2016

Instruments Training & Calibration Procedures

Manual

Doosan Power System Arabia

INDEX

15. **Calibration procedure for OXYZEN ANALYZER**
16. **Calibration procedure for CONTROL VALVE / DAMPER DRIVE**
17. **Calibration procedure for PH ANALYZER**
18. **Calibration procedure for SILICA ANALYZER**
19. **Calibration procedure for DO ANALYZERS**

D. FEMILIZATION OF CONTROL SYSTEMS

1. **ON – OFF Control**
2. **Open-Loop Control**
3. **Feed- Forward Control**
4. **Closed-Loop control**
5. **Programmable Logic Controllers (PLCs)**
6. **Distributed Control Systems (DCS)**
7. **Supervisory Control and Data Acquisition (SCADA)**
8. **PID CONTROLLER**

A. Different type of Instruments in power plant:-

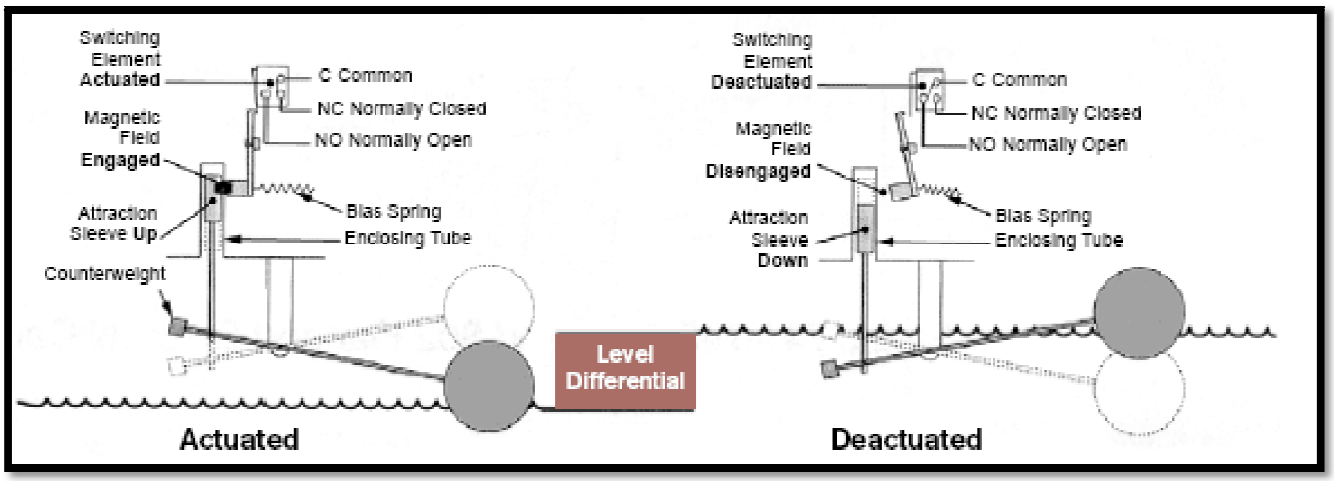
1. Level measurement

a. Point level measurement devices

They monitor material level at a preset point, which could be either a low level (in order for example to avoid the danger of a pump running dry) or a high level (in order to avoid a spillage or leakage)

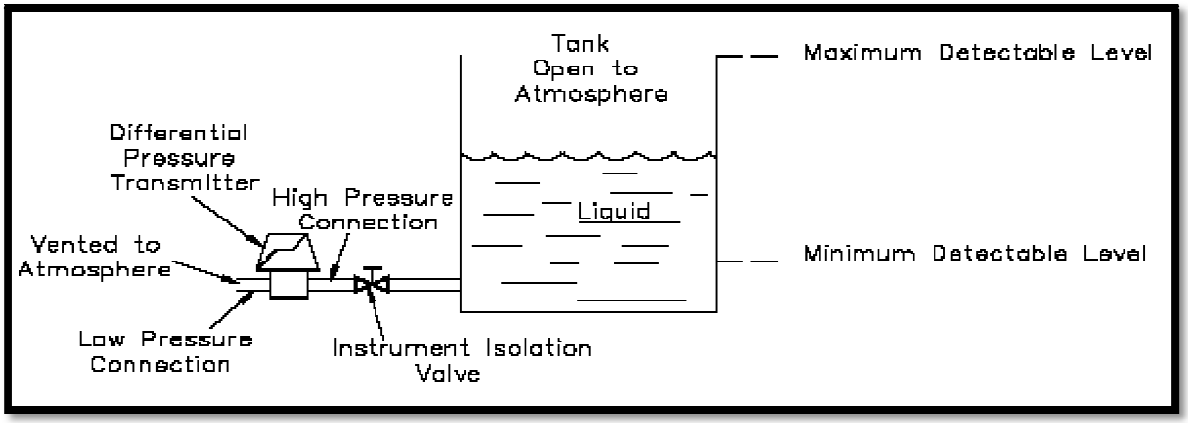
b. Mechanical float type level measurement devices

This is perhaps the most simple, inexpensive and simple to install method. A float is connected with a rod that is mounted to a tank wall and linked to a switch. As the level fluctuates, the switch opens and closes accordingly. Major disadvantages of the mechanical floats are the following: firstly, float must be recalibrated in case the density of the liquid changes and secondly, foreign materials can build up on the float, thus impeding its reliable operation.

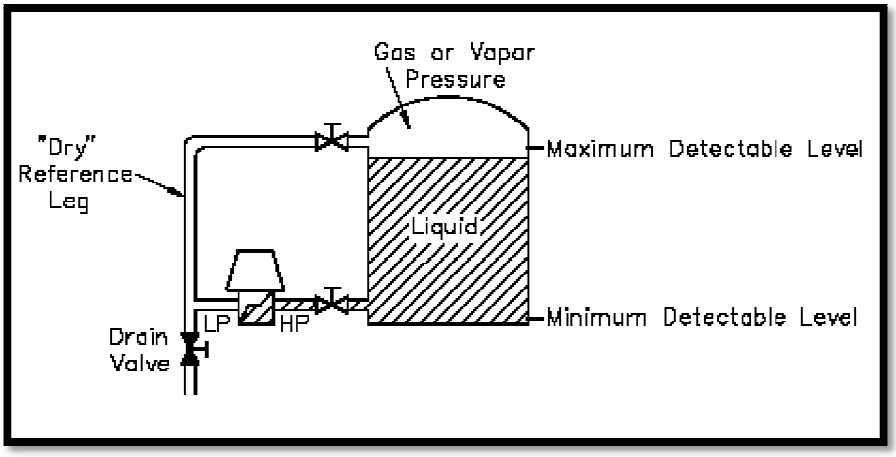


c. Differential pressure - level measurement devices

The high pressure side of a differential-pressure instrument is typically connected to the bottom of the tank, while the low pressure side is connected to the vapor space at the top of the tank. The measured pressure differential corresponds to the pressure of the liquid column of the tank. If the fluid density remains constant, this measurement method yields a true level reading. In case of pressurized vessels, differential pressure measurement devices require a sealing fluid. Typical applications: water tanks-vessels.



