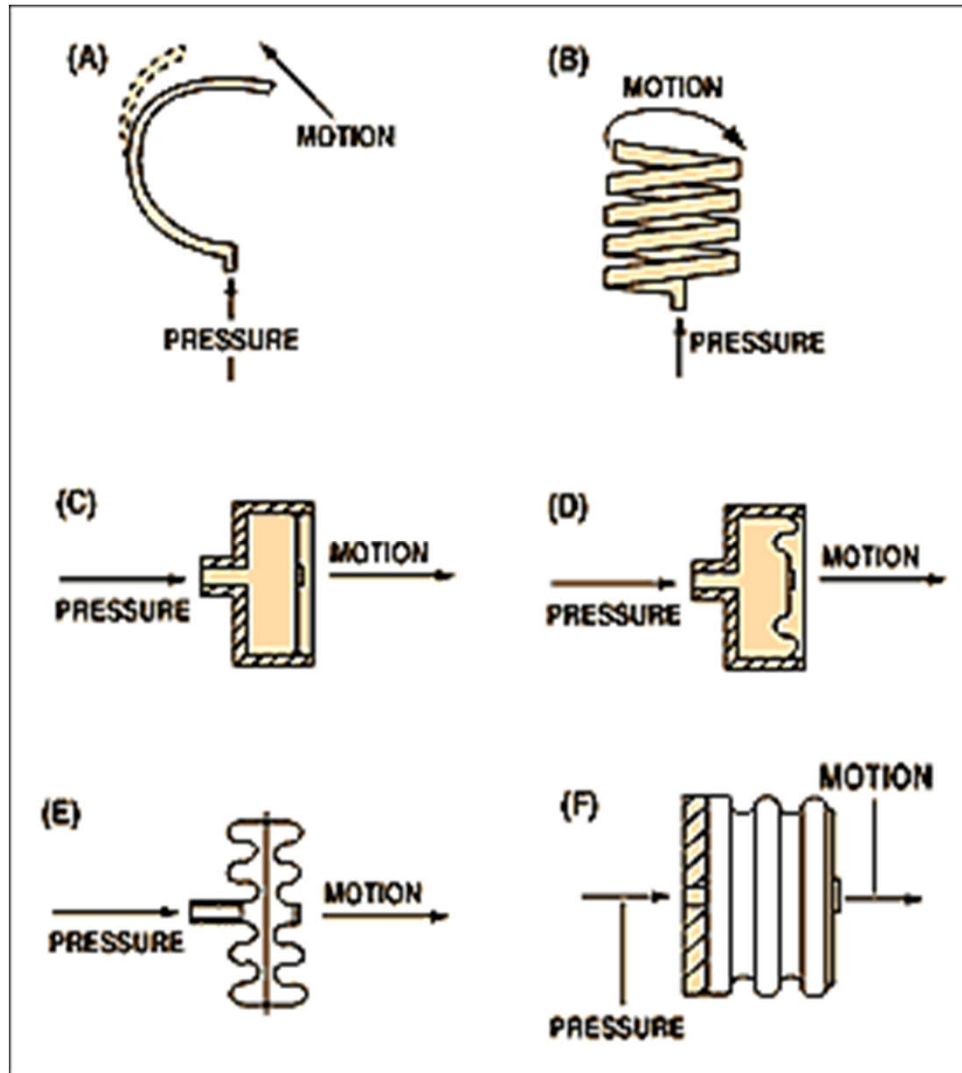


PRESSURE SENSING ELEMENTS

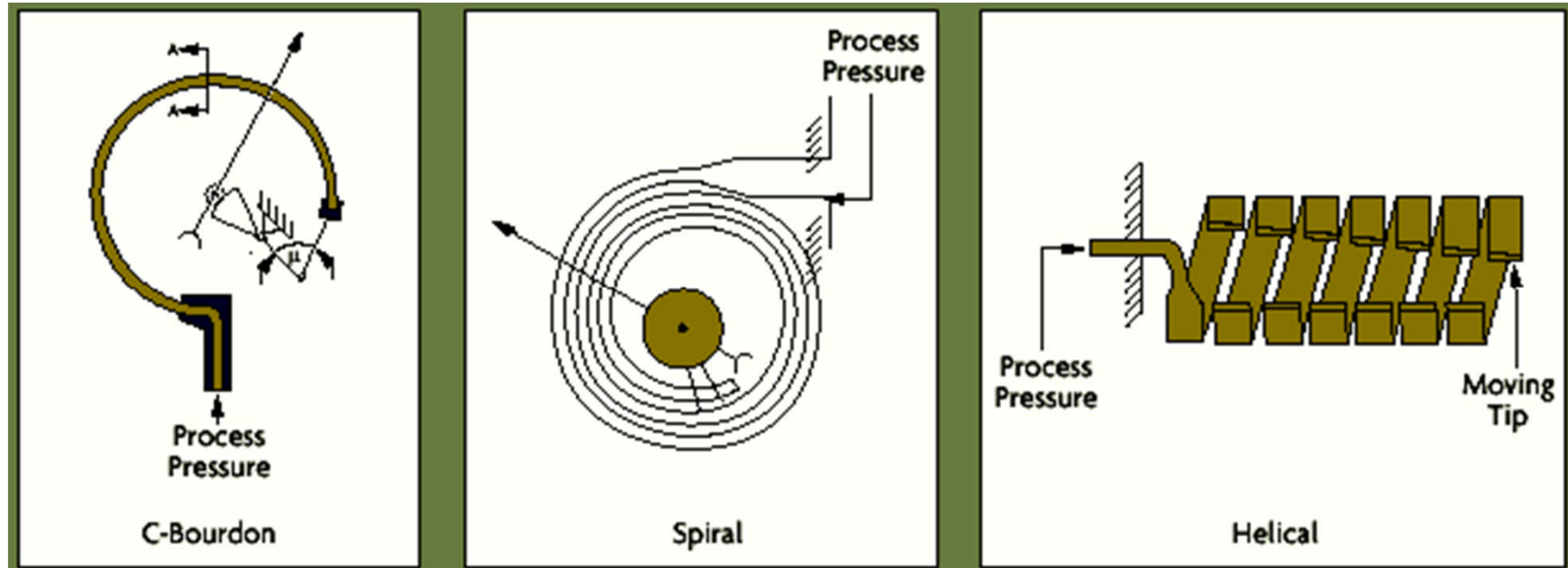
PRESSURE MEASUREMENTS



Mechanical PRESSURE Sensors

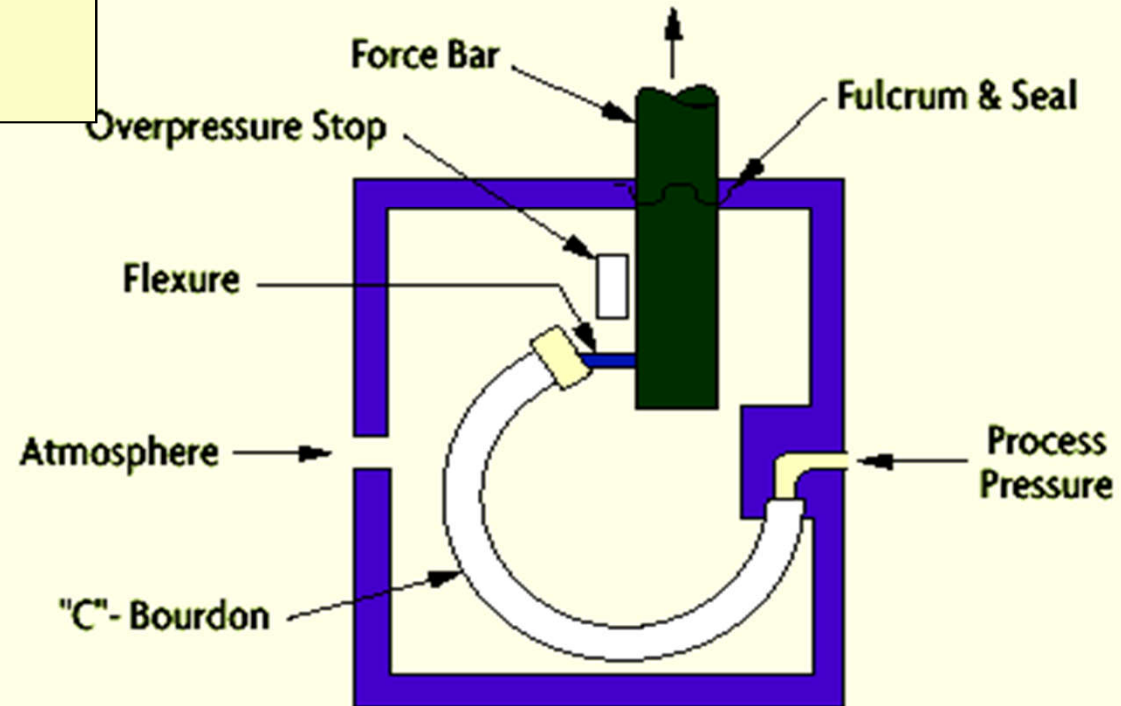


BOURDON TUBES

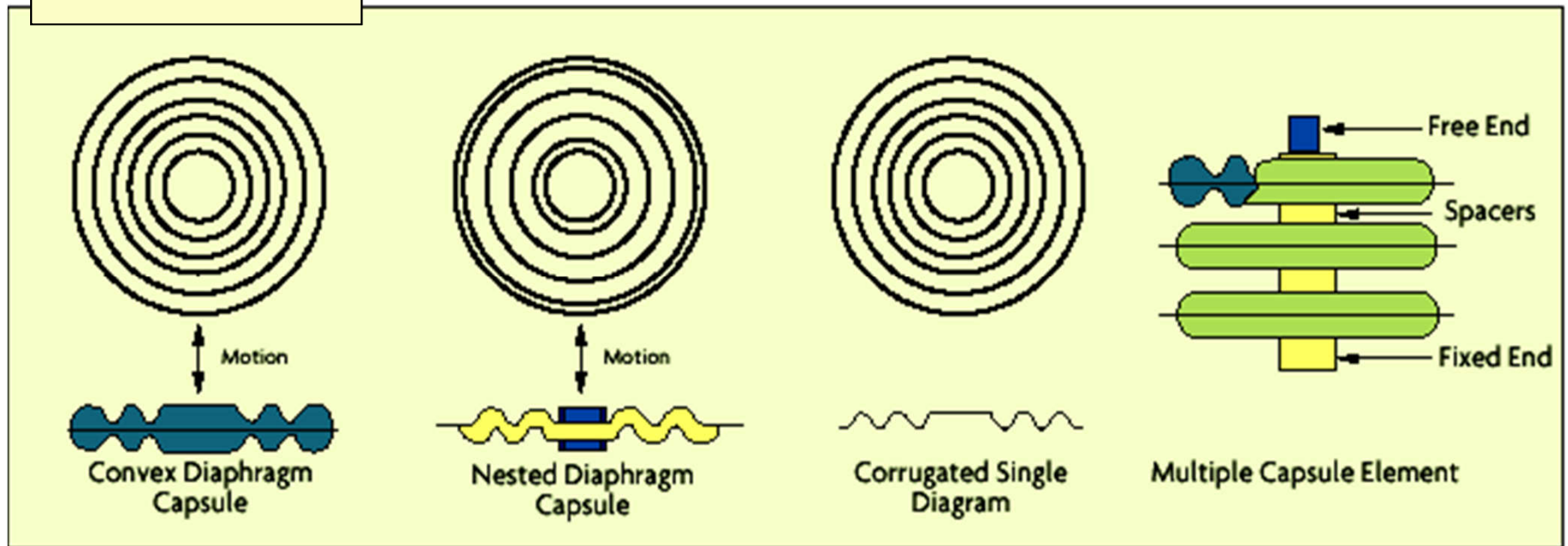


Bourdon Tube Overpressure Protection

**Omega : Process
Pressure
Measurement**

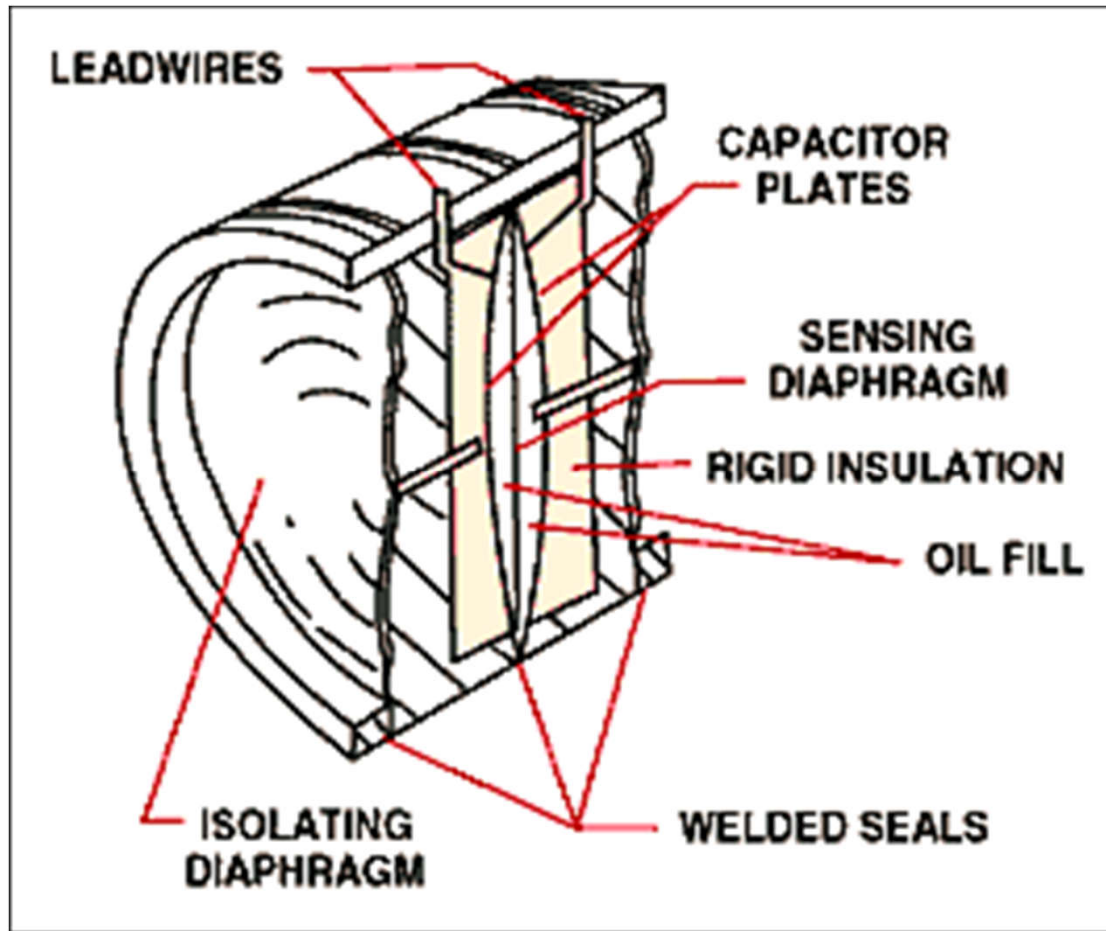


Diaphragm Pressure Sensors



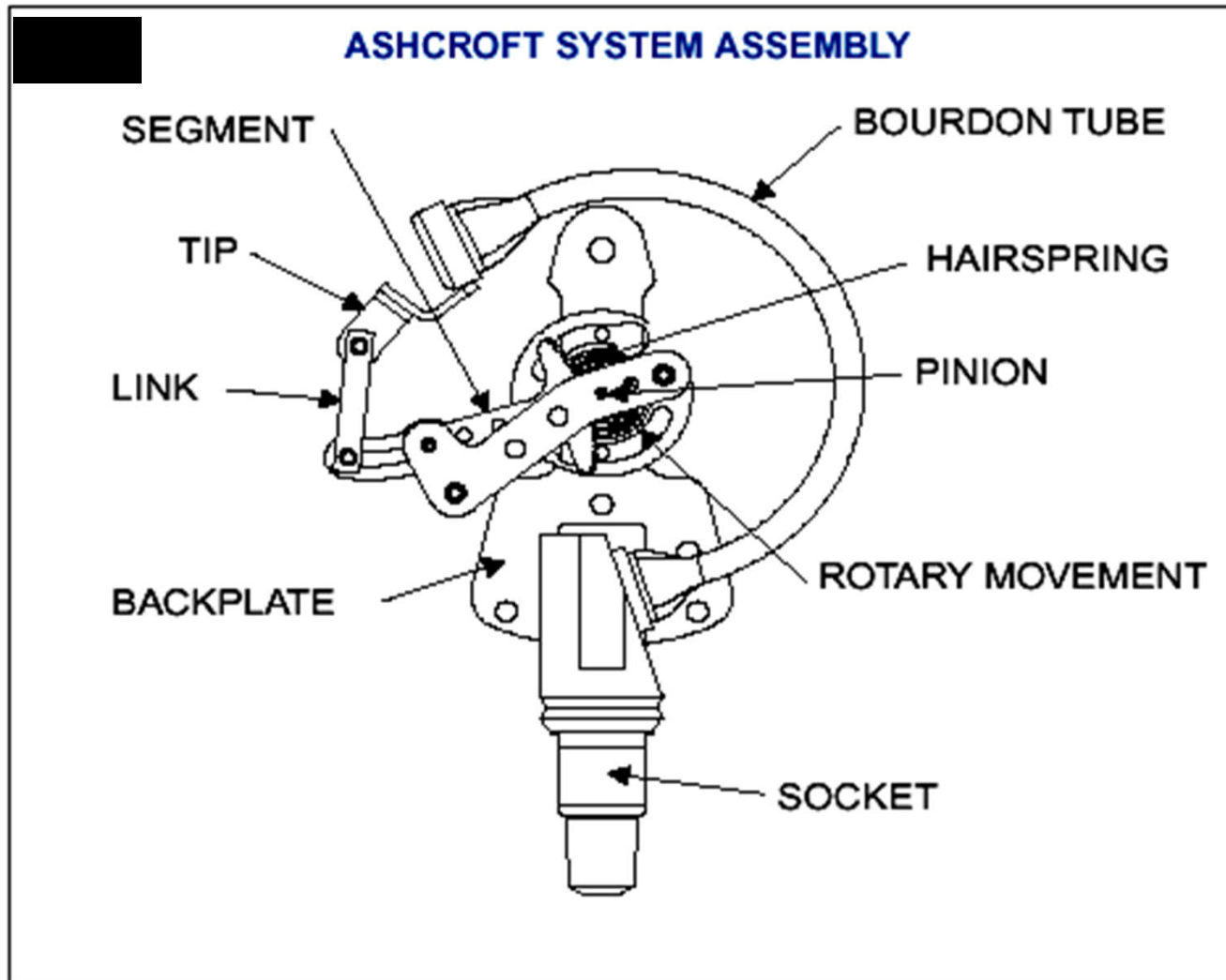
Diaphragm Pressure Sensors

P & Delta-P Diaphragm Capsule



PRESSURE GUAGES

Pressure Gage Movement



Digital Pressure Gages



Analog Pressure Gages



Analog Pressure Gages



Bottom Connection



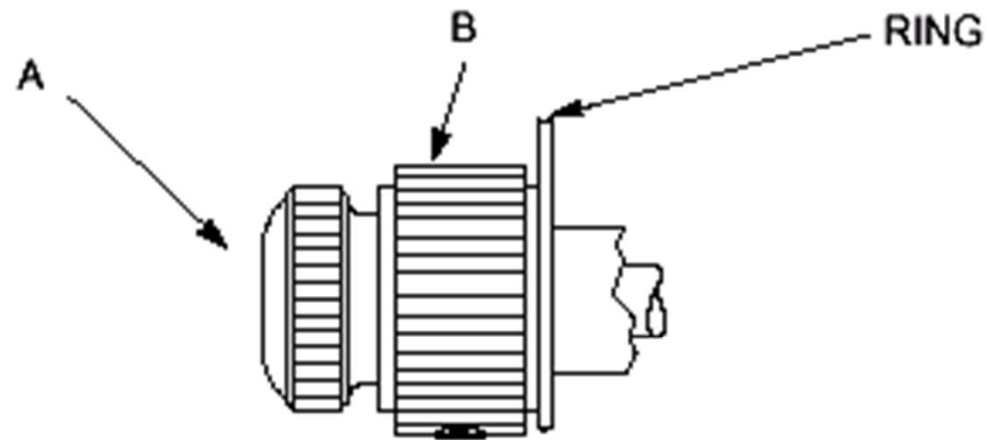
**Bottom Connection
Diff Pressure**



**Back Connection
Surface Mount**

P. GUAGE ZERO ADJUSTMENT

TYPE 1082 EXTERNAL ZERO ADJUST FEATURE*

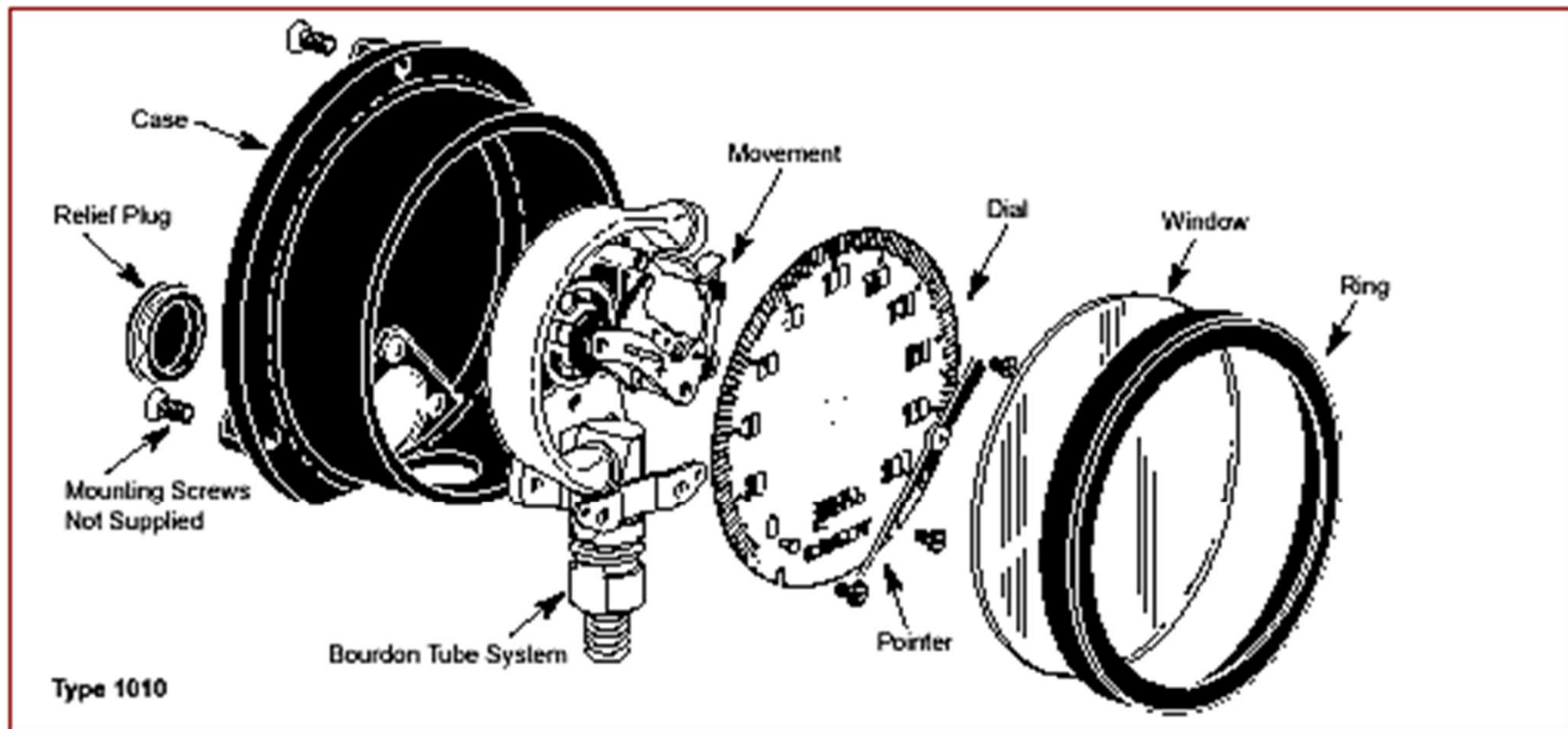