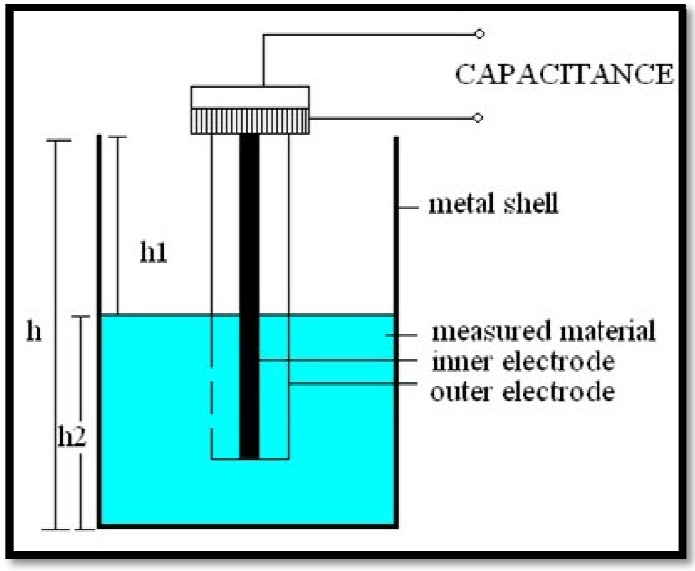
Open tank level measurement



Close tank level measurement

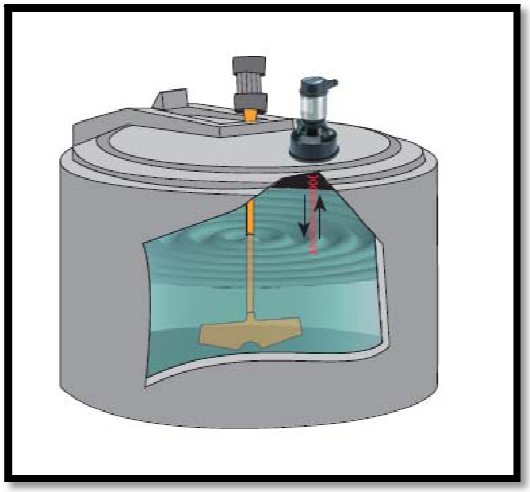
d. Capacitance level measurement devices

These typically consist of two (2) parallel conductive plates that are separated by a proper insulator. A metal probe (measurement electrode) senses the amount of present material by measuring the difference in the probe's capacitance when either air or material is present inside the vessel. A second reference electrode is also included in order to close the circuit and allow current flow. Capacitance measurement devices are generally easy to install and have no moving parts, thus minimizing maintenance costs. On the other hand, any changes due to temperature or chemical composition of the material inside the vessel will alter the dielectric properties, thus resulting to errors and the need for recalibration. Typical applications for capacitance level devices: acids, caustics, aromatic compounds, adhesives etc



e. Ultrasonic level measurement devices

Ultrasonic devices employ a piezoelectric crystal stored inside a transducer. Sound energy is released towards the material and reflected back to the transducer, which converts the sound energy back to an electric signal. A proper signal processor then analyses this echo and calculates the distance between the target (material level) and the transducer, taking into consideration that the time lapse between the initiation of the sound signal and its return back is proportional to the distance between the target and the transducer. Ultrasonic technology is mainly used for continuous level measurements. Ultrasonic devices are easy to install, have no moving parts and are not in contact with the vessel material. Thus, materials compatibility issues are avoided. One of the disadvantages of this technology is that foreign particles like dust or vapour can affect the reliability and accuracy of the ultrasonic device. Typical application for ultrasonic type level devices: chemical storage tanks, rain water - sewage water open basins, sludge containers of treatment plants etc

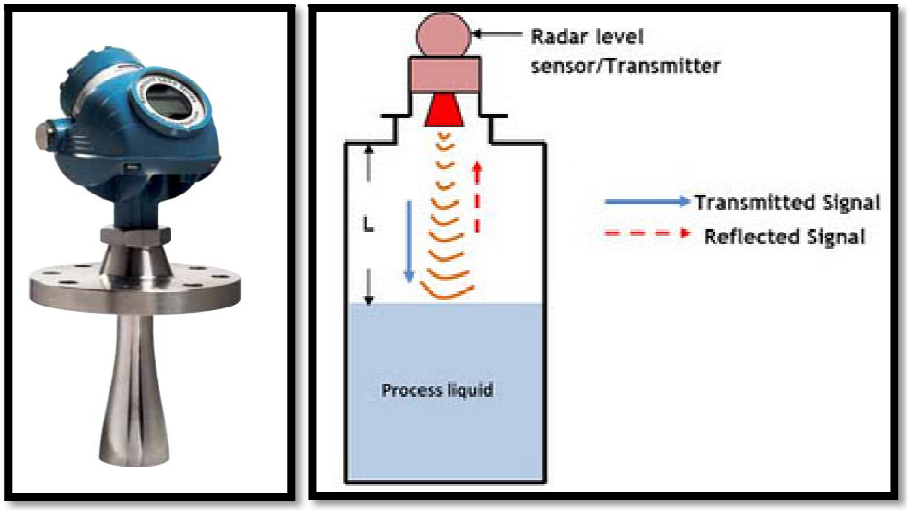


Vessel with agitator and ultrasonic level measurement device

f. Radar type level measurement devices

Radar devices transmit an electromagnetic wave towards the material. The overall transit time to and from the target (material level) is calculated and directly related to the distance in between taking into consideration that the difference between the transmitter and receiver frequency is directly proportional to the distance covered. Use of electromagnetic wave presents the advantage that the signal is not affected by environmental factors such as temperature, humidity, pressure, vapor, dust or

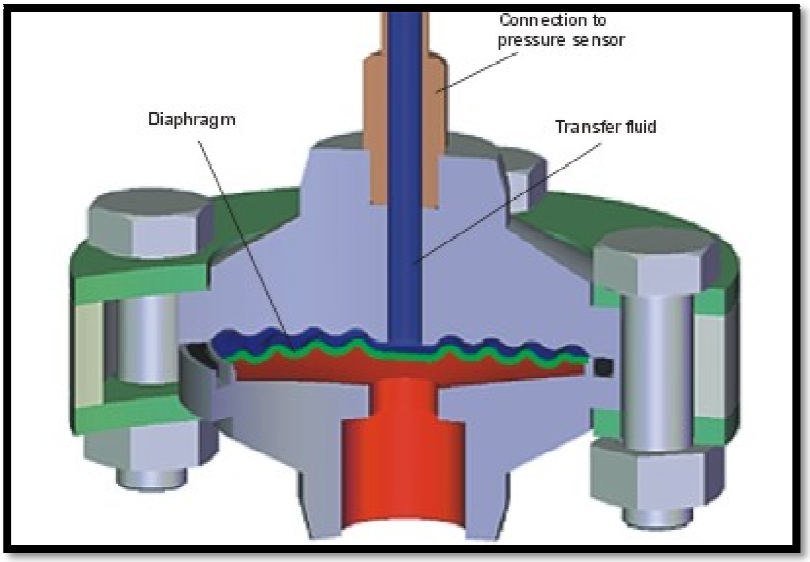
others. Typical applications: chemical bulk-storage vessels, slurries and sludge, sterile applications, sticky, viscous and crystallizing products, underground tanks etc.