INSTRUCTIONS FOR USE:

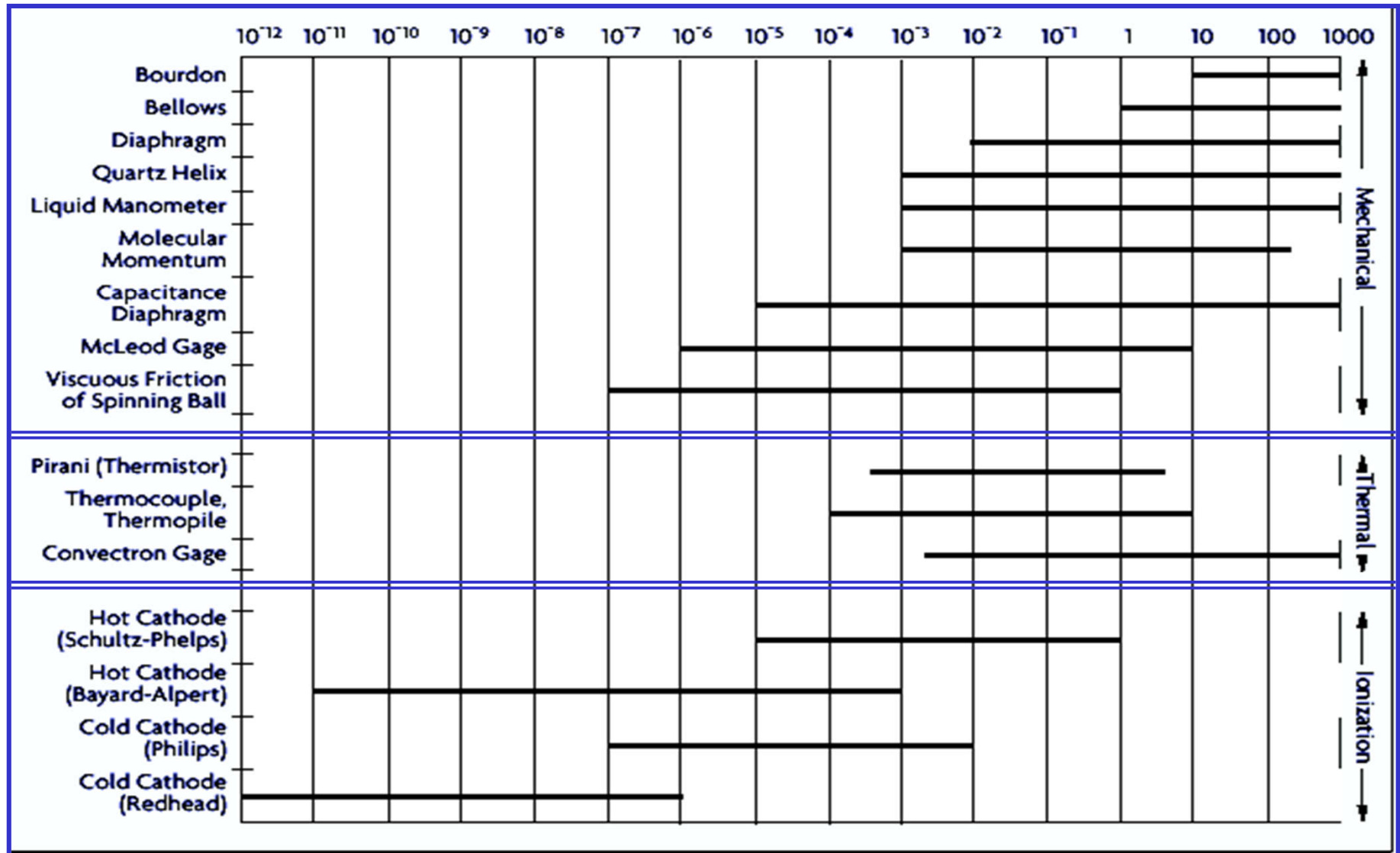
LOOSEN RING LOCKING **SCREW "A"**
OBTAIN REQUIRED ADJUSTMENT BY ROTATING
KNOB "B" CLOCKWISE OR COUNTER-CLOCKWISE.
TIGHTEN **SCREW "A"** DOWN ON **KNOB "B"**

*Applicable only for test gauge with hinged ring design.

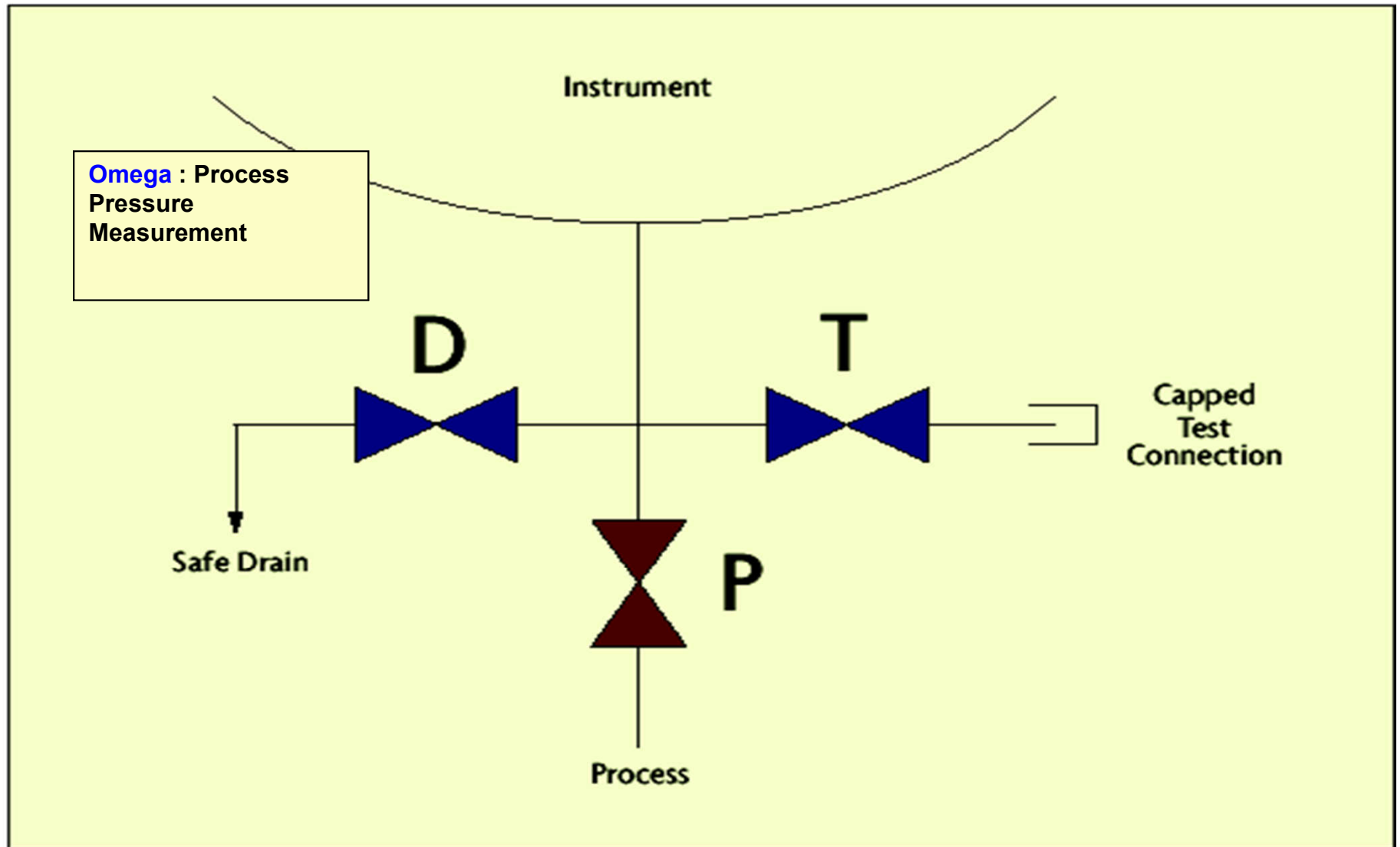
Pressure Gage Internals



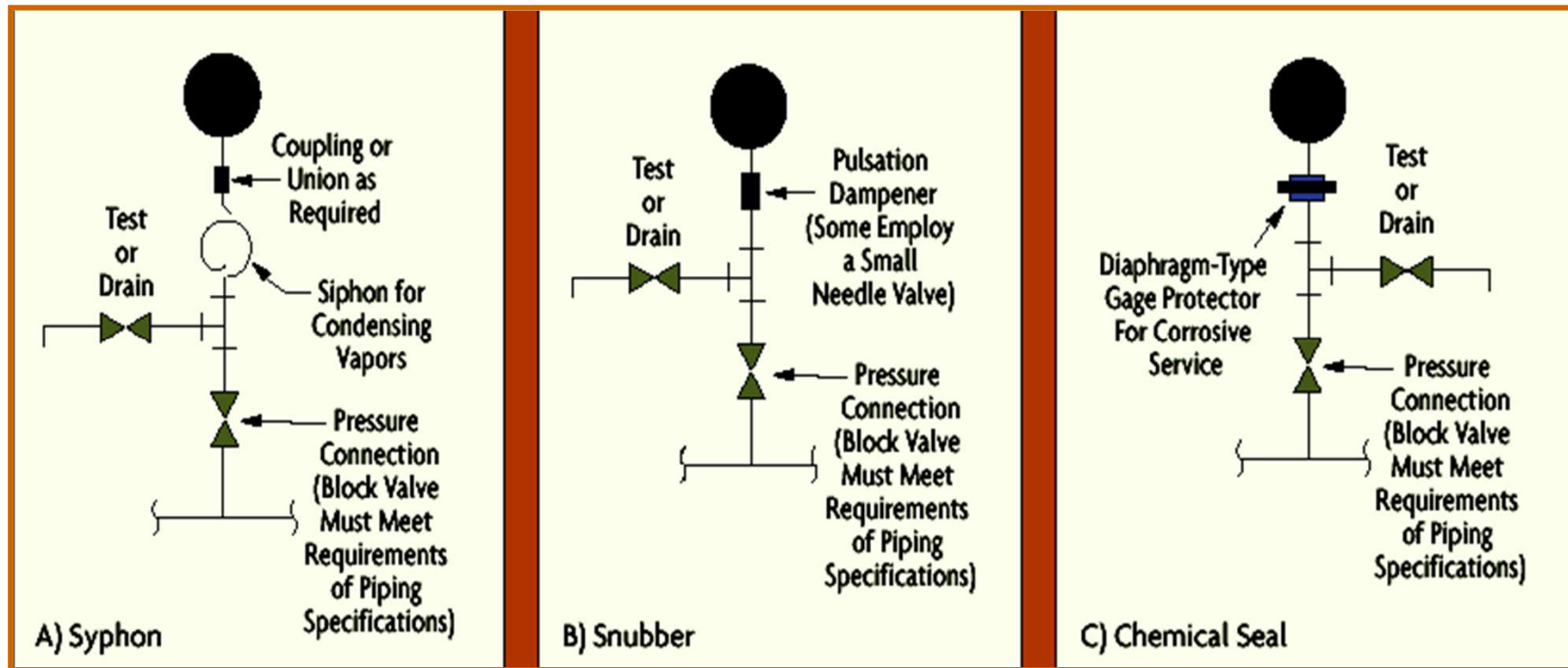
VACUUM GAUGE PRESSURE MEASUREMENT RANGES



3 - Valve Manifold

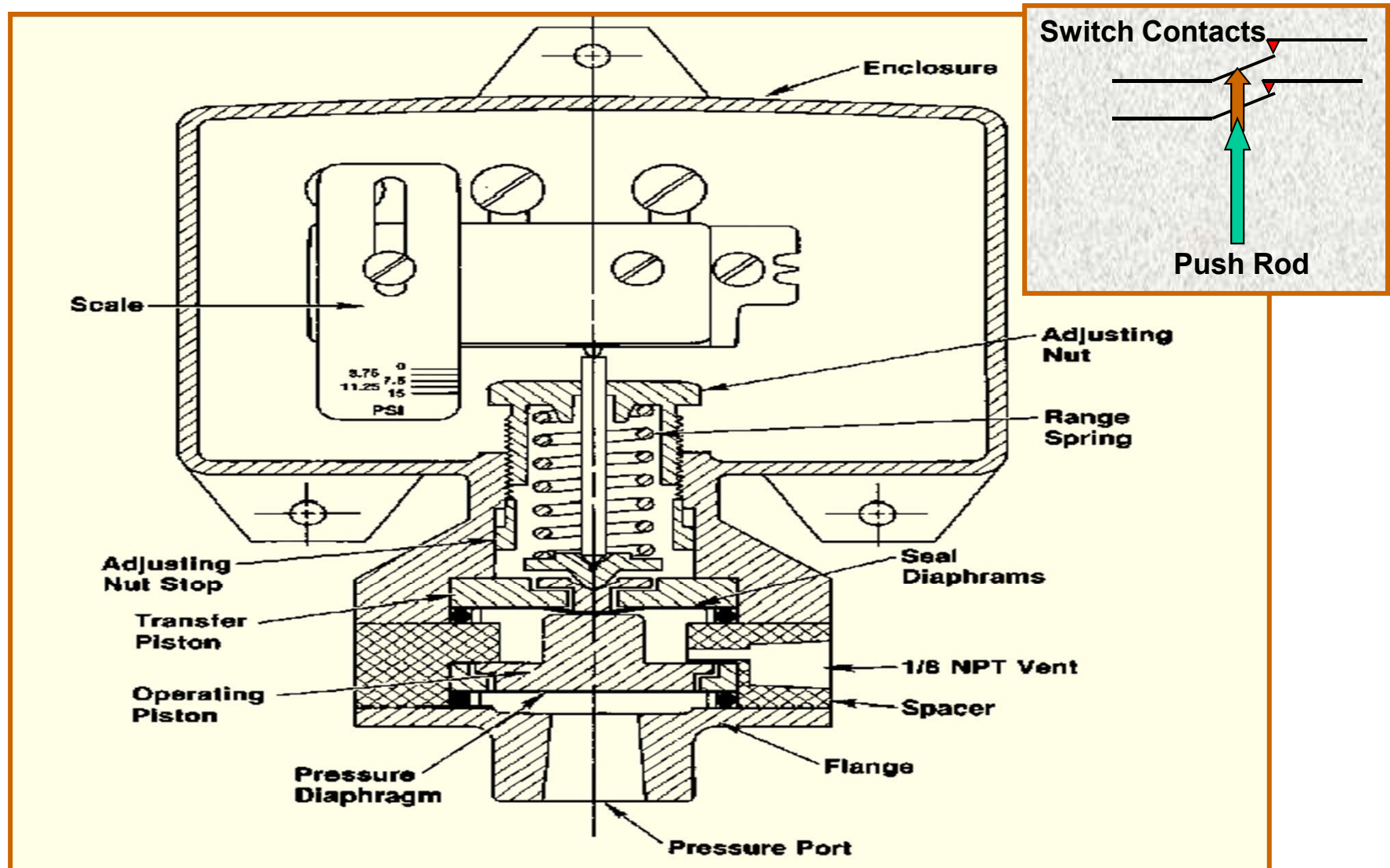


Pressure Gauge Accessories



PRESSURE SWITCHES

Pressure Switches -1



Pressure Switches-2

Type 400 Enclosure

UL and CSA listed instrument quality snap-action switch for reliable operation. Ratings up to 10A dc or 20A ac. Hermetically sealed switch also available.

Epoxy-coated aluminum enclosure for corrosion resistance. Meets NEMA 3, 4, 4X, 13 and IP66 requirements.