2. *Pressure measurement*

a. Pressure transmitter

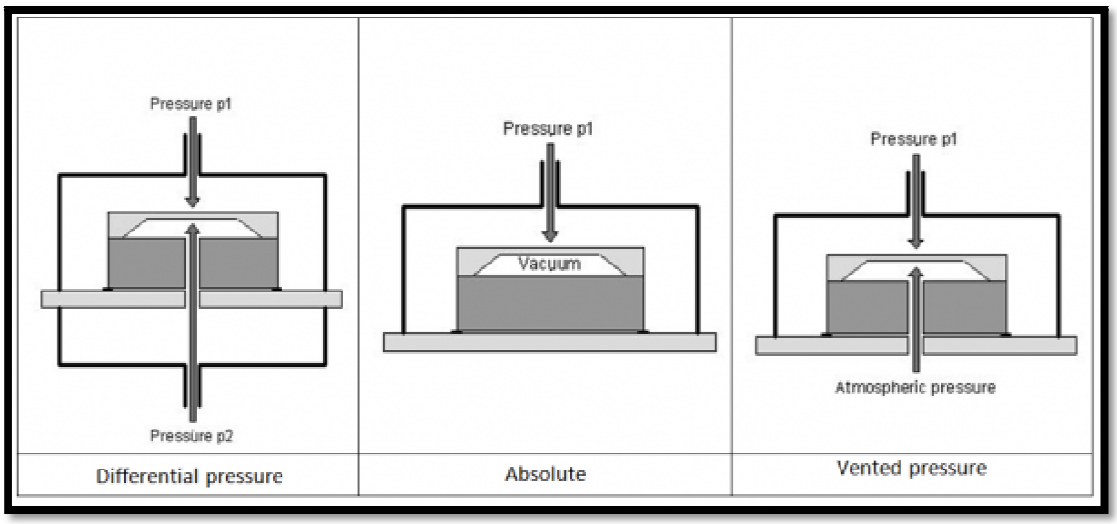
Different Type of pressure transmitter



Internal image of pressure transmitter

Pressure measurements are one of the most common measurements taken and recorded in the Power Station ranging from very low, i.e. condenser vacuum to very high i.e. hydraulic pressures in some actuator systems. Between these two limits of say 30-40 millibar absolute to 300 bar are to be the measurements of different process media-steam, water, oil, air, gas etc. and each with varying degree of accuracy and reliability.

1. **Absolute pressure** is zero-referenced against a perfect vacuum, using an absolute scale, so it is equal to gauge pressure plus atmospheric pressure.
2. **Gauge pressure** is zero-referenced against ambient air pressure, so it is equal to absolute pressure minus atmospheric pressure. Negative signs are usually omitted. To distinguish a negative pressure, the value may be appended with the word "vacuum" or the gauge may be labeled a "vacuum gauge."
3. **Differential pressure** is the difference in pressure between two points.

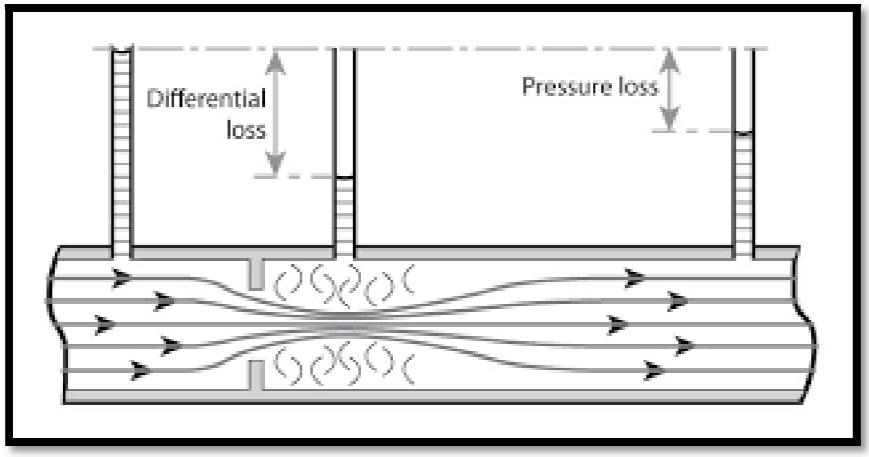


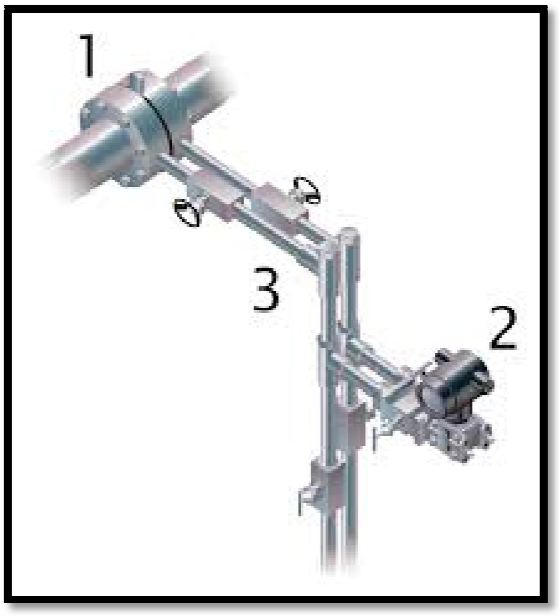
Many techniques have been developed for the measurement of pressure and vacuum. Instruments used to measure pressure are called pressure gauges or vacuum gauges.

3. Flow measurement

a. Differential Pressure Flow meters

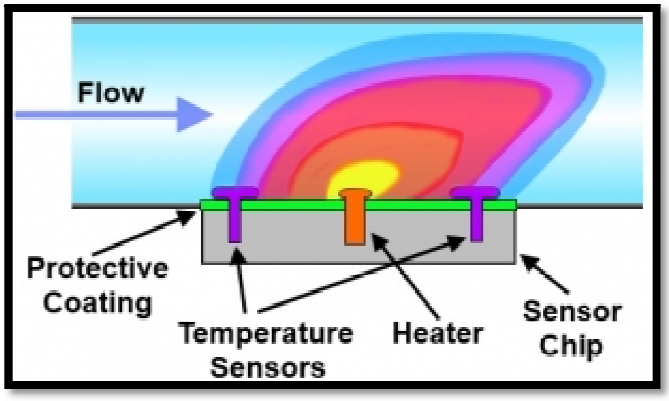
In a differential pressure drop device the flow is calculated by measuring the pressure drop over an obstructions inserted in the flow. The differential pressure flow meter is based on the Bernoulli, where the pressure drop and the further measured signal is a function of the square flow speed.





b. Calorimetric Flow meter

The physical set up includes two positive temperature coefficient (PTC) thermistors placed in the wall of the sensor or in the tip of the probe. These are also known as posistors. They are used to determine changes when the resistance increases with increasing temperature.

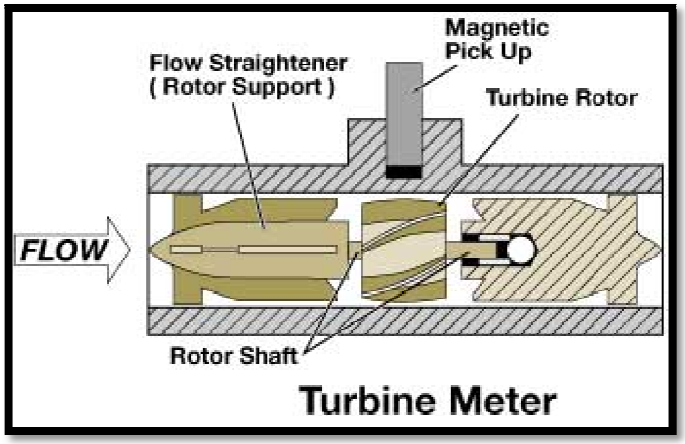


c. Turbine Flow meter

There is many different manufacturing design of turbine flow meters, but in general they are all based on the same simple principle:

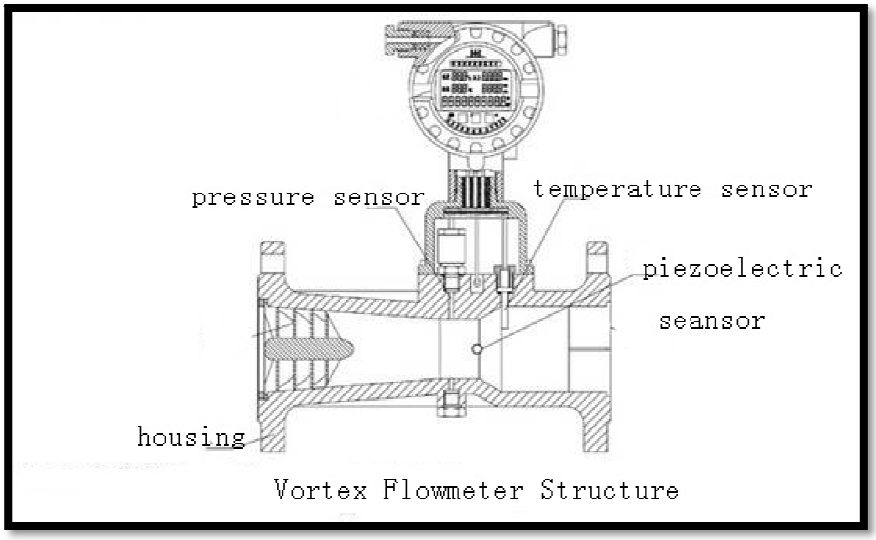
If a fluid moves through a pipe and acts on the vanes of a turbine, the turbine will start to spin and rotate. The rate of spin is measured to calculate the flow.

The turndown ratios may be more than 100:1 if the turbine meter is calibrated for a single fluid and used at constant conditions. Accuracy may be better than +/-0,1%.



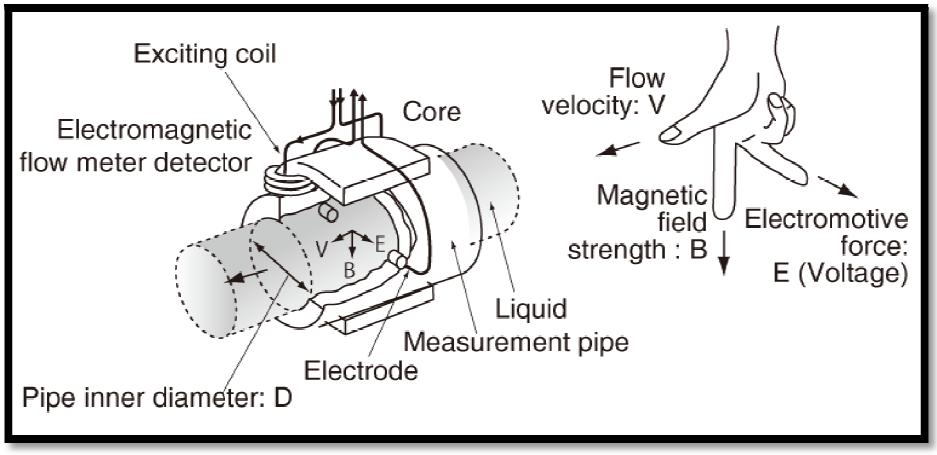
d. Vortex Flow Meter

An obstruction in a fluid flow creates vortices in a downstream flow. Every obstruction has a critical fluid flow speed at which vortex shedding occurs. Vortex shedding is the instance where alternating low pressure zones are generated in the downstream. These alternating low pressure zones cause the obstruction to move towards the low pressure zone. With sensors gauging the vortices the strength of the flow can be measured.



e. Electromagnetic Flow meter

An electromagnetic flow meter operate on Faraday's law of electromagnetic induction that states that a voltage will be induced when a conductor moves through a magnetic field. The liquid serves as the conductor and the magnetic field is created by energized coils outside the flow tube.



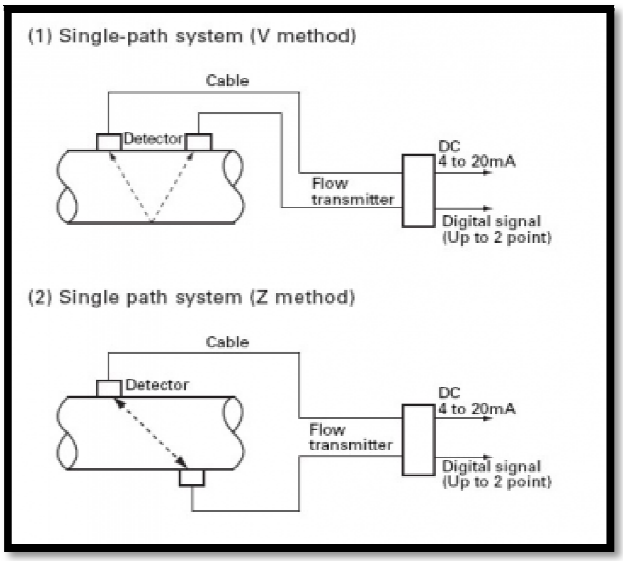
The voltage produced is directly proportional to the flow rate. Two electrodes mounted in the pipe wall detect the voltage which is measured by a secondary element.

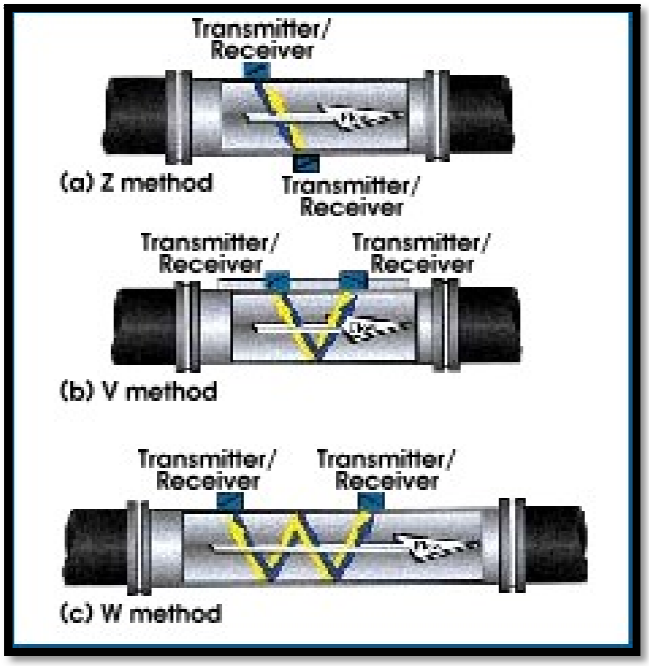
Electromagnetic flow meters can measure difficult and corrosive liquids and slurries, and they can measure flow in both directions with equal accuracy. Electromagnetic flow meters have relatively high power consumption and can only be used for electrical conductive fluids as water.

f. Ultrasonic Doppler Flow meter

The effect of motion of a sound source and its effect on the frequency of the sound was observed and described by Christian Johann Doppler. The frequency of the reflected signal is modified by the velocity and direction of the fluid flow

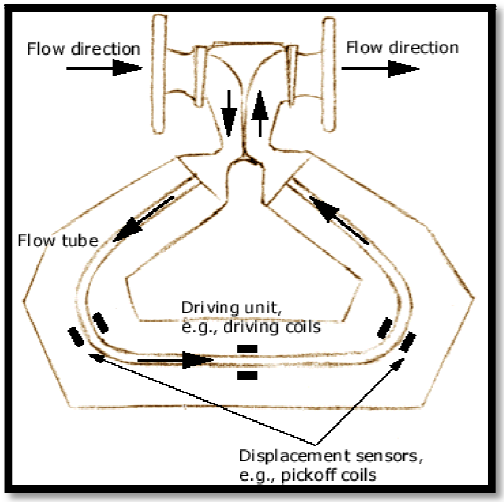
If a fluid is moving towards a transducer, the frequency of the returning signal will increase. As fluid moves away from a transducer, the frequency of the returning signal decrease. The frequency difference is equal to the reflected frequency minus the originating frequency and can be use to calculate the fluid flow speed





g. Coriolis Flow meter

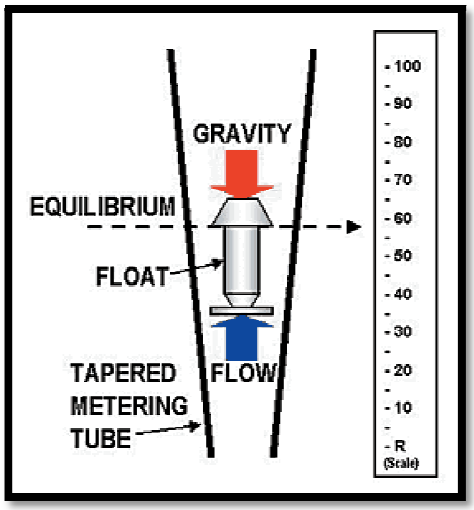
Direct mass measurement sets Coriolis flow meters apart from other technologies. Mass measurement is not sensitive to changes in pressure, temperature, viscosity and density. With the ability to measure liquids, slurries and gases, Coriolis flow meters are universal meters.Coriolis Mass Flow meter uses the Coriolis effect to measure the amount of mass moving through the element. The fluid to be measured runs through a U-shaped tube that is caused to vibrate in an angular harmonic oscillation. Due to the Coriolis forces, the tubes will deform and an additional vibration component will be added to the oscillation. This additional component causes a phase shift on some places of the tubes which can be measured with sensors.The Coriolis flow meters are in general very accurate, better than +/-0,1% with an turndown rate more than 100:1. The Coriolis meter can also be used to measure the fluids density.



h. Rota-meter Flow meter

The rotameter consists of a vertically oriented glass (or plastic) tube with a larger end at the top, and a metering float which is free to move within the tube. Fluid flow causes the float to rise in the tube as the upward pressure differential and buoyancy of the fluid overcome the effect of gravity. The float rises until the annular area between the float and tube increases sufficiently to allow a state of dynamic equilibrium between the upward differential pressure and buoyancy factors, and downward gravity factors.

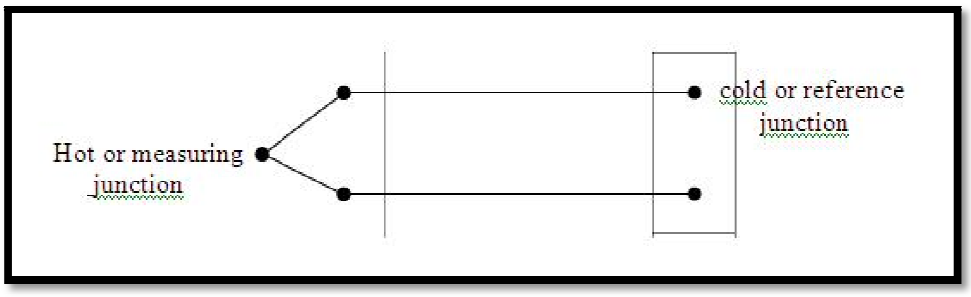
The height of the float is an indication of the flow rate. The tube can be calibrated and graduated in appropriate flow units.

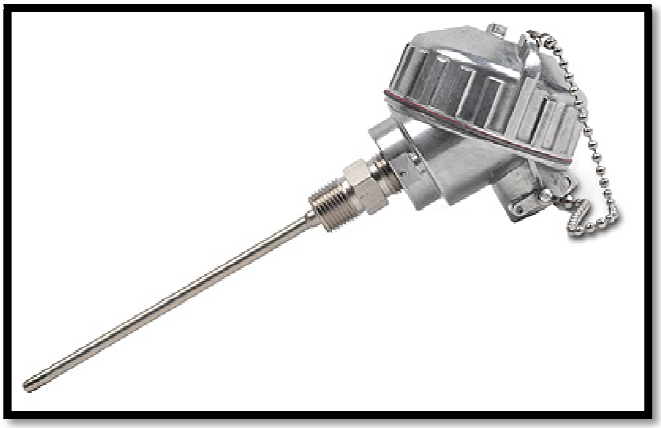


4. *Temperature measurements*

a. Thermocouple (T/C)

Thermocouples: It is a simple device consisting of a dissimilar metal wires joined at their ends. When an of each wire is connected to a measuring instrument thermocouples becomes an accurate and sensitive temperature measuring device.





Thermocouples Types and Range:

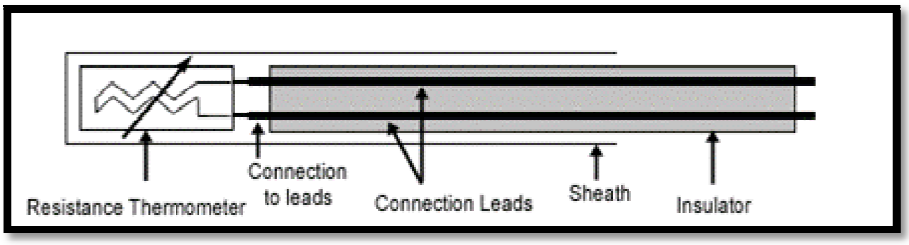
Type T/C	Positive wire & color	Negative wire & color	Range °F
(J)	Iron & White	Constantan & Red	-300 to1400
(K)	Chromel & Yellow	Alumel & Red	-300 to2300
(E)	Chromel & Purple	Constantan & Red	-300 to1600
(T)	Copper & Blue	Constantan & Red	-300 to 650
(R)	Platinum and 10%Rhodium & Black	Platinum & Red	32 to 2700
(S)	Platinum and 13%Rhodium & Black	Platinum & Red	32 to 2700

b. Resistant temperature detector(RTD)

RTD's are generally used for precise temperature measurement. It consists of a five wire wrapped around an insulator and enclosed in a metal. The most sheath of a resistance thermometer resembles that of bimetallic thermometer bulb.
PRINCIPLE: "Resistance increases as temperature increase"

$Rt. = Ro (1 + \alpha t)$
Rt. = Resistance of Temperature to measured.

Ro. = Resistance of zero temperature.
α = Co. off of thermal (expansion).
t = Temperature to be measured.
These metals have a positive temperature co-efficient of expansion. Therefore resistance increases as the temperature increases.



Physical Architecture of an RTD

Types of material used: (1) Platinum (2) Nickel
these metals have a positive temperature co-efficient of expansion. Therefore resistance increases as the temp. Increases.

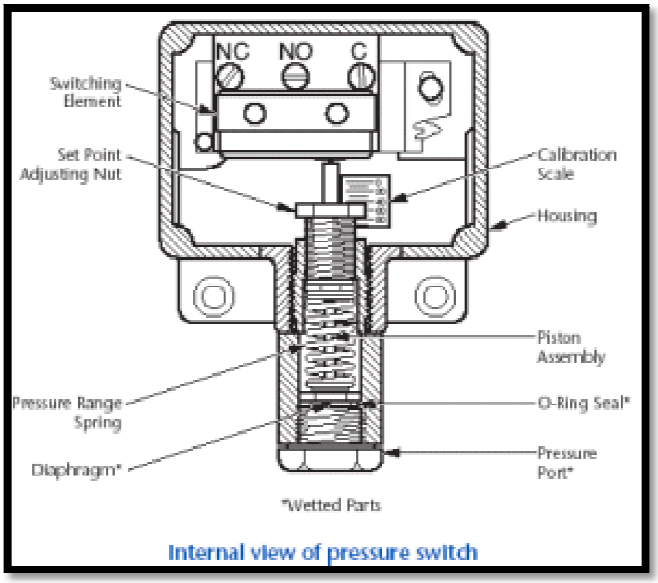
Calculation of Resistance or Pt100.