Accessible adjustment for convenient switch setting, includes vibration-resistant feature.

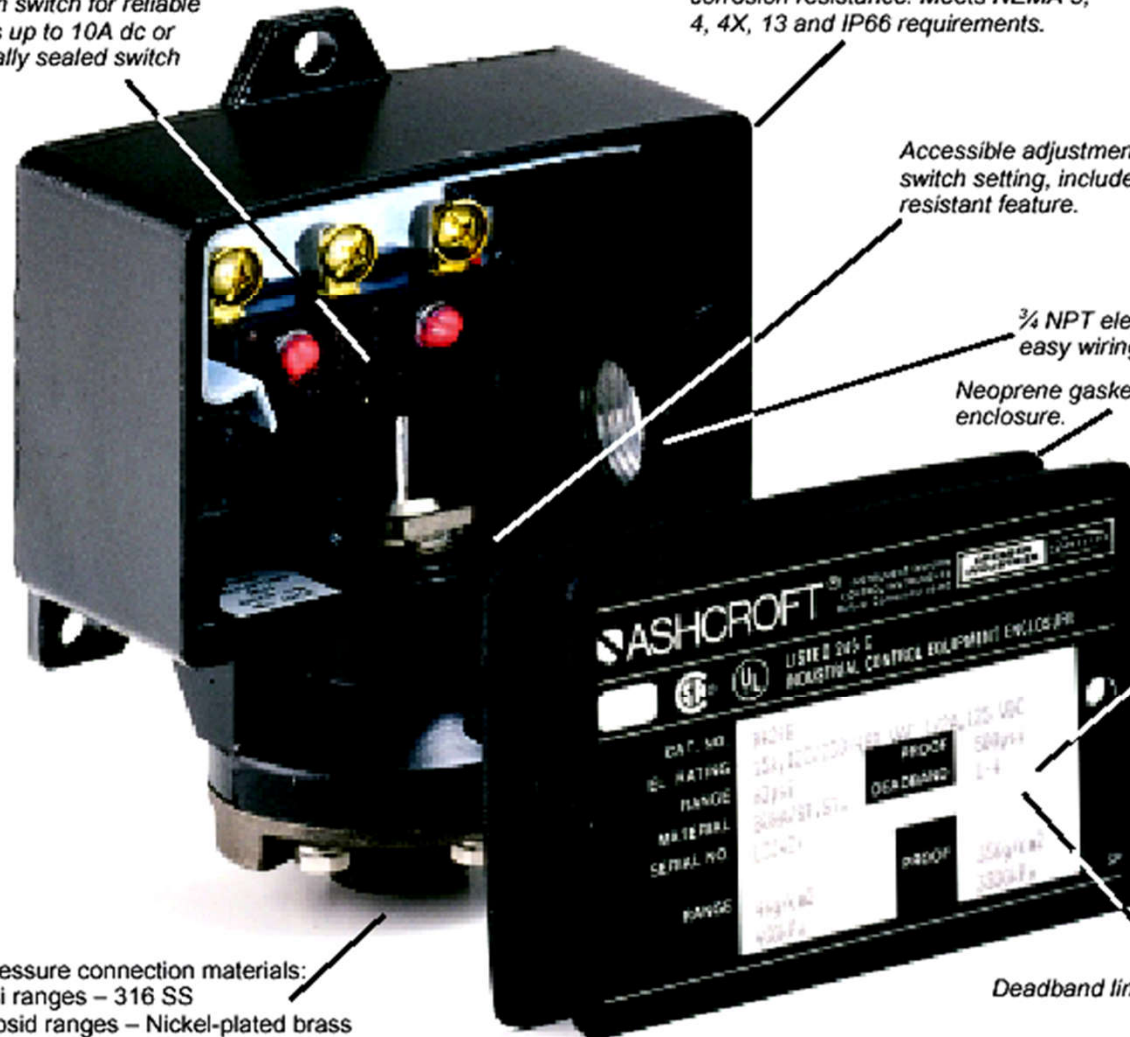
$\frac{3}{4}$ NPT electrical connection for easy wiring.

Neoprene gasket for sealing enclosure.

High proof pressure

Deadband limits for each switch.

Standard pressure connection materials:
Pressure psi ranges – 316 SS
Differential psid ranges – Nickel-plated brass
Pressure and differential I.W. ranges –
Epoxy-coated carbon steel



Pressure Switches- 3

Type 700 Enclosure

UL and CSA listed instrument quality snap-action switch for reliable operation. Ratings up to 10A dc or 20A ac. Hermetically sealed switch also available. Dual (2 SPDT) shown.

Epoxy-coated aluminum enclosure and cover for corrosion resistance. Class 1, Division 1 & 2, Groups B, C, D, Class 2, Division 1 & 2, Groups E, F, G, NEMA 7 & 9 and IP66.

Buna-N O-ring for sealing enclosure.

Terminal block wiring standard on dual switches. Optional (XK3) on single switches.

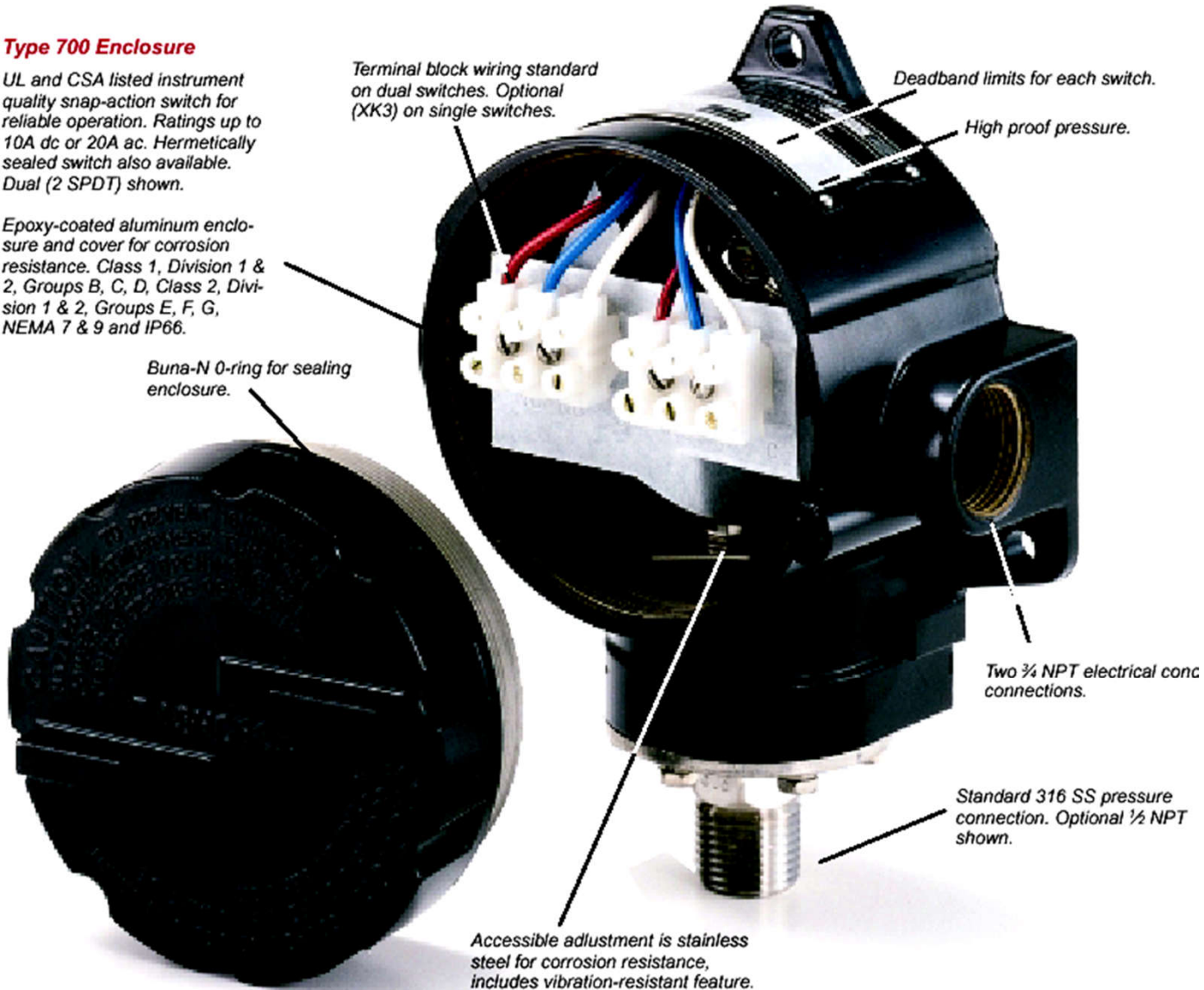
Deadband limits for each switch.

High proof pressure.

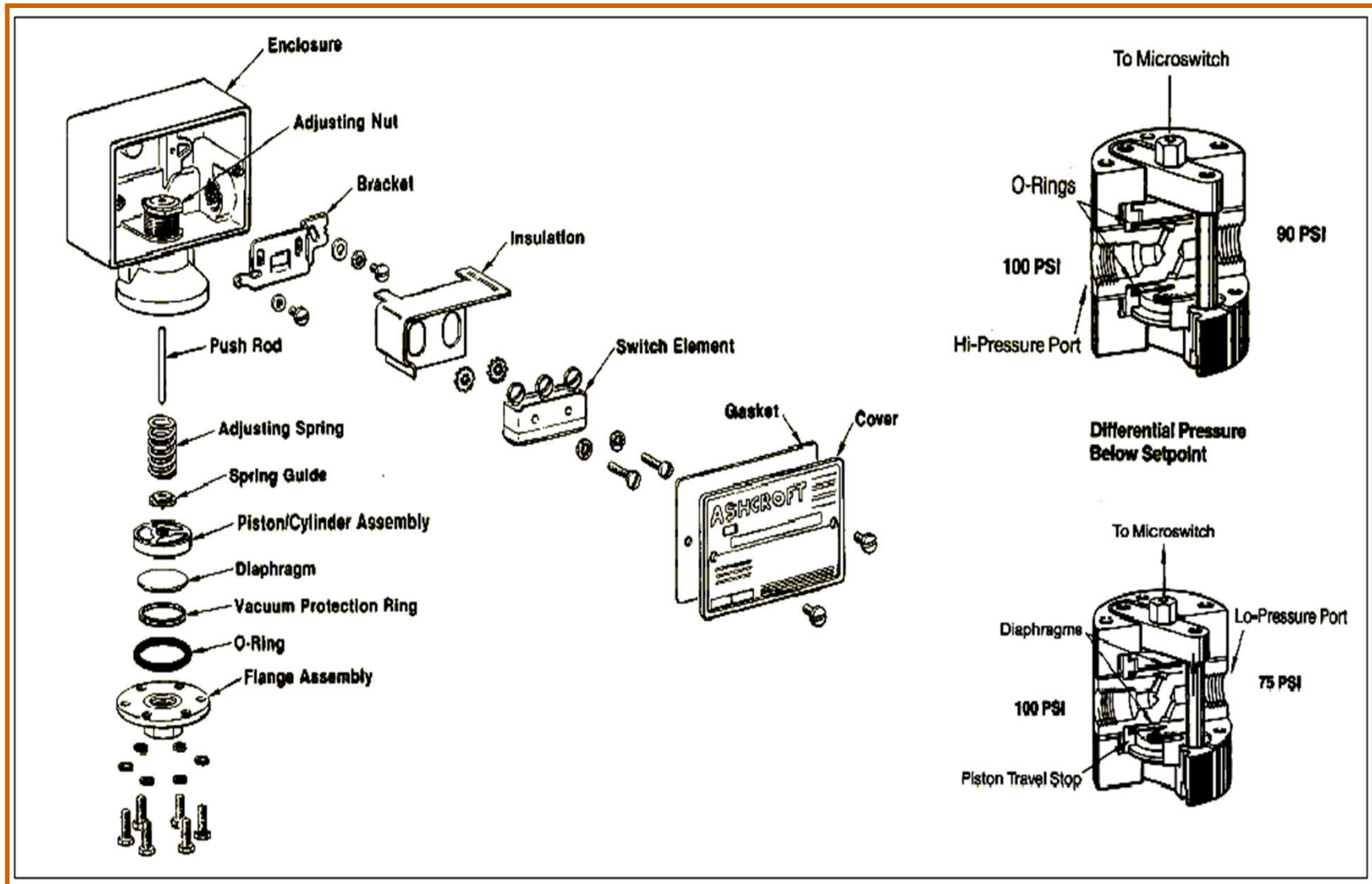
Two 3/4 NPT electrical conc connections.

Standard 316 SS pressure connection. Optional 1/2 NPT shown.

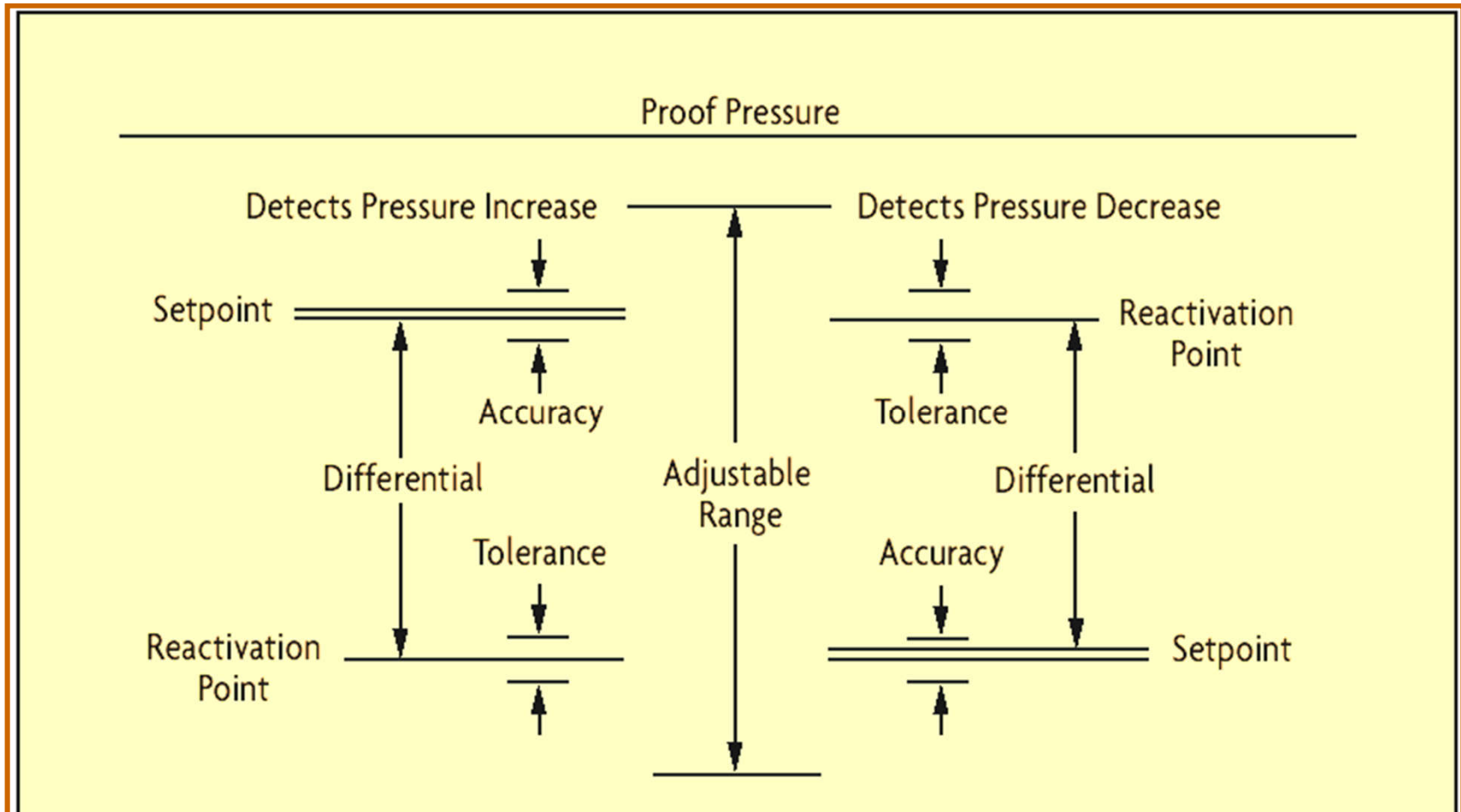
Accessible adjustment is stainless steel for corrosion resistance, includes vibration-resistant feature.