Ro. = 100x for platinum = 0.00385 /c.
To calculate Resistance at 100'c.
R100 = 100 [1+ (38.5 x 10 4 x 100)]
= 100 + (100 x 0.385)
R100 = 138.5
Resistance at 100'c = 138.5

5. Switch

a. Pressure switch

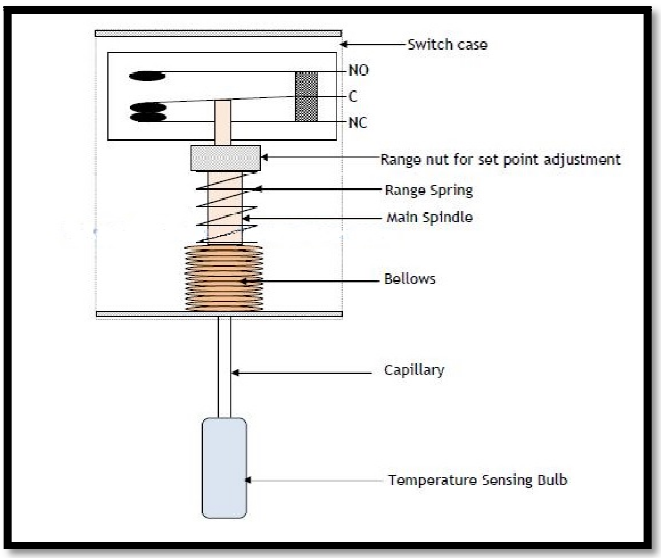
A **pressure switch** is a form of switch that closes an electrical contact when a certain set pressure has been reached on its input. The switch may be designed to make contact either on pressure rise or on pressure fall.



Internal view of pressure switch

b. Temperature switch

The temperature switch consists of a pressure switch that has a sealed temperature sensing bulb attached directly to the pressure port. (An optional remote temperature sensing bulb can be connected to the pressure port with an armor-clad capillary.) The temperature sensing system is partially filled with a fluid. Process temperature changes cause proportional vapor pressure changes in the temperature sensing bulb that act on the diaphragm/piston assembly to actuate and de-actuate a snap-action electrical switching element at discrete process temperatures. The instrument's behavior is determined by the vapor pressure principle. (The 105 range unit is similar, except the fill fluid is inert gas.)



c. Level switch

Level switches are used to detect liquid levels, or interfaces between liquids. These level measurements are indicated via an electrical switching action. Level switches can be used either as an alarm device or as control switches, turning something on or off, such as a pump, or sending a signal to a valve actuator. What makes level switches special is that they have a switched output and can be either electromechanical or solid state, either normally open or normally closed.

Type of Level switch

Chambered

Compact

RF

Top Mount

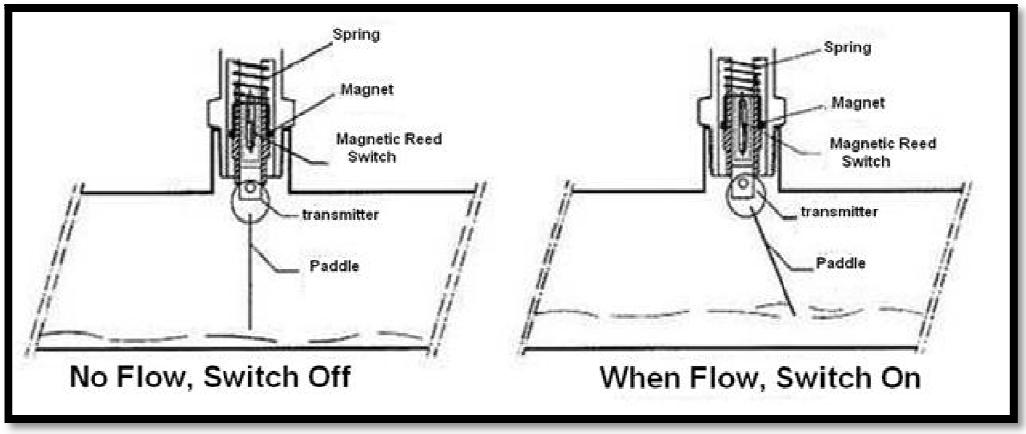
Ultrasonic

Wireless

d. Flow switch

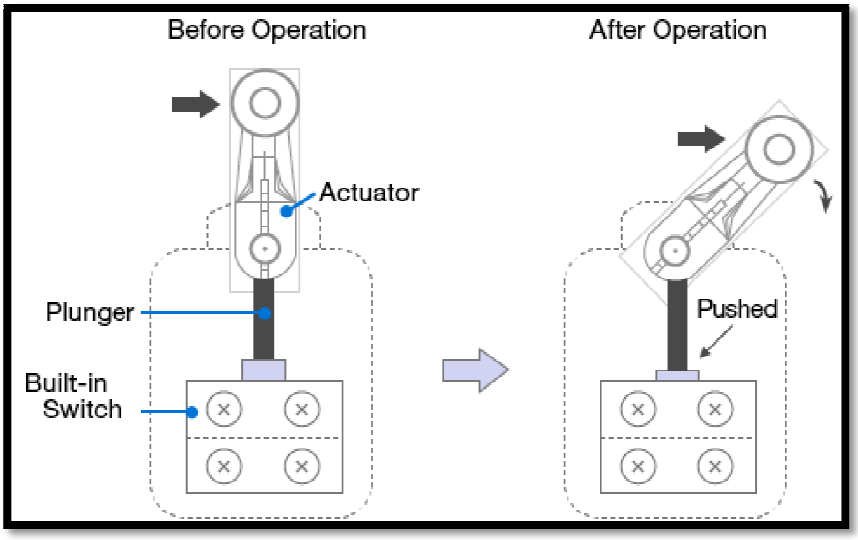
A flow switch is a device that monitors the flow of air, steam or liquid. It sends a "trip signal" to a different device in the system, such as a pump. The flow switch can indicate to the pump to shut off or to turn on. Some of the general uses are for pump protection, for cooling-circuit protection and alarms for too high or too low flow rates.

A flow switch can perform specific functions based on need. For example, it can stop a motor when no flow is present, start a motor when a flow is present, and sound an alarm when the flow stops or shut off an alarm when the flow is appropriate



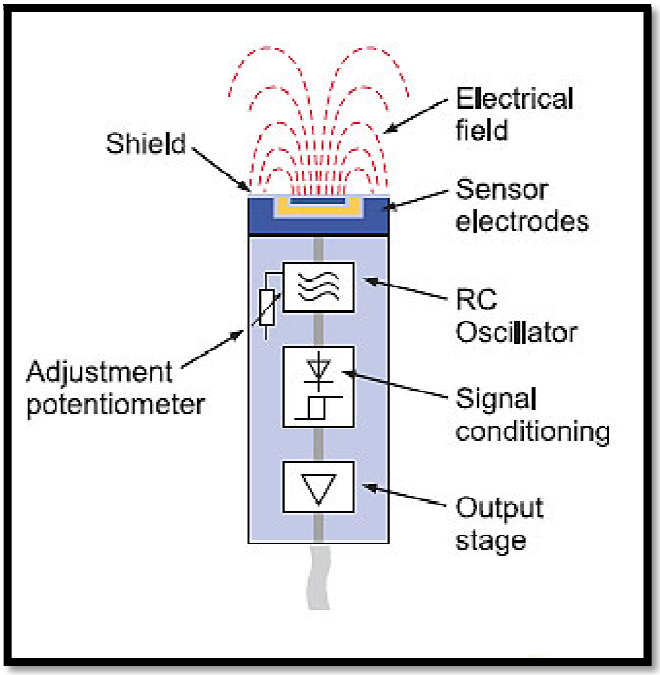
e. Electrical Limit switch

A limit switch is an electromechanical device that consists of an actuator mechanically linked to a set of contacts. When an object comes into contact with the actuator, the device Operates the contacts to break an electrical connection