Pressure Switch Components

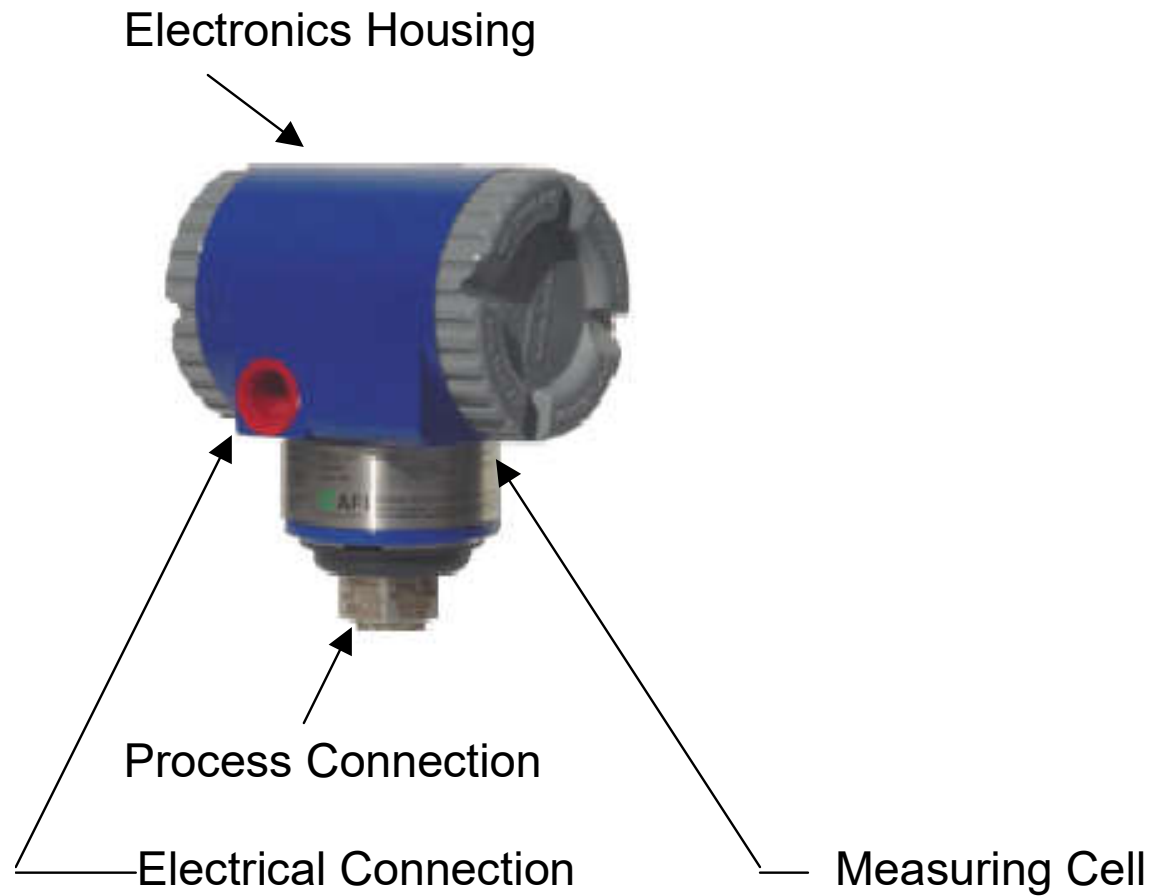


Pressure Switch Terminology



PRESSURE TRANSMITTERS

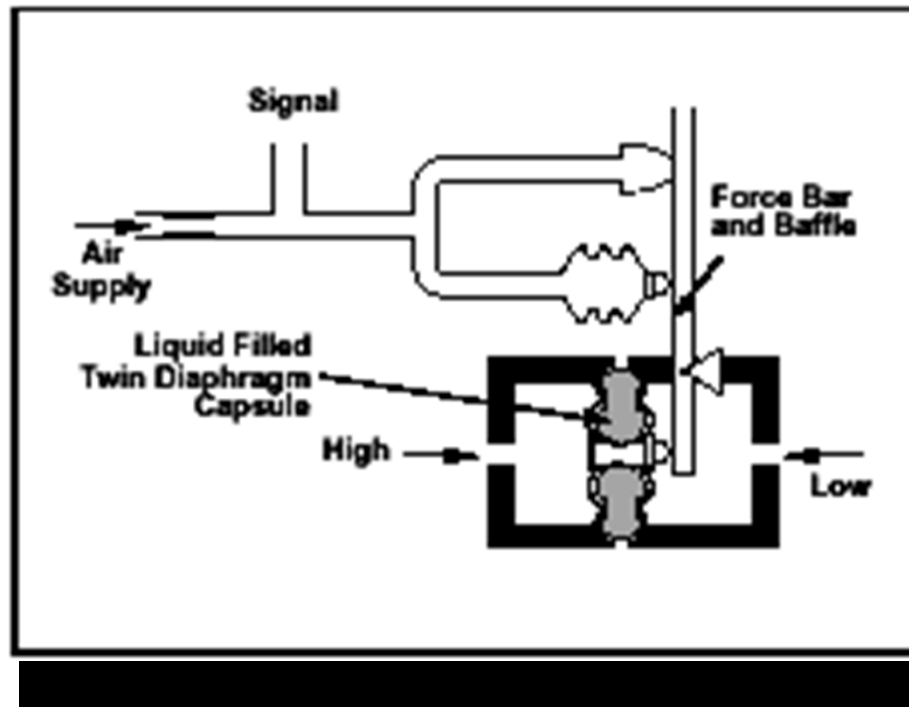
PRESSURE TRANSMITTERS



Pressure Transmitter

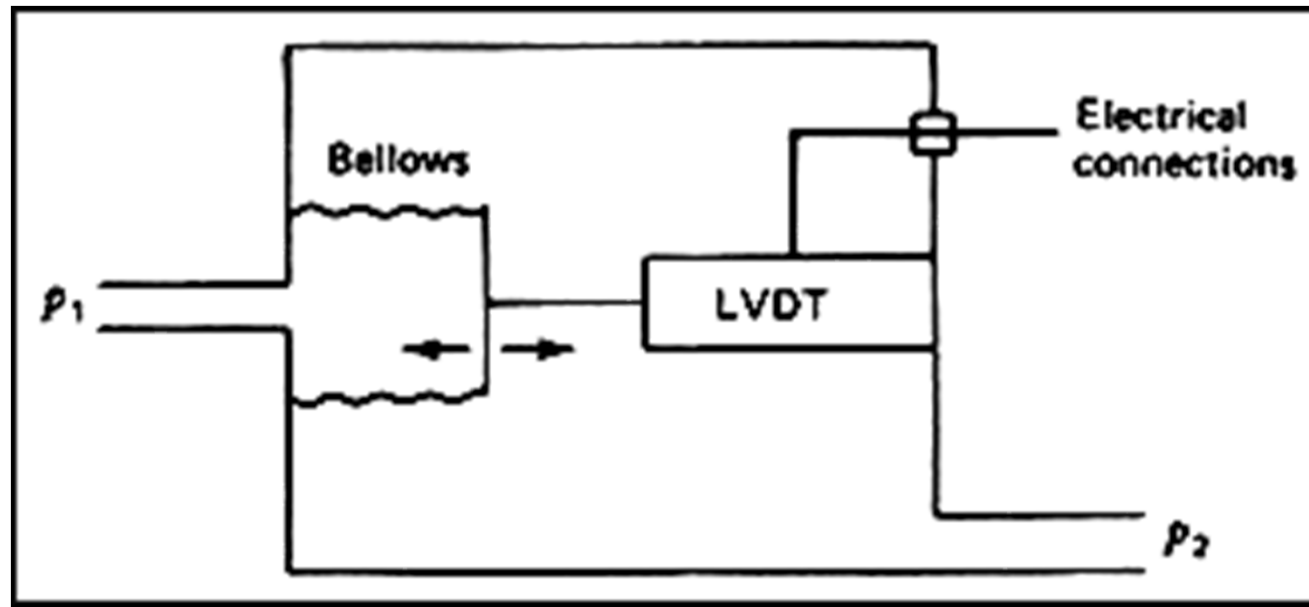
PNEUMATIC PRESSURE TRANSMITTERS

Pneumatic Pressure Transmitters Principle



ELECTRONIC PRESSURE TRANSMITTER

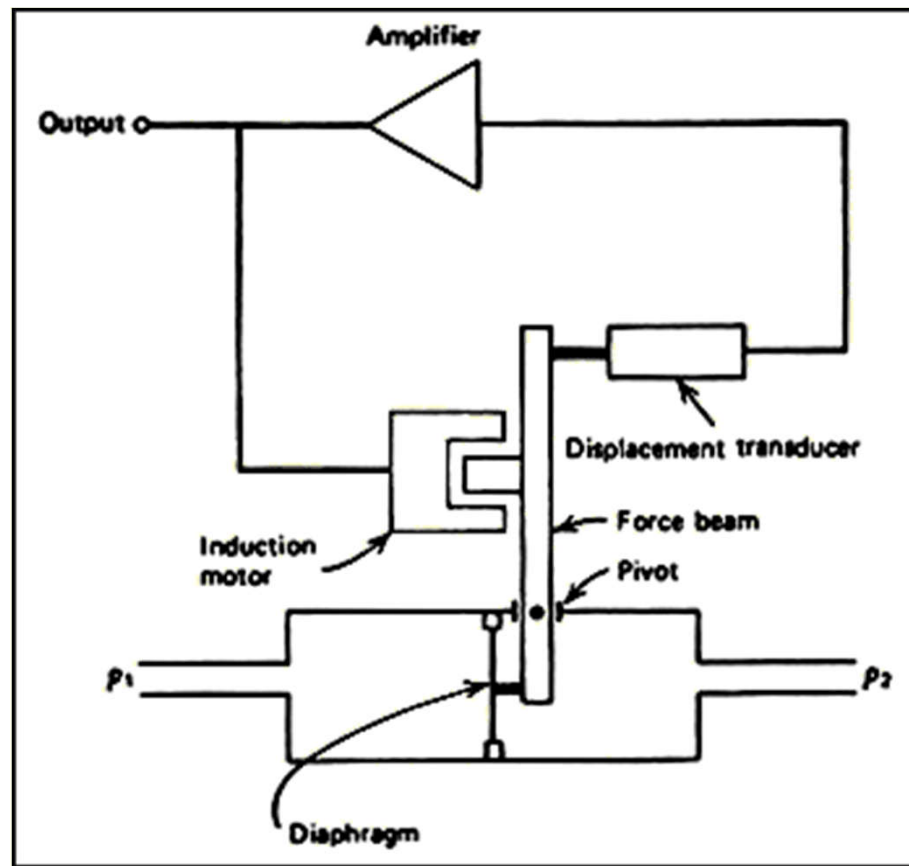
Principle of Operation -1



LVDT = Linear Voltage Differential Transformer

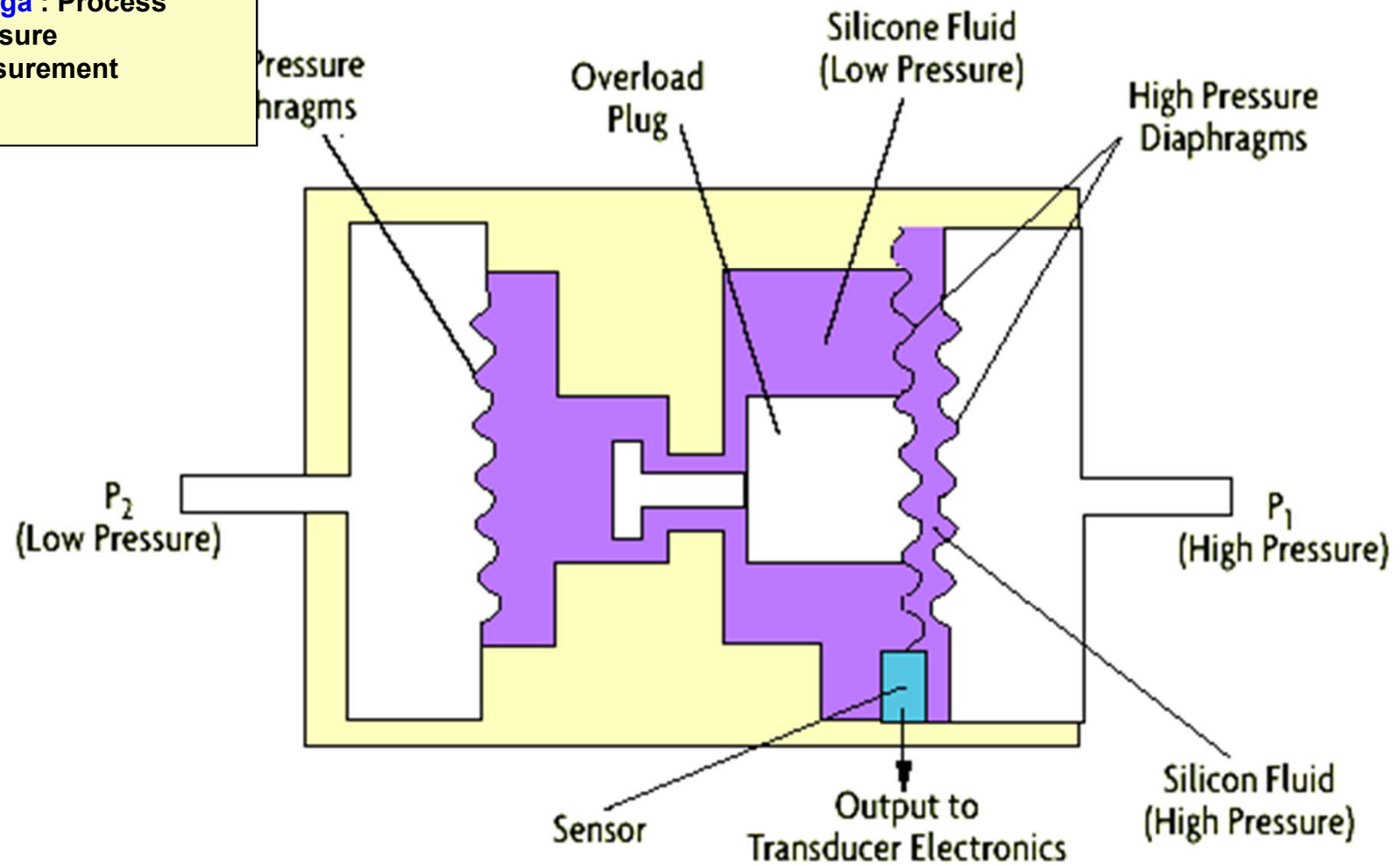
ELECTRONIC PRESSURE TRANSMITTER

Principle of Operation -2

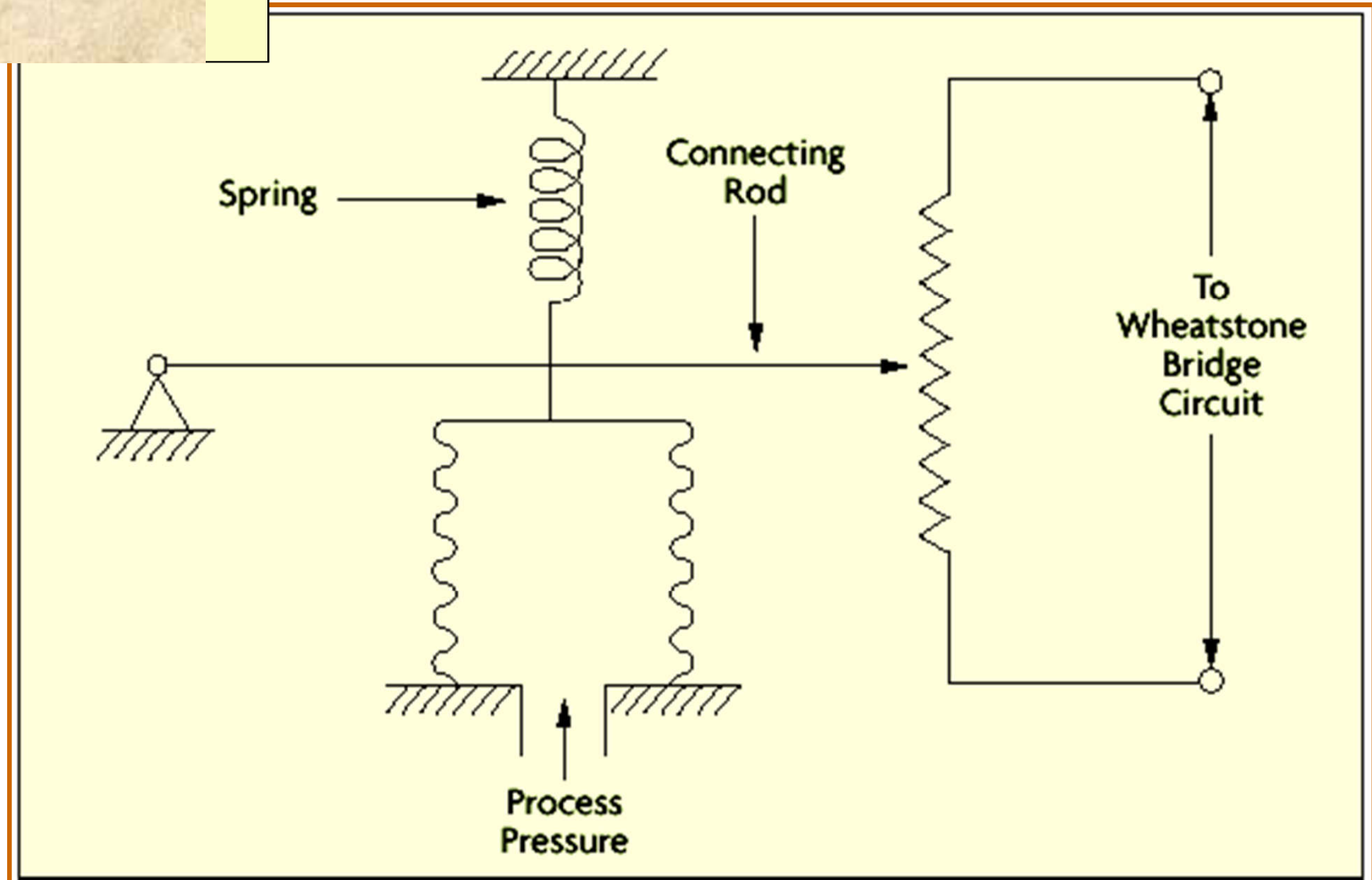


Strain Gauge-Based Pressure Cell

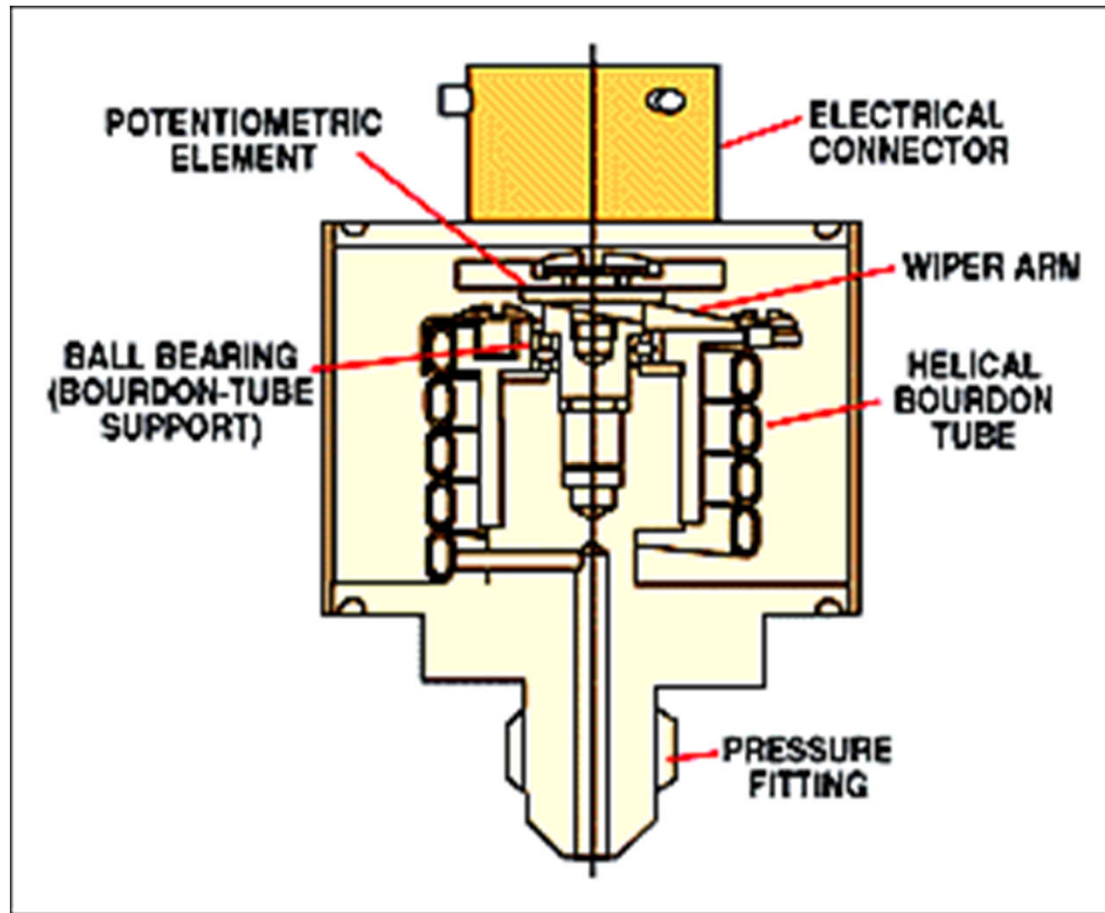
Omega : Process
Pressure
Measurement



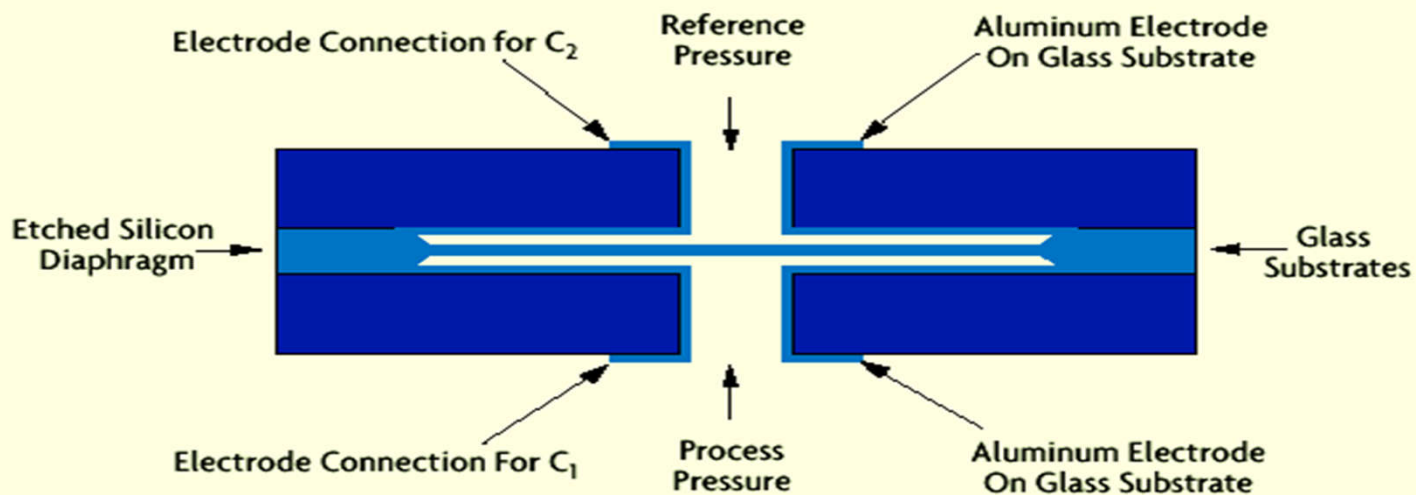
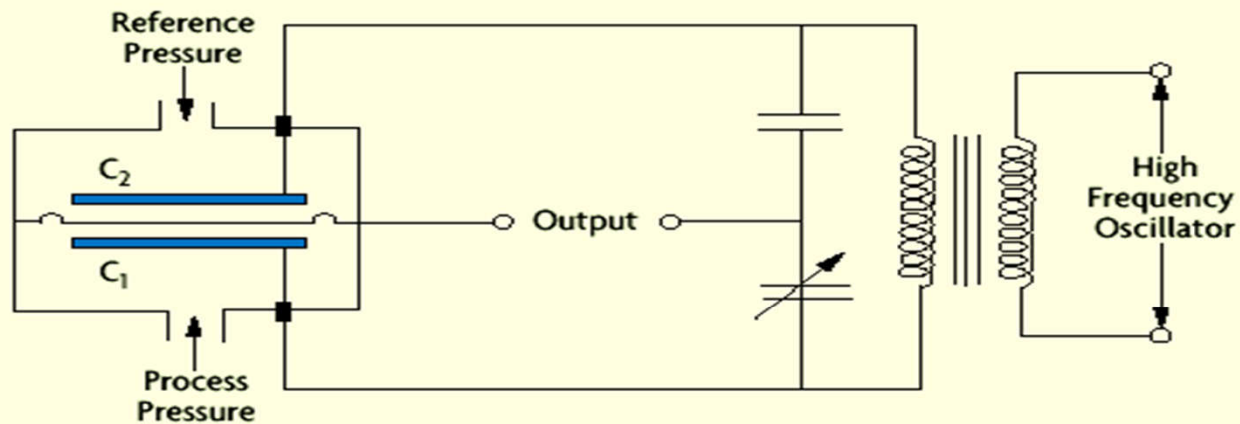
Potentiometric Pressure Transducer



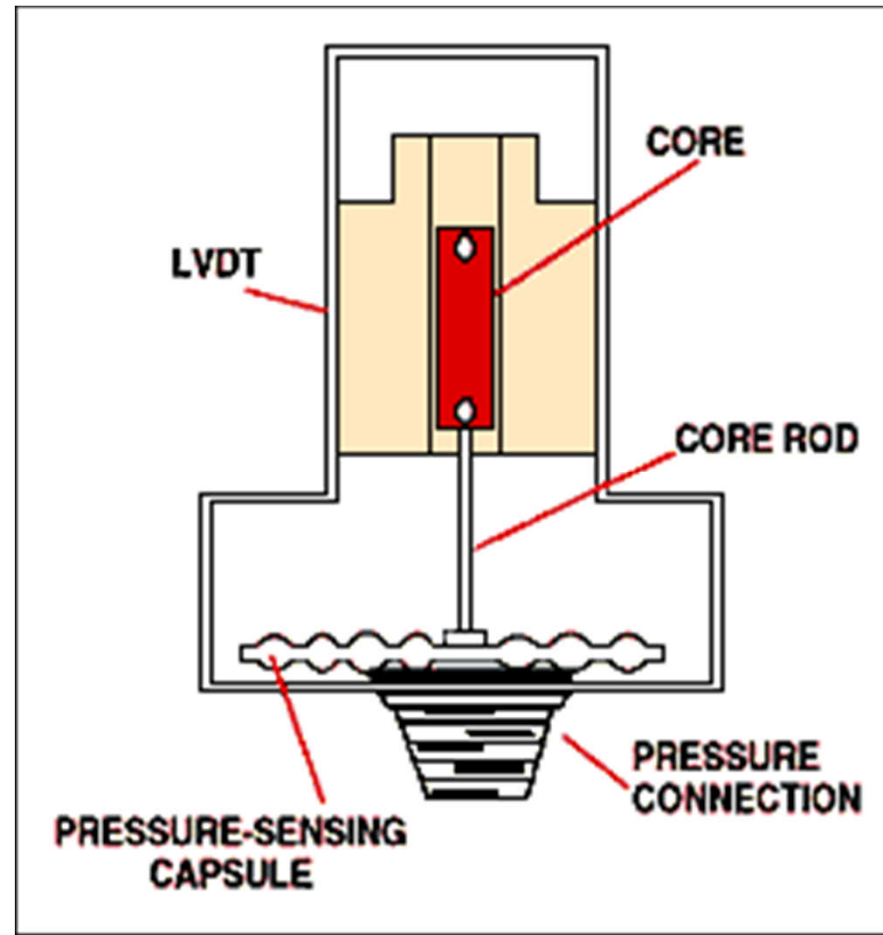
POTENTIOMETRIC PRESSURE TRANSMITTERS



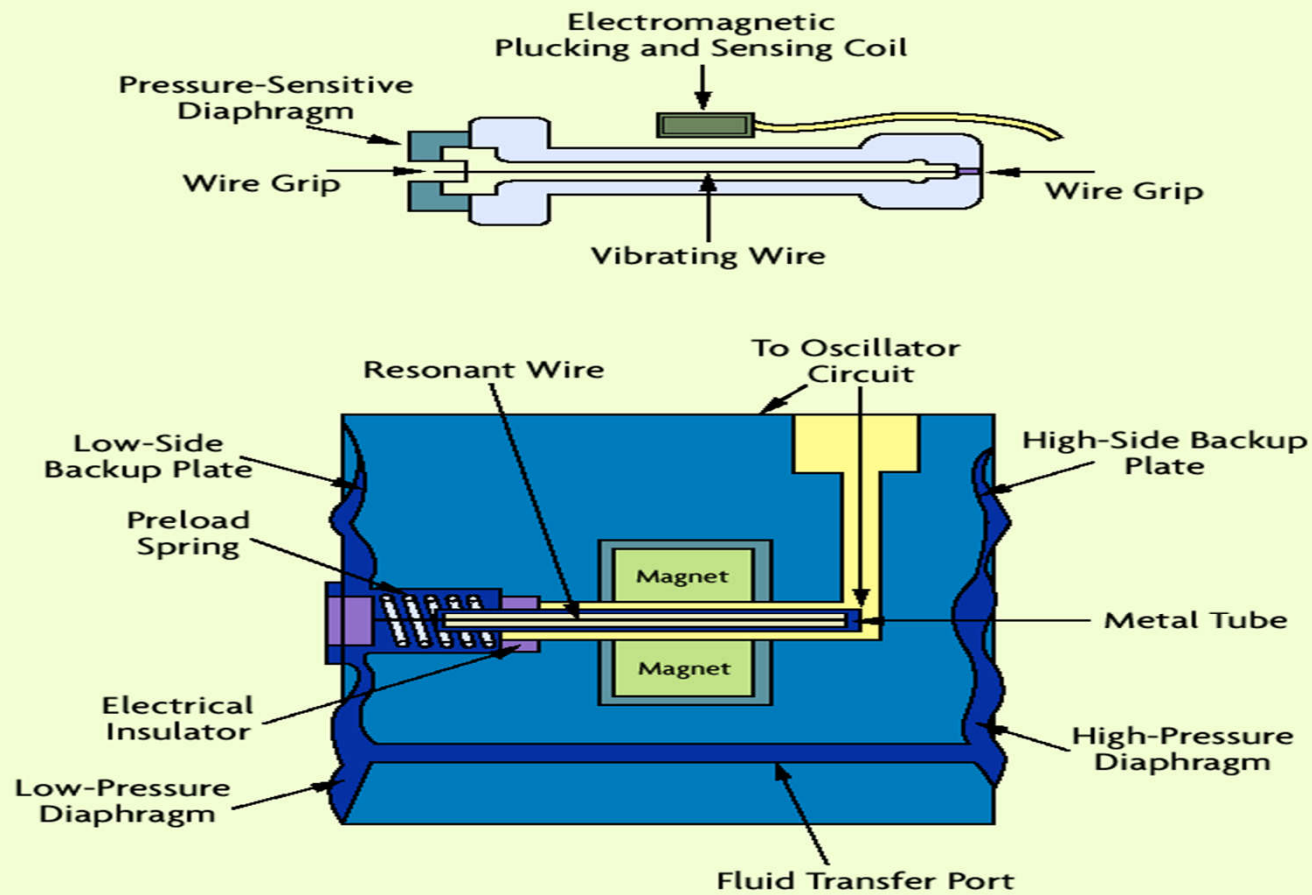
Capacitance Based Pressure Cell



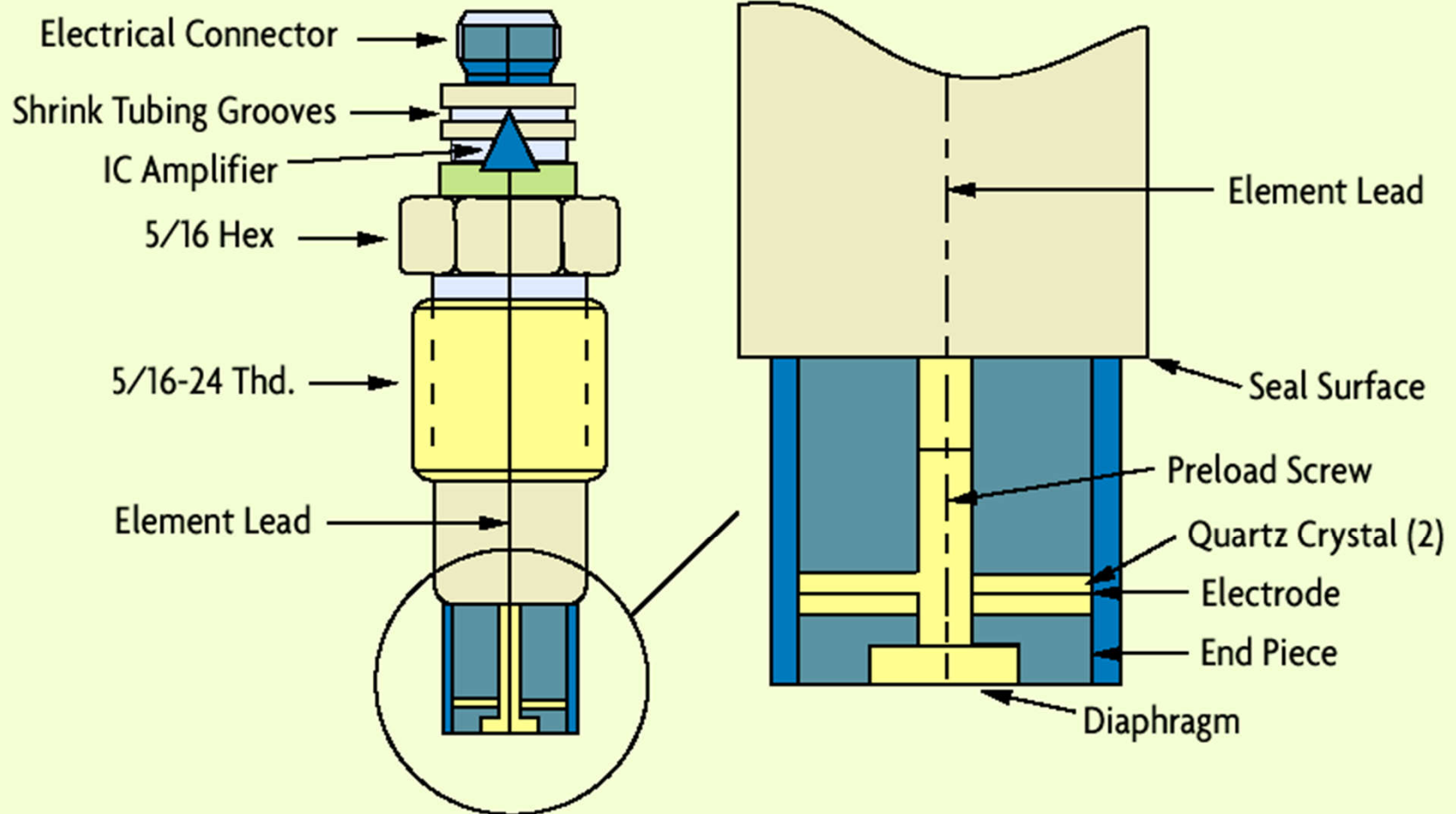
ELECTRONIC LVDT PRESSURE TRANSMITTERS



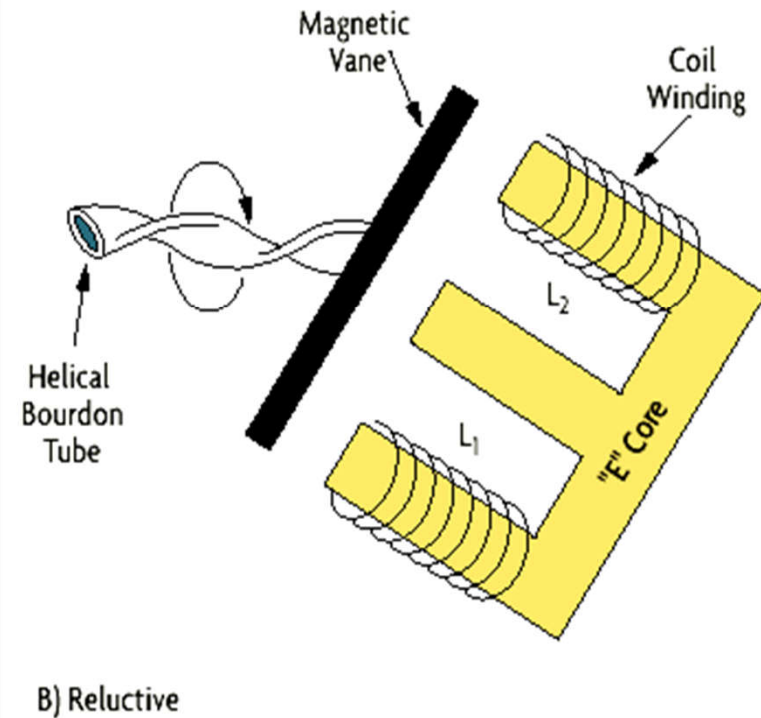
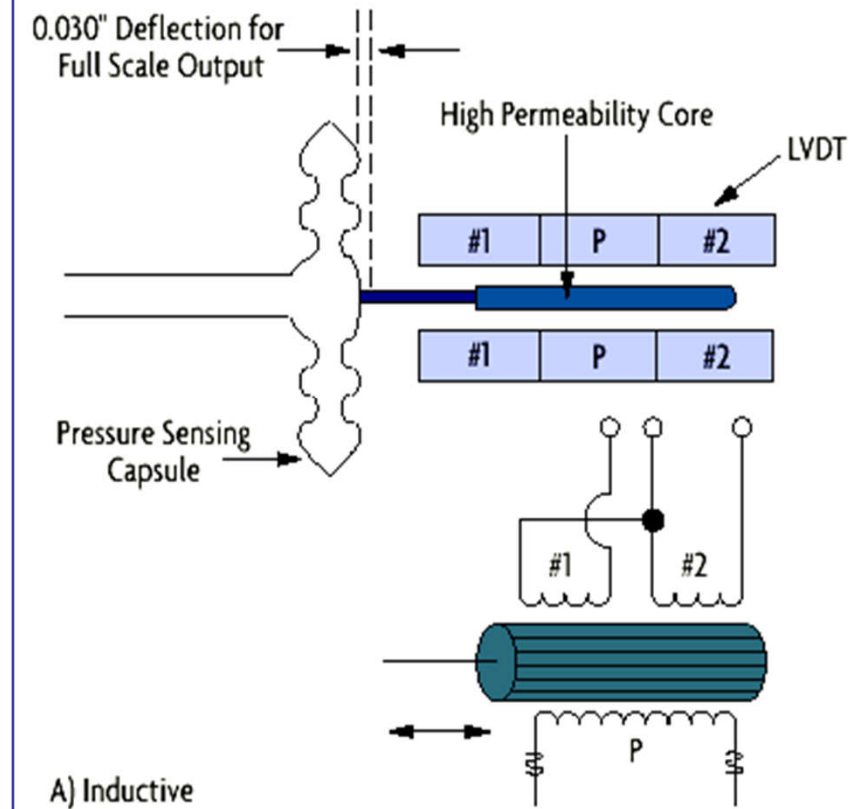
Resonant Wire Pressure Transducer