f. Proximity switch

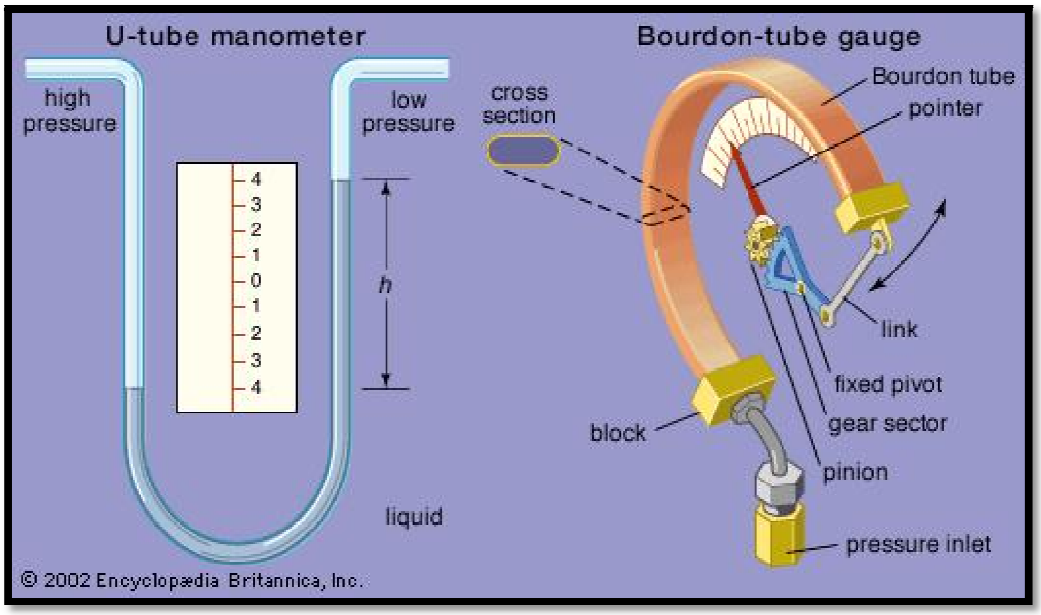
A proximity sensor often emits an electromagnetic field or a beam of electromagnetic radiation (infrared, for instance), and looks for changes in the field or return signal. The object being sensed is often referred to as the proximity sensor's target. Different proximity sensor targets demand different sensors. For example, a capacitive or photoelectric sensor might be suitable for a plastic target; an inductive proximity sensor always requires a metal target.



6. Gauge

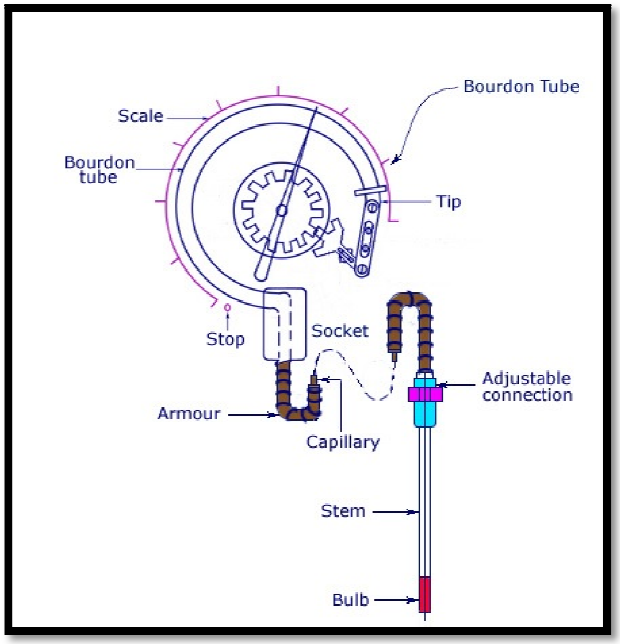
a. Pressure gauge

Instruments **used** to measure **pressure** are called **pressure gauges** or vacuum **gauges**.



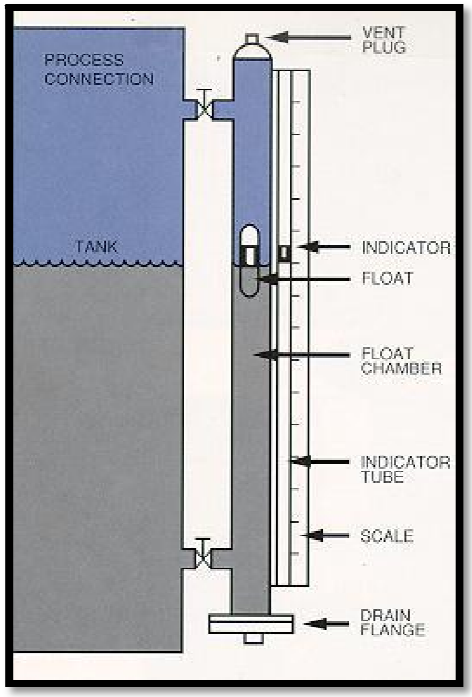
b. Temperature gauge

Instruments **used** to measure **temperature** are temperature **gauges**. Temperature gauges operate on the gas-actuated, bimetal or expansion principle.



c. Level gauge

A **magnetic level gauge** is used to measure the level of fluids. A magnetic level gauge includes a “floatable” device that can float both in high and low density fluids.



7. *Control valve/Damper actuators*

a. Solenoid Operated valve

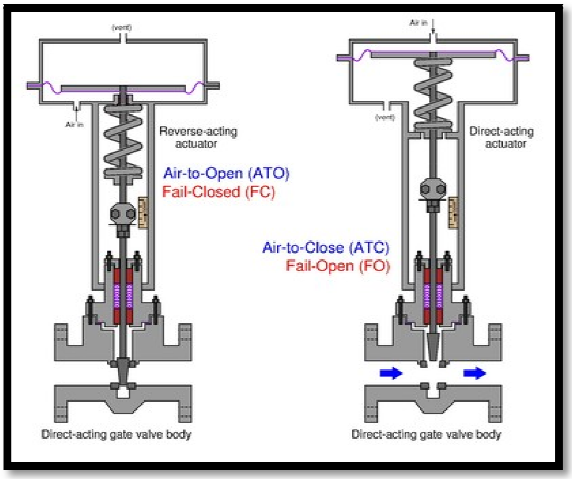
Like the name suggests, on/off valves are designed to shutoff and to open fully with no ability to regulate effectively through the range of travel.

b. Shut off valve

Shutoff valves often provide a safety function as they are called to stop flow quickly and positively as in a gas service shutoff valve or a heat activated shutoff valve.

c. Pneumatic Control valve

The control valve regulates the rate of fluid flow as the position of the valve plug or disk is changed by force from the actuator.



d. ON/OFF Damper

ON/OFF damper operate only full open or full close position it not working in regulating mode. It is used as gate valve for air duct in power plant.

e. Control Damper

A damper is a valve or plate that stops or regulates the flow of air inside a duct, chimney, VAV box, air handler, or other air handling equipment. it used for controlling the air flow. Actuator operates in between 0 to 100% scale range.

f. ESV Valve

A shut down valve (Emergency Shutdown Valve or ESV) is an actuated valve designed to stop the flow of a hazardous fluid upon the detection of a dangerous event. This provides protection against possible harm to people, equipment or the environment.