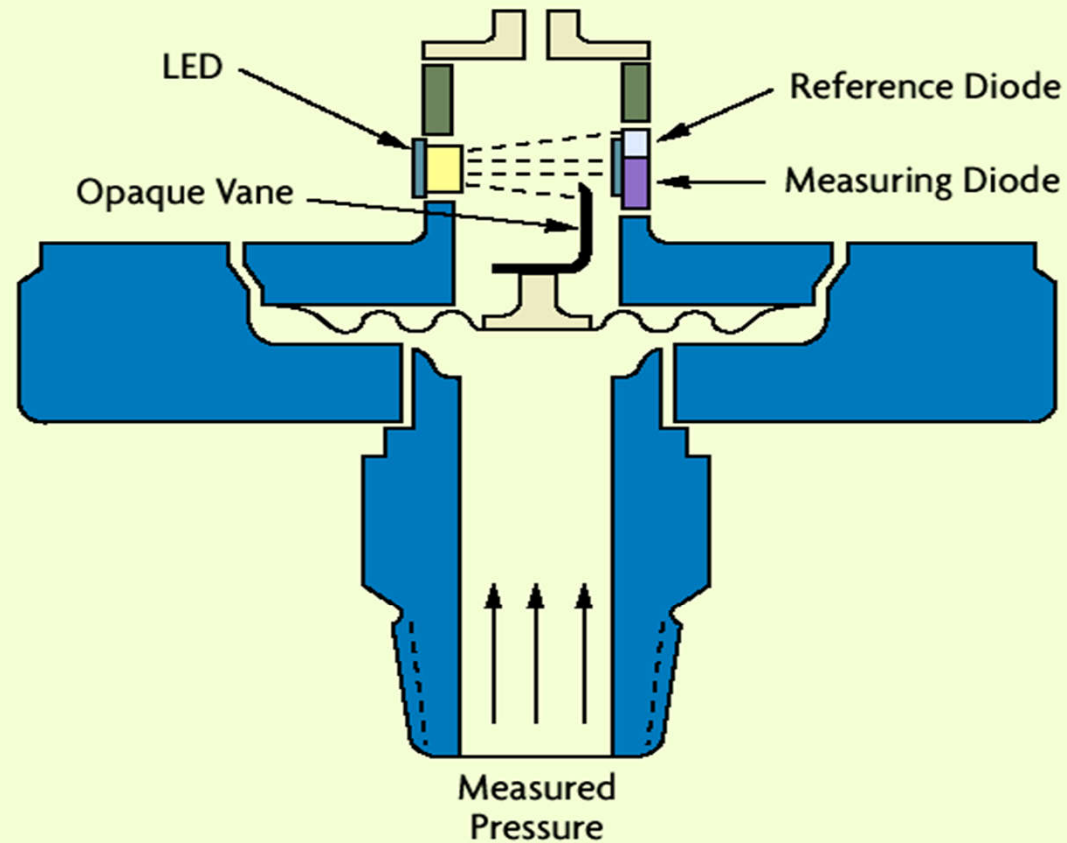
Piezoelectric Pressure Sensor



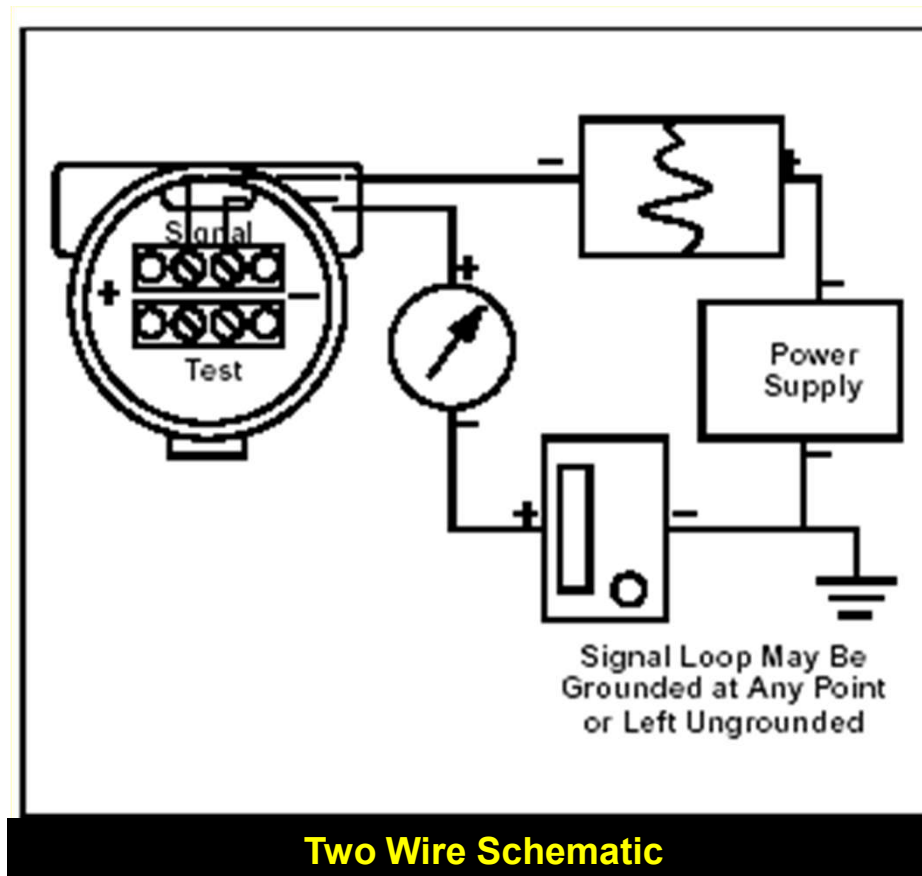
Magnetic Pressure Transducer



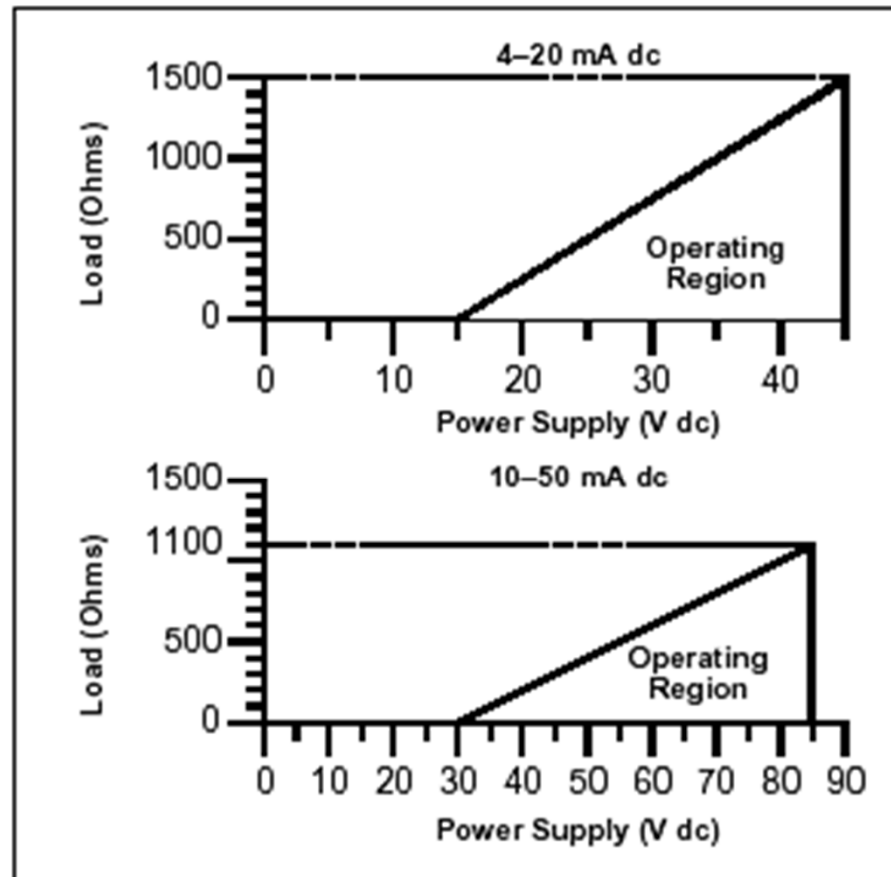
Optical Pressure Transducer



PRESSURE INSTRUMENT LOOP

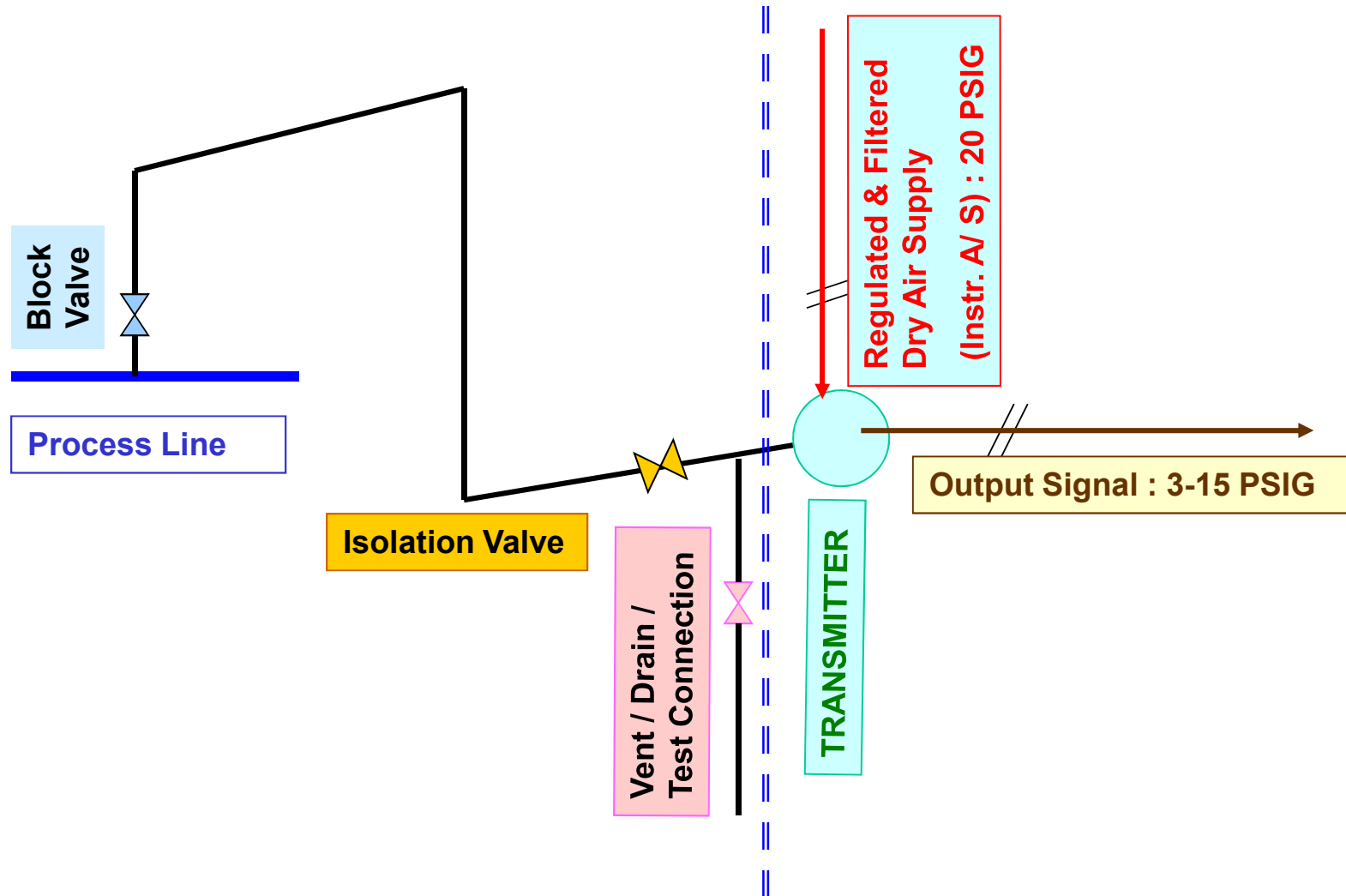


PRESSURE TRANSMITTER POWER

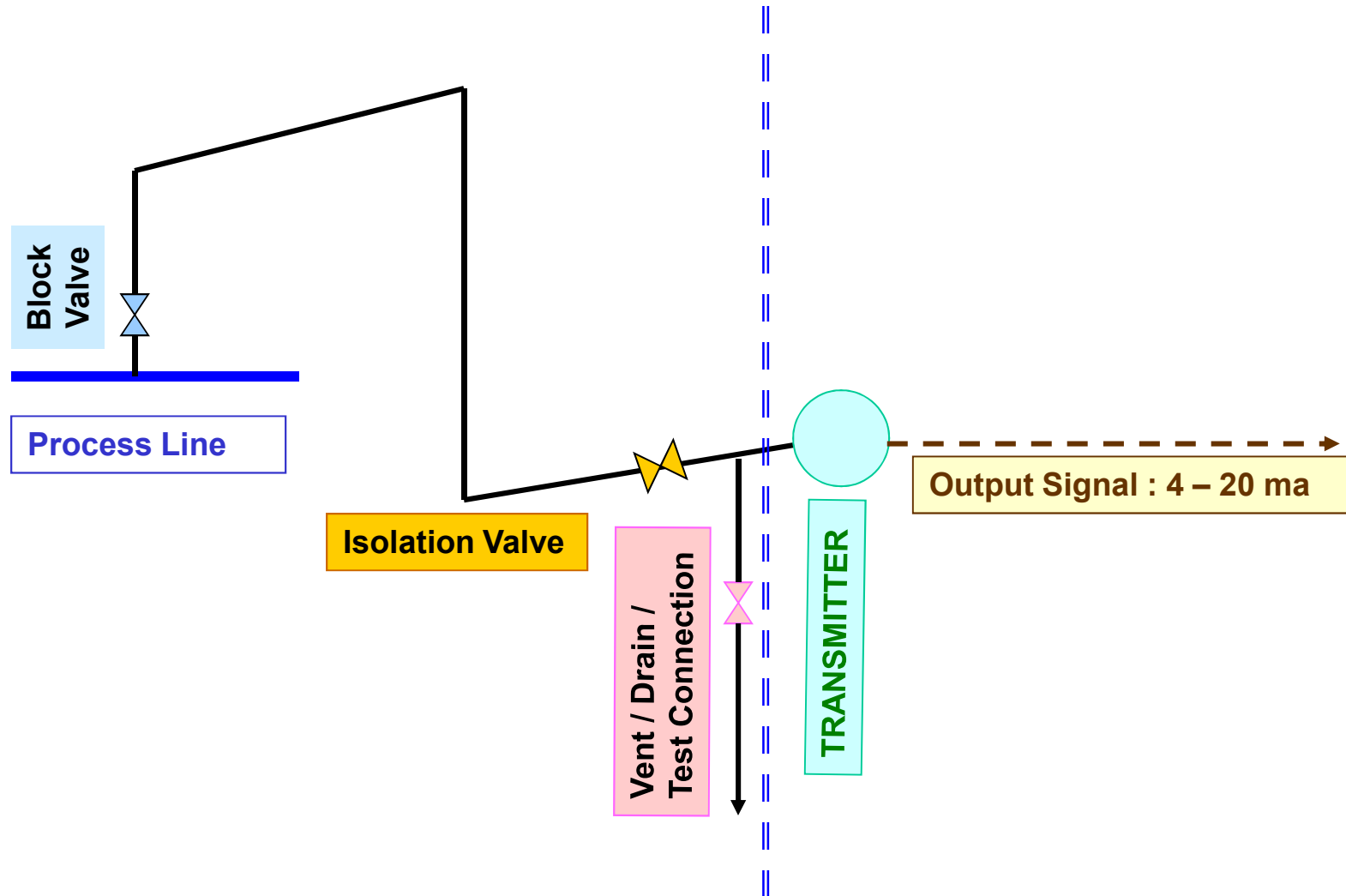


Load imitation

Pneumatic Transmitter Installation



Electronic Transmitter Installation

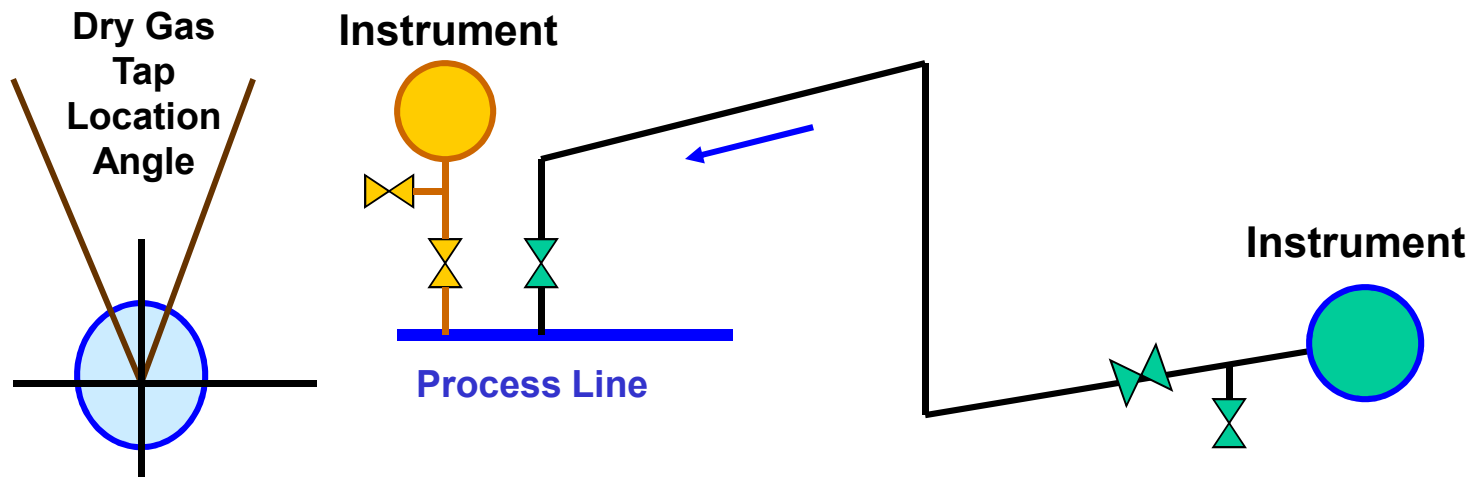


Notes On Transmitter Installation - 1

• DRY GAS SERVICE:

- Process Tap shall be vertical from top of line.
- The Instrument to be mounted above line if visibility & accessibility are maintained.
- If instrument is to be mounted below the line, Process Tap shall be vertical from top of line, then inclined towards the line, then vertical down to the location of the instrument.

This is to ensure any moisture or vapor condensate will return back to the process line, therefore eliminating pockets in the instrument process impulse lines.

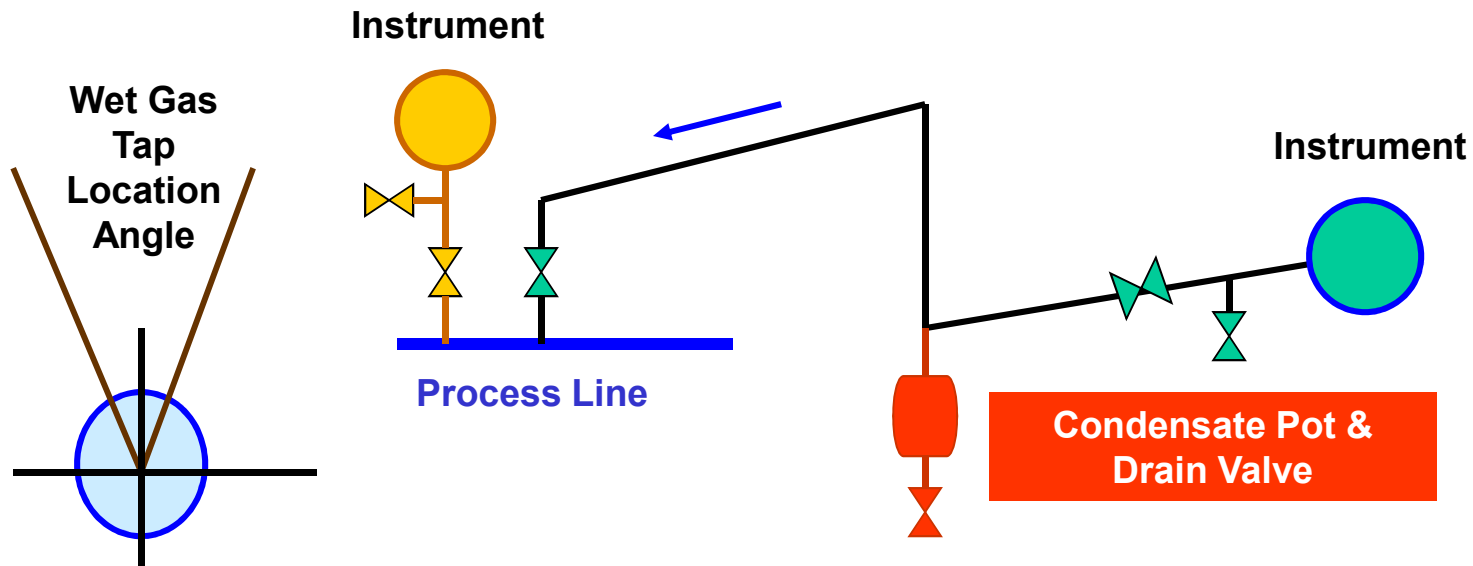


Notes On Transmitter Installation - 2

• WET GAS SERVICE:

- Process Tap shall be vertical from top of line.
- The Instrument to be mounted above line if visibility & accessibility are maintained.
- If instrument is to be mounted below the line, Process Tap shall be vertical from top of line, then inclined towards the line, then vertical down to the location of the instrument.
- A condensate pot with drain valve shall be added at lower part of impulse lines.

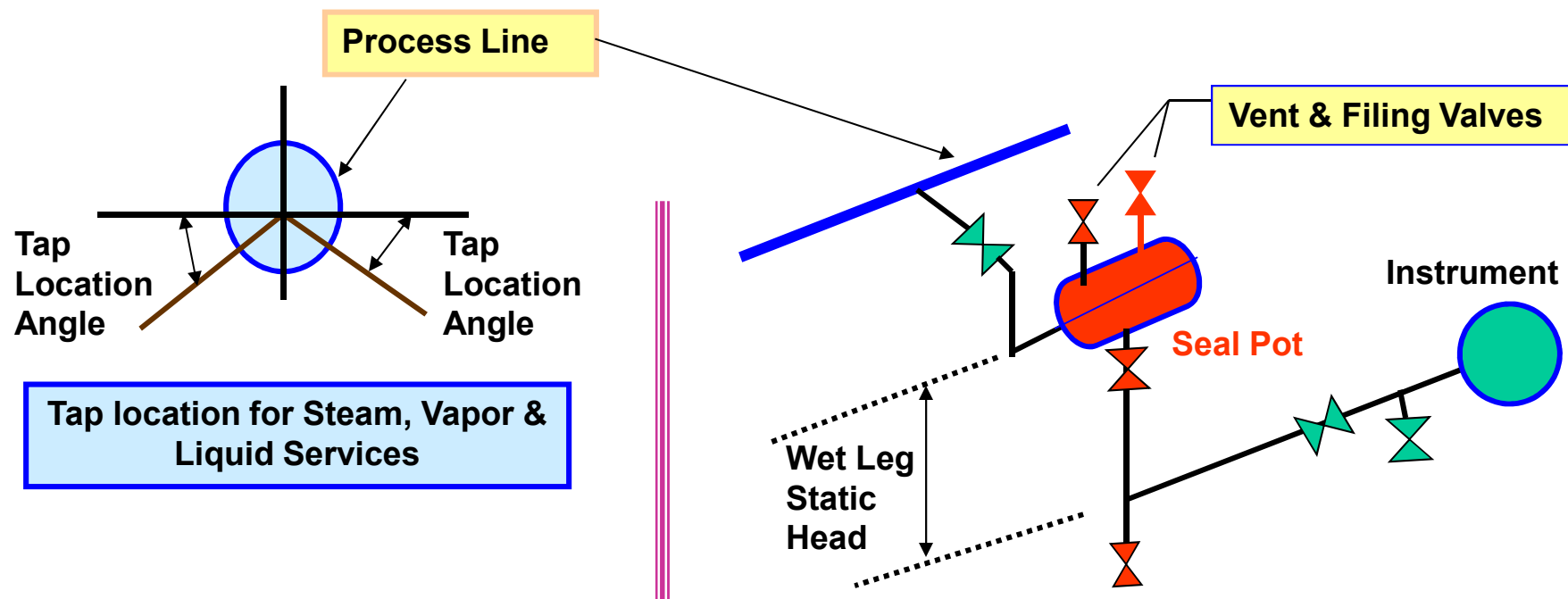
This is to ensure any moisture or vapor condensate will return back to the process line, therefore eliminating pockets in the instrument process impulse lines.



Notes On Transmitter Installation - 3

• VAPOR OR STEAM SERVICE:

- Process Tap shall be **as indicated in the left sketch below.**
- The Instrument to be mounted below line with Condensate / seal pot as indicated on the right sketch below.
- Wet leg shall be taken into consideration in the instrument calibration.

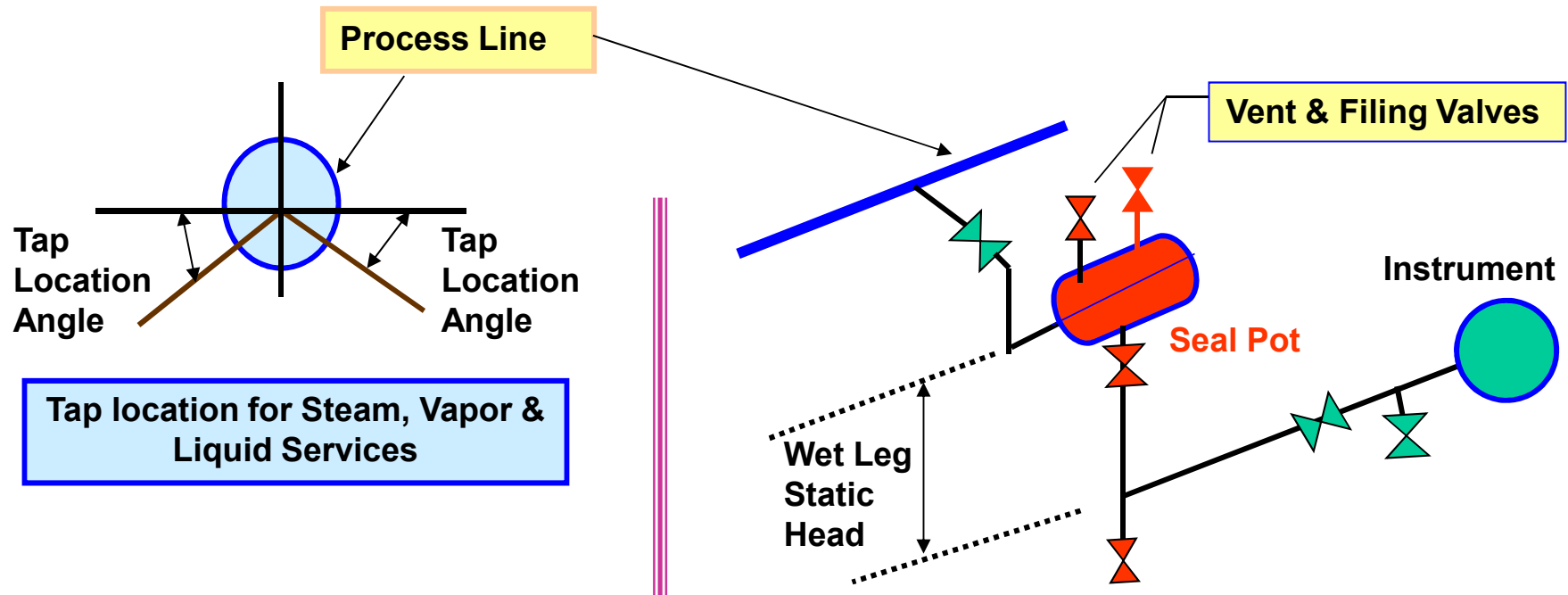


Seal pots are used for : (a) Steam or vapor applications (b) Isolation of Instrument from direct contact with process fluid

Notes On Transmitter Installation - 4

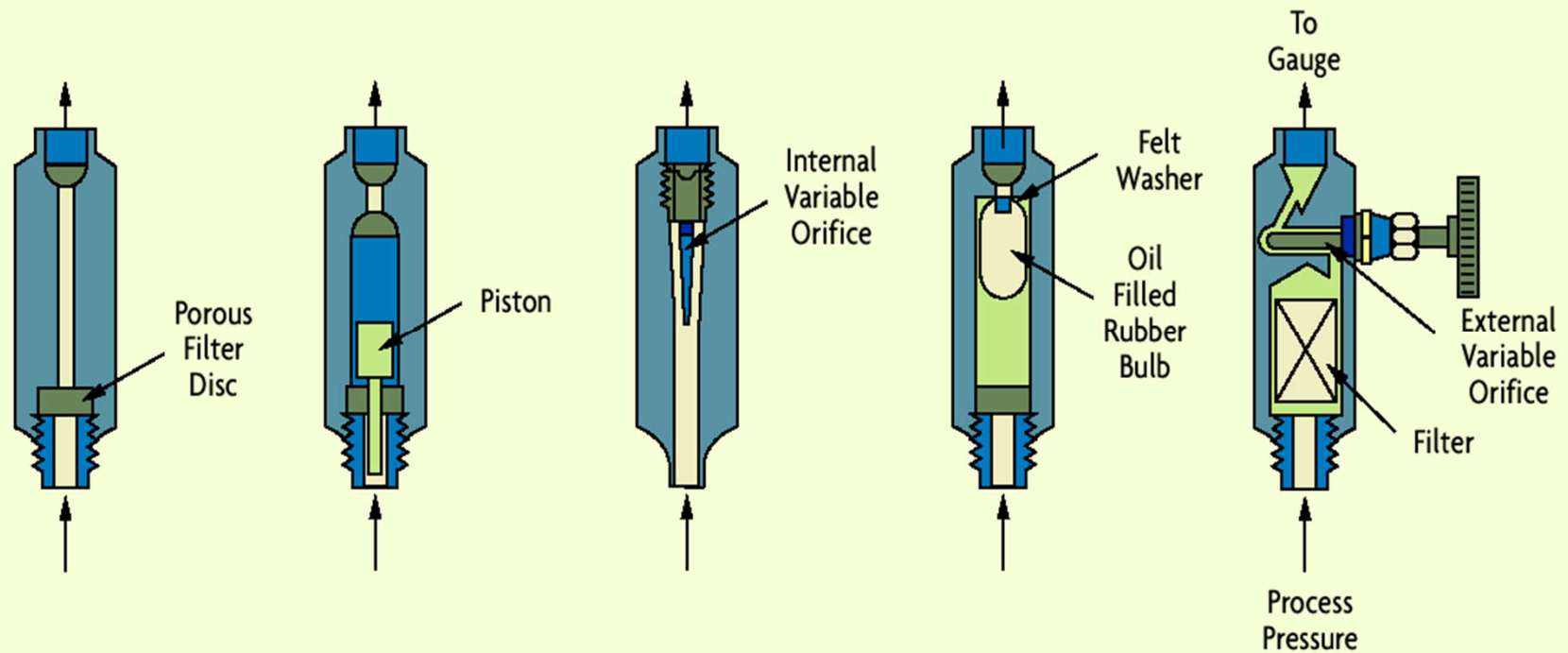
• LIQUID SERVICE:

- Process Tap shall be **as indicated in the left sketch below.**
- The Instrument to be mounted below line
- Seal pot - as indicated on the right sketch below- shall be used for corrosive liquids services.
- Wet leg static head shall be taken into consideration in the instrument calibration.

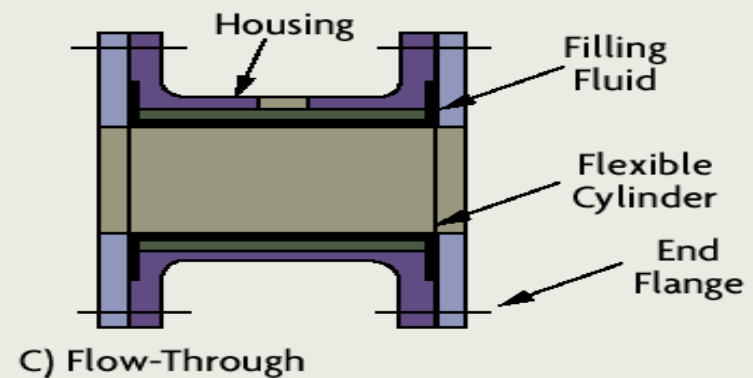
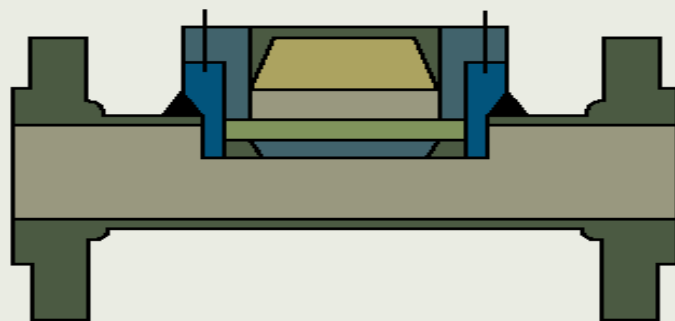
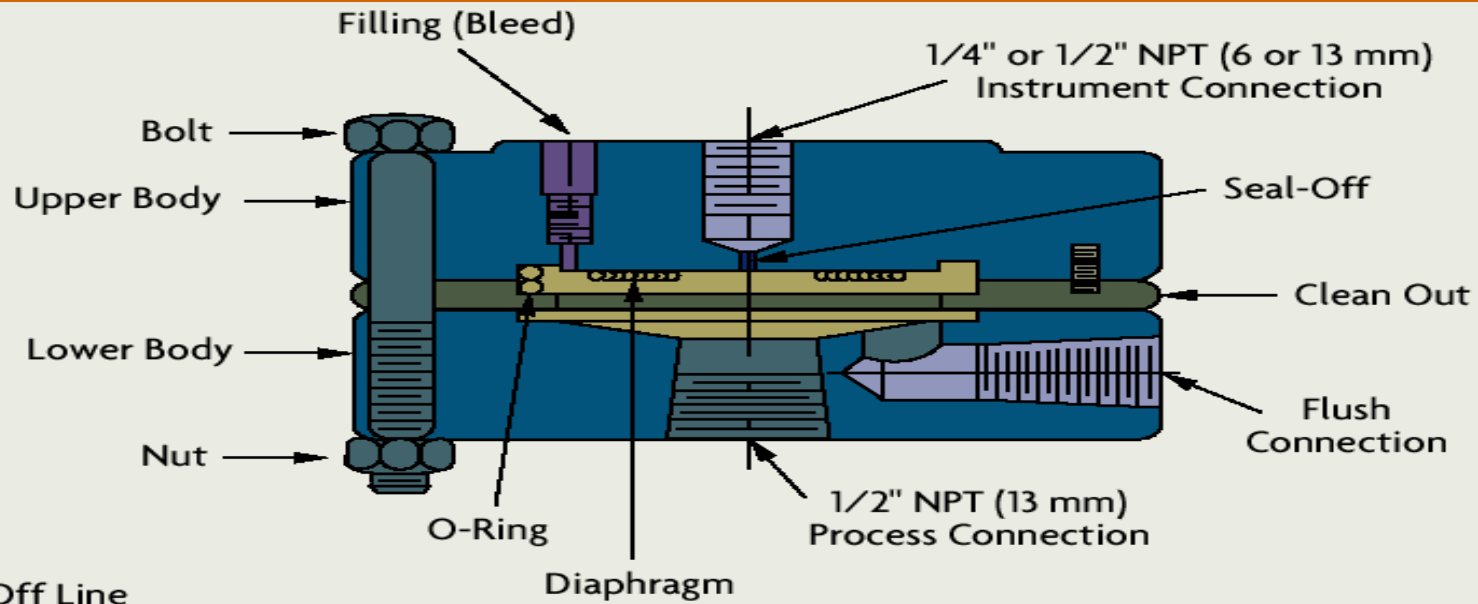


Seal pots are used to Isolation of Instrument from direct contact with process fluid

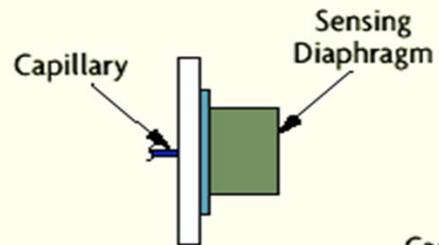
PULSATION DAMPER & SNUBBER DESIGNS



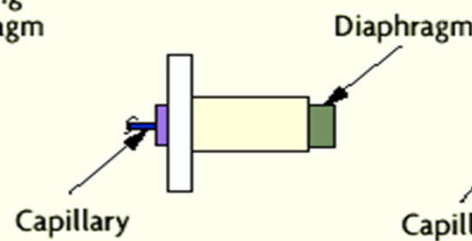
CHEMICAL SEAL DESIGNS



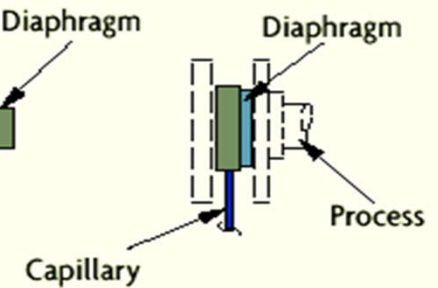
VOLMETRIC SEAL ELEMENT DESIGNS



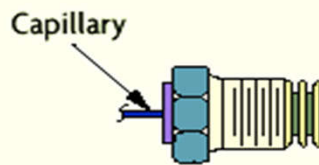
EXTENDED
DIAPHRAGM



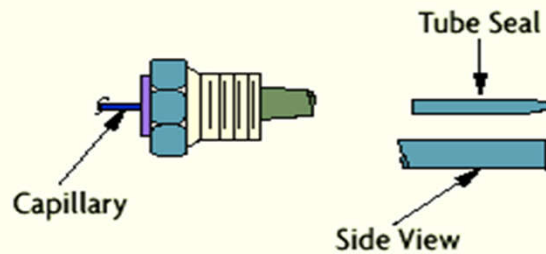
FLANGED AND SCREWED
BUTTON DIAPHRAGMS



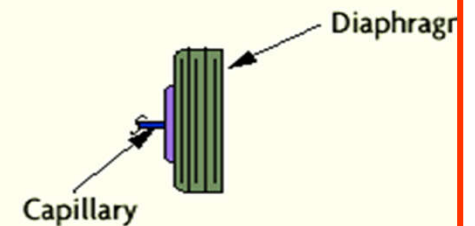
WAFER ELEMENT



BELLOWS-TYPE
SEAL



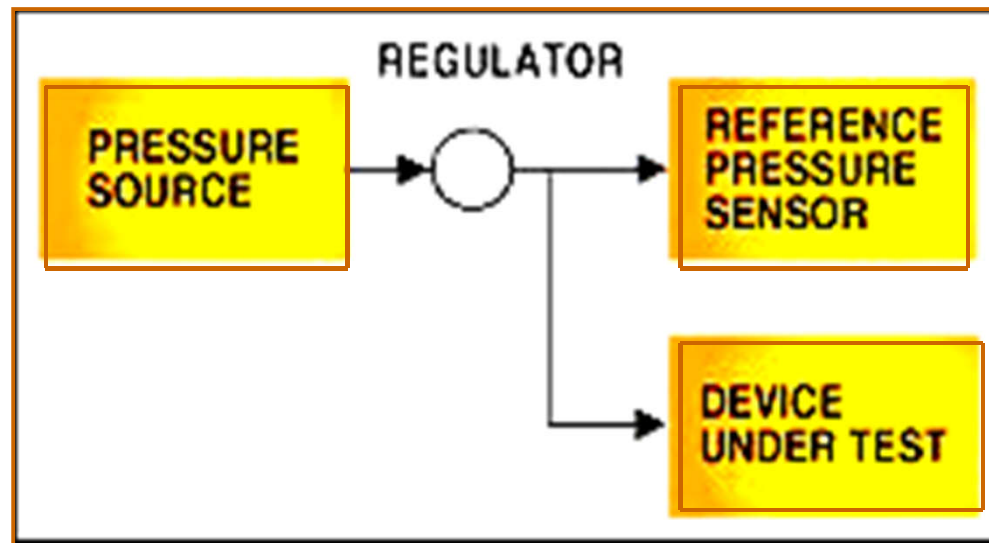
BOURDON-TYPE
SEAL



SCREWED SANITARY
ELEMENT

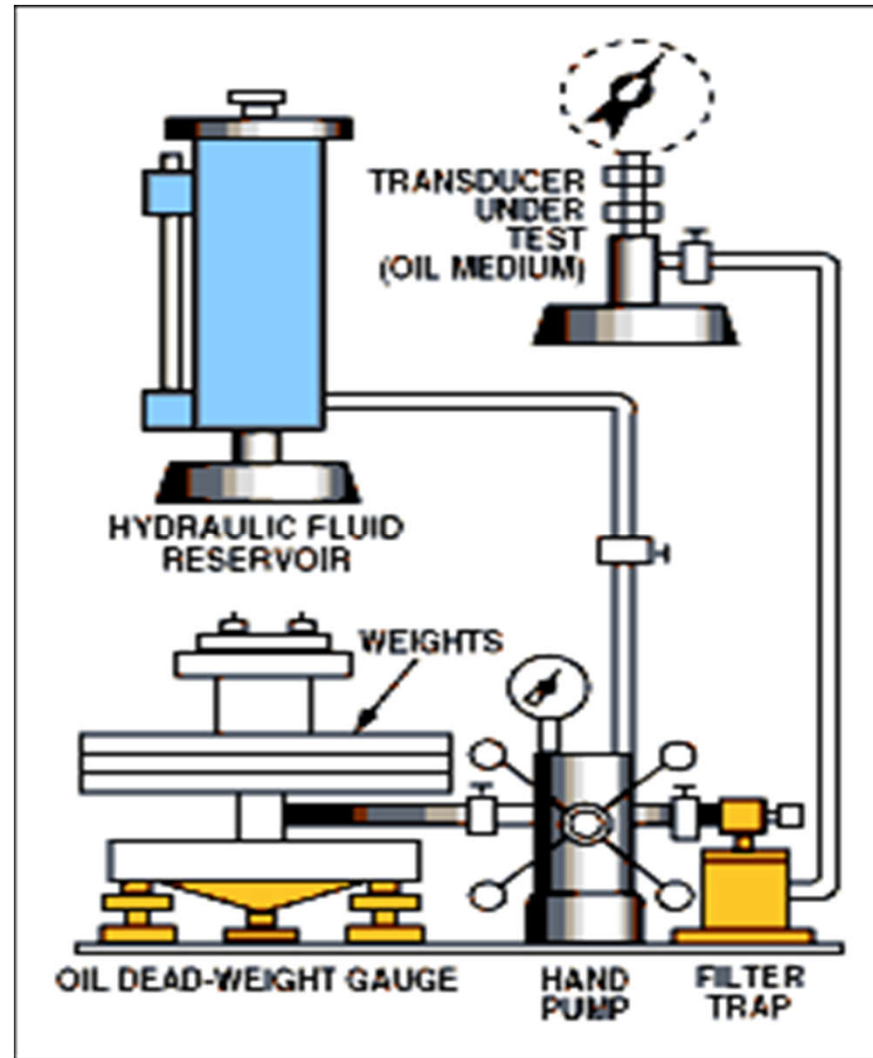
PRESSURE INSTRUMENTS TESTING

Pressure Instruments Testing Principle



PRESSURE INSTRUMENTS TESTING

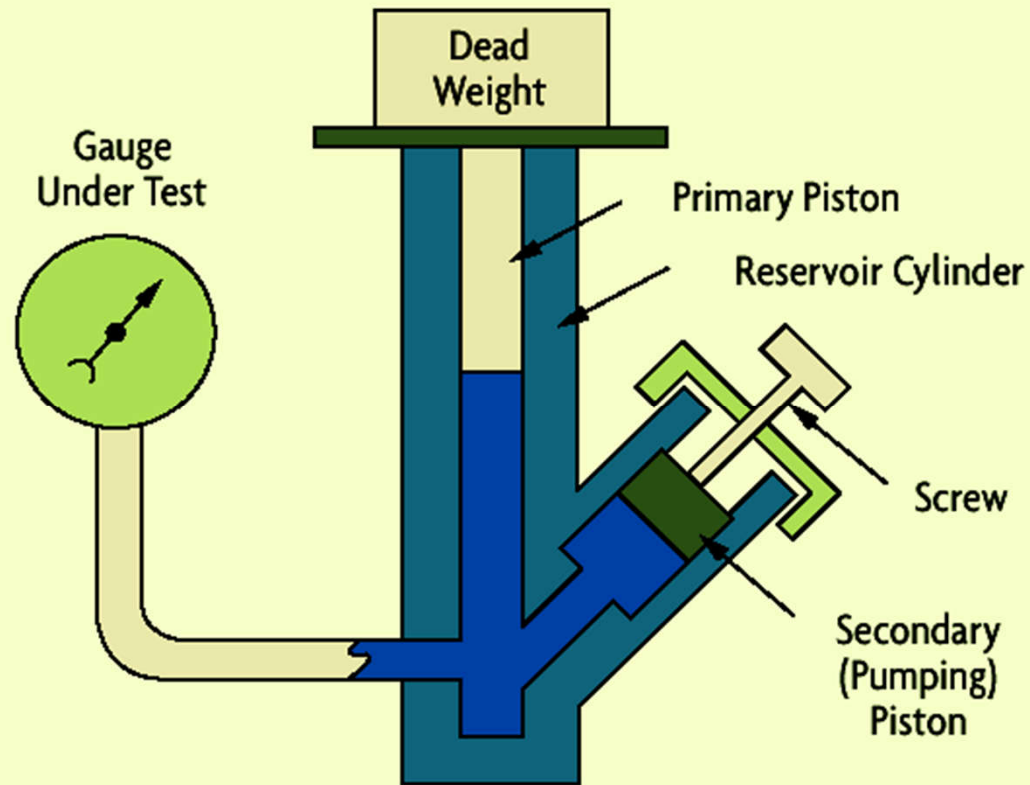
Pressure Instruments Testing : Dead Weight Tester -1



PRESSURE INSTRUMENTS TESTING

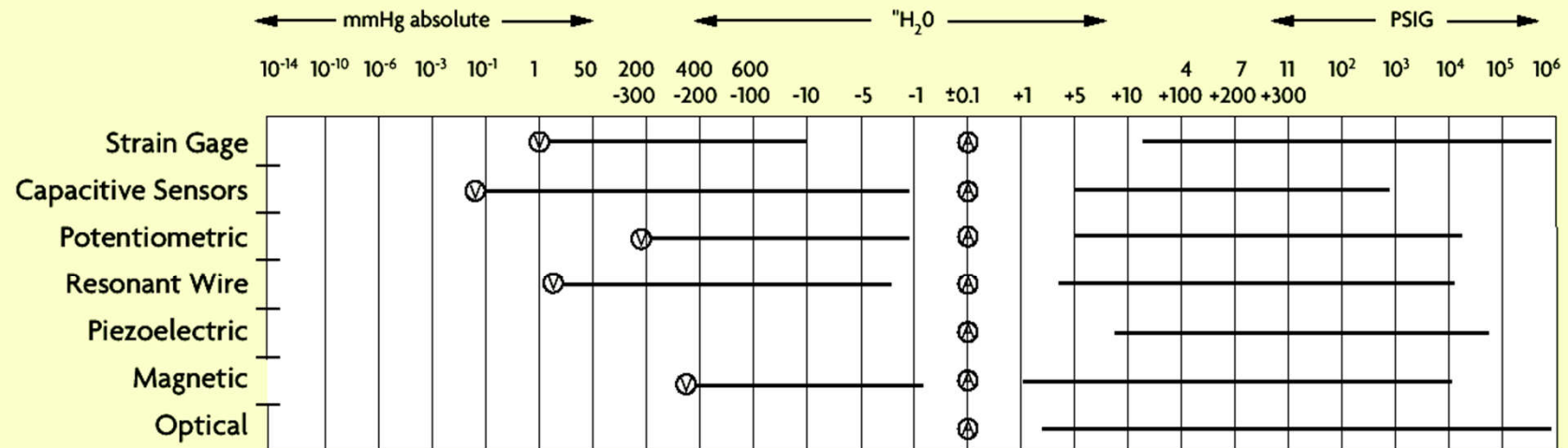
DEAD WEIGHT TESTER -2

Omega : Process
Pressure
Measurement



Electronic Pressure Sensor Ranges

Omega : Process Pressure Measurement

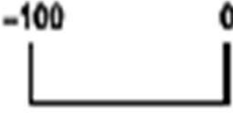


ⓧ Indicates that the device uses full-vacuum reference in its operation

Ⓐ Indicates that the instrument uses atmospheric pressure reference

RANGE & SPAN TERMINOLOGY

TABLE 1. Illustrations of the Use of Range and Span Terminology.

Typical Ranges	Name	Range	Lower Range Value	Upper Range Value	Span	Supplementary Data
	—	0 to 100	0	100	100	—
	Suppressed Zero Range	20 to 100	20	100	80	Suppressed Ratio = 0.25
	Elevated Zero Range	-25 to 100	-25	100	125	—
	Elevated Zero Range	-100 to 0	-100	0	100	—
	Elevated Zero Range	-100 to -20	-100	-20	80	—

MISCELLANEOUS

OPERATING CONDITIONS

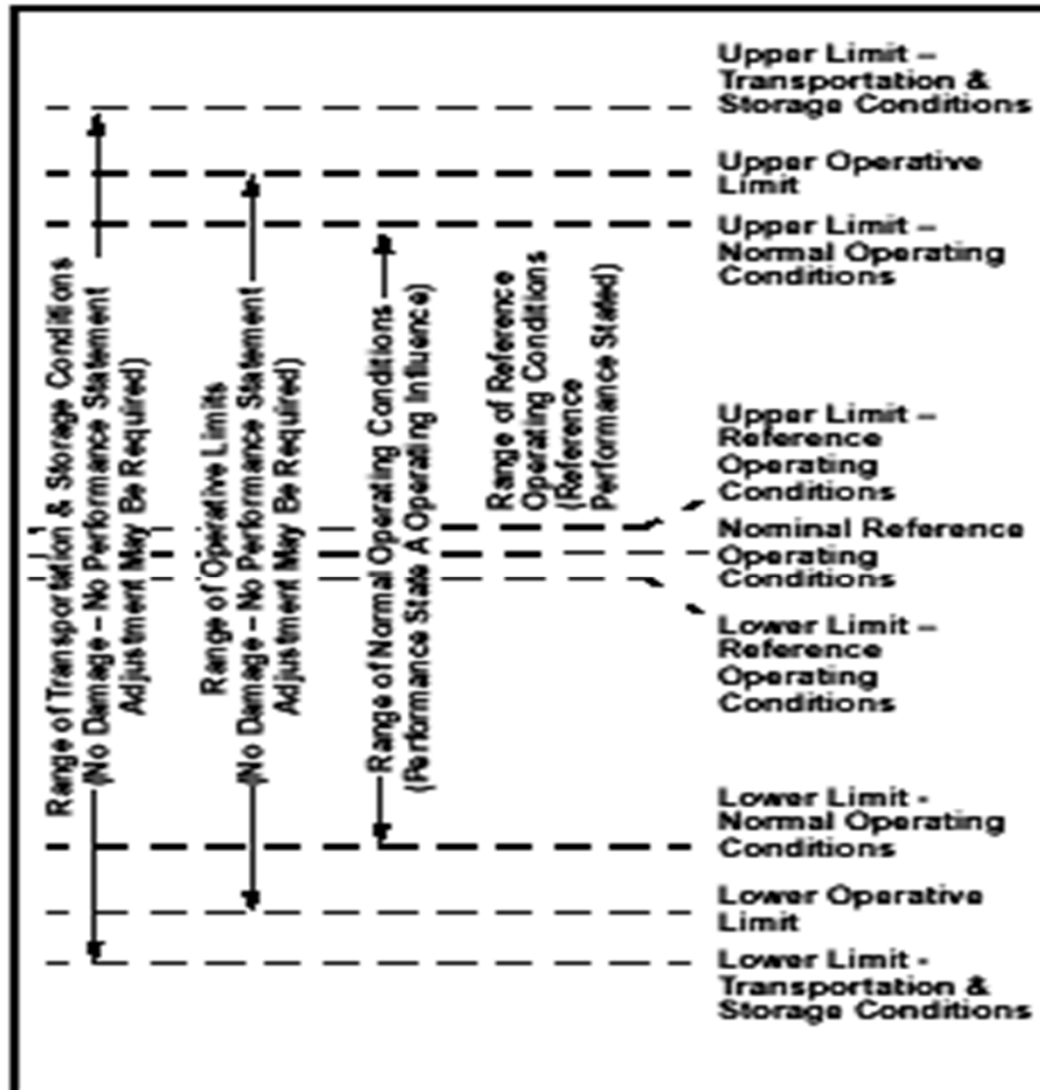


FIGURE 10. Diagram of Operating Conditions.

PRESSURE GAUGE STD RANGES

STANDARD RANGES										
Pressure Range	Figure Interval	Minor Graduation	Compound Range		Figure Interval		Minor Graduation			
					Inches Mercury	psi	Inches Mercury	psi		
0/15	1	0.2	30" Hg vac./0/15psi 30" Hg vac./0/30psi 30" Hg vac./0/60psi 30" Hg vac./0/100psi 30" Hg vac./0/150psi 30" Hg vac./0/300psi		5	3	1	0.5		
0/30	5	0.5			10	5	1	1		
0/60	5	1			10	10	2	1		
0/100	10	1			10	10	2	1		
0/160	20	2			10	20	5	2		
0/200	20	2			30	25	5	5		
0/300	30	5			Combination Range		Figure Interval		Minor Graduation	
0/400	50	5								
0/600	50	10	Inner Scale psi		Outer Scale Feet Water		psi		Feet Water	
0/800	100	10								
0/1000	100	10	0/15		0/34		3		5	
0/1500	200	20								
0/2000	200	20	0/30		0/70		5		10	
0/3000	300	50								
0/5000	500	50	0/60		0/140		5		20	
0/6000	1000	100								
0/7500	1000	100	0/100		0/230		10		20	
0/10,000	1000	100								
0/15,000	2000	200	0/160		0/370		20		50	
0/20,000	2000	200								
			0/200		0/460		20		50	
			0/300		0/690		25		50	
Vacuum Range	Figure Interval	Minor Graduation	Dial Size	Retard Range						
30-0 inches Mercury	5 inches	0.5 inches	4½"	0/15 psi retard to 30 psi 0/30 psi retard to 60 psi		10" Hg Vac/5 psi retard to 30" Hg and to 15 psi				

PRESSURE GAUGE : CASE SEECT & MOUNT

TABLE A – CASE SELECTION AND MOUNTING

Dial ⁽¹⁾ Size (Inches)	Order Code	Case Type	Case: Material Finish	Ring: Material Finish Style	Mounting	Connection
4½," 6" 8½," 12"	(45) (60) (85) (12)	1010	Aluminum Black, epoxy coated	Steel Black, Slip	Stem Surface	Lower Back
4½," 6" 8½"	(45) (60) (85)	1017	Aluminum Black, epoxy coated	Steel Black, Hinged*	Flush	Back
4½," 6" 8½"	(45) (60) (85)	1220	Phenolic Black	SS Snap Black, Hinged	Stem Surface Flush	Lower or Back Lower or Back Back, specify X54

TABLE B – SYSTEM, CONNECTION & LOCATION

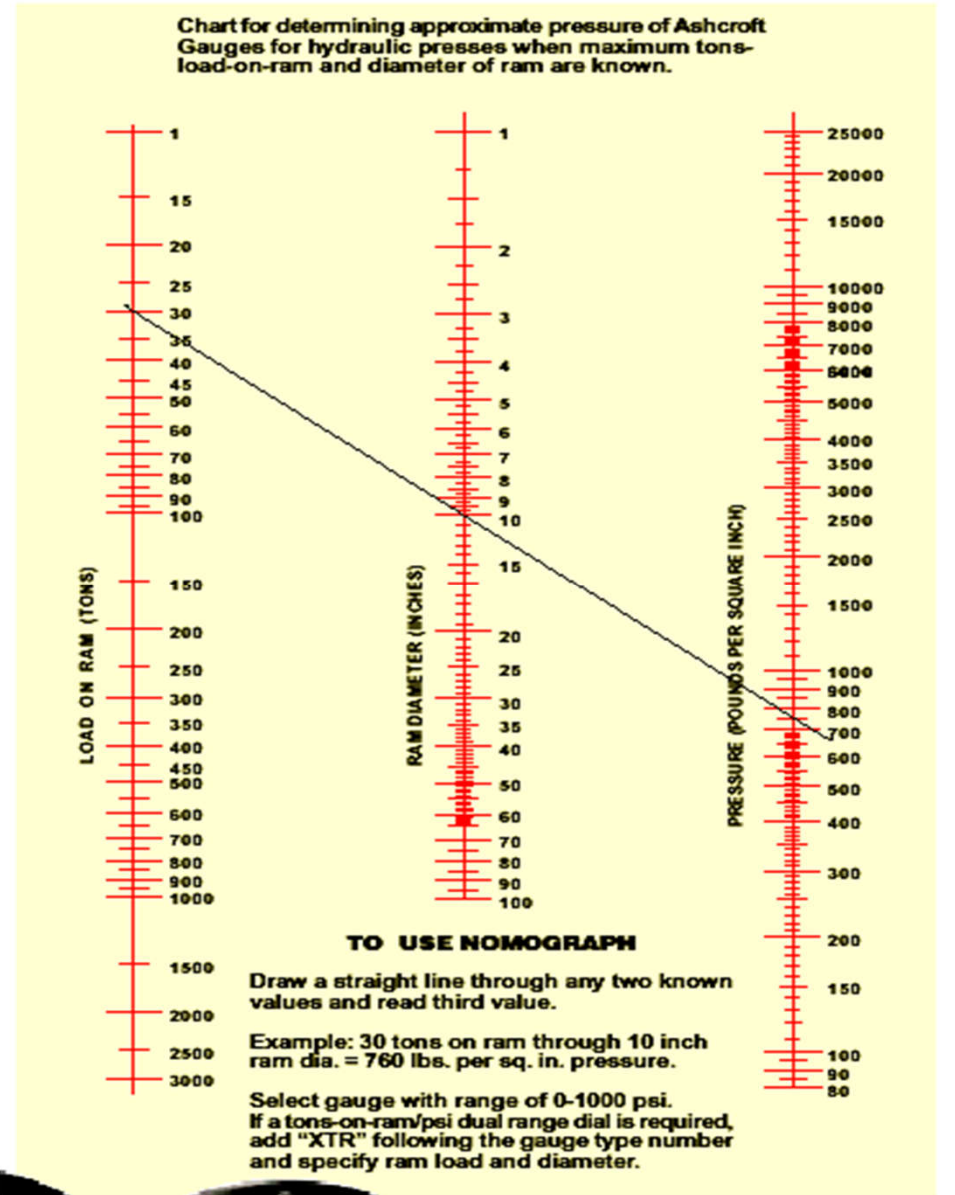
Bourdon Tube ⁽²⁾ & Tip Material (all joints TIG welded except code "A")	Socket Material Code	Tube & Socket Code	Case Style	NPT Conn Code	Connection Location & Code	Range Selection Limits (psi)
C510 Grade A Phosphor Bronze Tube, Brass Tip, Silver Brazed	C360 Brass	(A)	Open Front	(04) ½ STD (02) ¼ OPT	Lower (L) or Back (B)	vac./1000
4130 Alloy Steel	1019 Steel	(B)				vac./5000
316 SS	1019 Steel	(R)				vac./20,000
316 SS	316 SS	(S)				vac./20,000
K 500 Monel ⁽³⁾	Monel 400	(P)				vac./20,000

(1) 8½" case is solid front and has hinged rings.

(2) For selection of the correct Bourdon system material, see the media application table on page 7.

(3) Use on applications where NACE MR-01-75 is specified for selection of the correct Bourdon system material. See the media selection table on page 7.

PRESSURE GAUGE LOAD



P. GAUGES : REFRIGERATION & HYDRAULIC SERVICE

Industrial Gauges

Refrigeration and Hydraulic Service

Ashcroft Hydraulic Gauges

Designed for use on hydraulic presses, pumps and systems using hydraulic fluid, Ashcroft general service gauge Types 1010, 1017 and 1220 with the XTR variation meet the needs of many hydraulic applications. Equipped with a slotted link and throttle screw, these gauges are available with either a psi range or a psi range with a corresponding tons-on-ram scale. Use the nomograph on this page to help determine the appropriate tons-on-ram scale.

Ashcroft Refrigeration Gauges

Ashcroft refrigeration gauge Types 1010, 1017 and 1220 are designed to meet the requirements of the refrigeration marketplace. Available with a bronze or 316 stainless steel Bourdon tube and socket, these gauges come standard with a pressure and corresponding temperature scale in red. Available refrigerants include Refrigerant 11, Refrigerant 12, Refrigerant 22, Refrigerant 502, Refrigerant 114, Refrigerant 500, Refrigerant 134A and Refrigerant 123.

To meet the stringent needs of an ammonia refrigeration system, Ashcroft offers gauge Types 1010, 1017 and 1220 with a 316 stainless steel Bourdon tube and socket. These gauges are offered standard with a pressure and corresponding temperature scale in red.

BELLOWS RANGE SELECTION

TABLE B – BELLOWS SYSTEM/RANGE SELECTION⁽¹⁾

Order Code	Bellows & Socket	Pressure Range Material	Vacuum Range	Compound Range	NPT Conn. ⁽²⁾	Available Case Size and Type
A	Brass	10" H ₂ O to 10 psi	10" H ₂ O to 20" mercury	5" H ₂ O vac. & 5" H ₂ O press. to 10" mercury vac. & 5 psi	¼	4½", 6", 8½" 1187 4½" 1188 4½", 6", 8½" 1189
S	316SS	10" H ₂ O to 10 psi	10" H ₂ O to 20" mercury	5" H ₂ O vac. & 5" H ₂ O press. to 10" mercury vac. & 5 psi	¼	4½", 6", 8½" 1187 4½" 1188 4½", 6", 8½" 1189
P	Monel	10" H ₂ O to 10 psi	10" H ₂ O to 20" mercury	5" H ₂ O vac. & 5" H ₂ O press. to 10" mercury vac. & 5 psi	¼	4½", 6", 8½" 1187 4½" 1188 4½", 6", 8½" 1189

(1) For selection of the correct bellows system material, see the media application table on page 7.

(2) Optional connection ½ NPT.

(3) Others ranges available: Consult factory.

Type 1189, X56, Back Connect