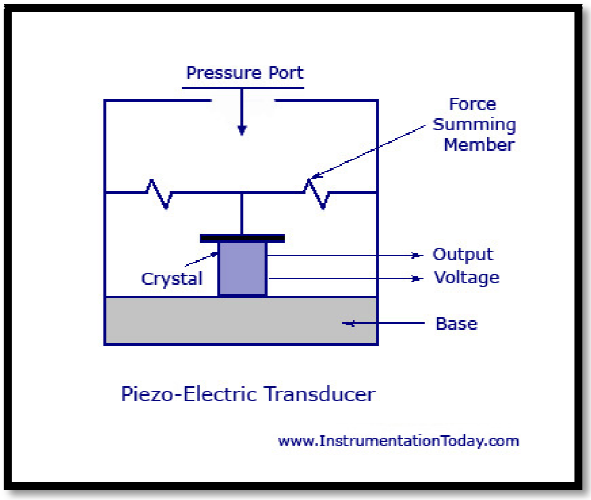
8. Sensors

a. Vibration sensor

Vibration is a mechanical phenomenon where by oscillations occur about an equilibrium point. The oscillations may be periodic, such as the motion of a pendulum—or random.

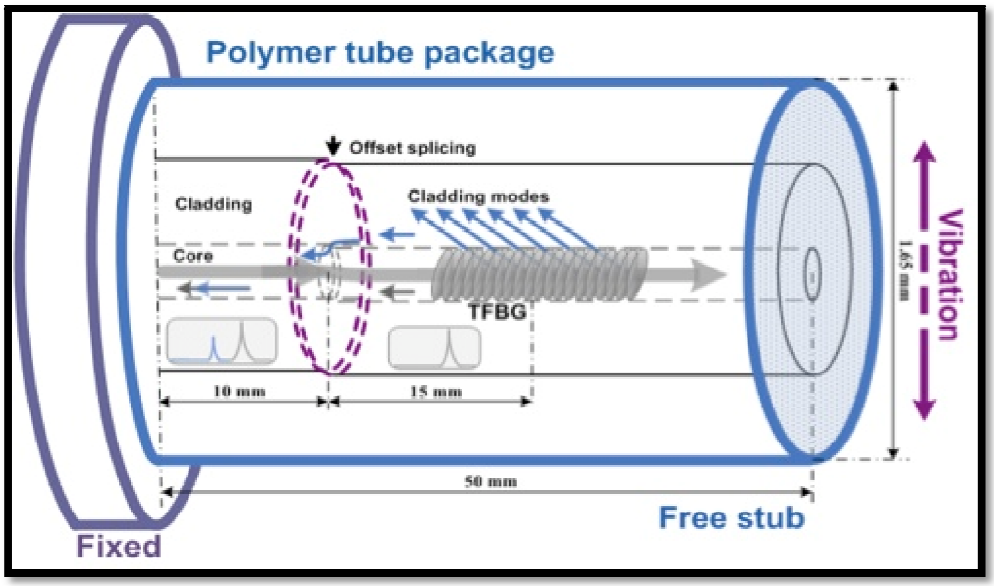
- Accelerometers (piezoelectric)

A piezoelectric accelerometer is an accelerometer that employs the piezoelectric effect. Piezo-electric accelerometers work by measuring the charge generated by a crystal that is being compressed or shear loaded by a mass influenced by acceleration. Accelerometers are the most effective method to measure the vibration



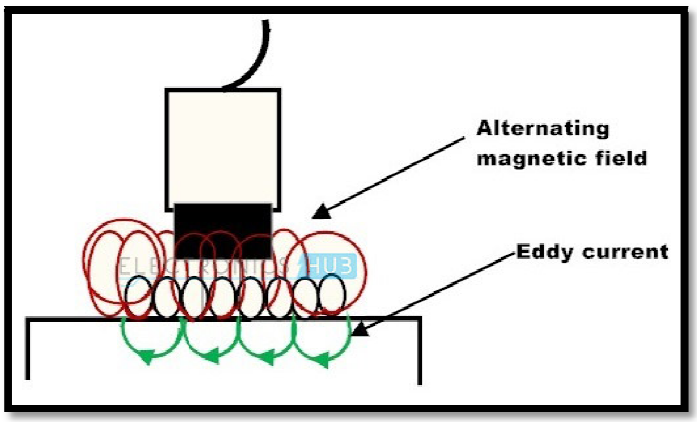
- Velocity Sensor.

  Velocity transducers are contact transducers, used to measure velocity. A velocity transducer contains a magnet, which is suspended between a spring and a damper. The magnet is surrounded by a coil. As the transducer vibrates, the magnet remains stationary due to inertia. The magnet moves within a coil, which generates electricity proportional to the velocity of the mass. Hence there is no power supply required



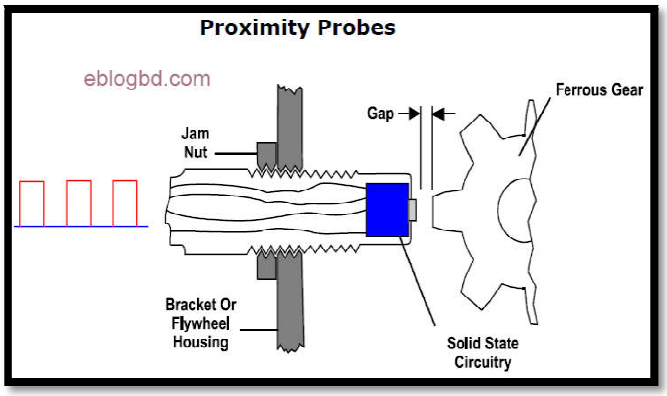
- Proximity Probes (capacitance or eddy current)

  Proximity sensors work on the eddy current principle. A proximity system consists of an eddy current probe, extension cable and driver. A high-frequency RF signal is generated by the driver, sent through the extension and probe cables and radiated from the probe tip. The tip consists of a precision wound copper coil inside a chemical and temperature resistant PEEK case. The tip is either mounted on a threaded stainless steel rod allowing easy gap adjustment on a bracket via two locking nuts or a flat, low profile mount. The driver demodulates the signal, amplifies and line arises it to provide an output proportional to the probe to target gap and/or vibration of the target.

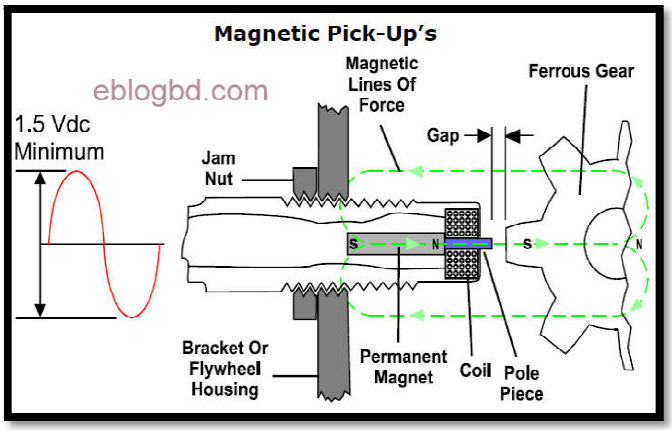


b. Speed sensor

Inductive Proximity sensor creates a magnetic field from their detection face, when a body moves towards or passes through the sensor magnetic field, eddy current is created in that target body. Then this eddy current in the target body generates its own magnetic field. The magnetic field of the target body distorts the magnetic field of the sensor. This change in the sensor's magnetic field triggers its output voltage, which is a speed signal.



PROXIMITY SPEED SENSOR

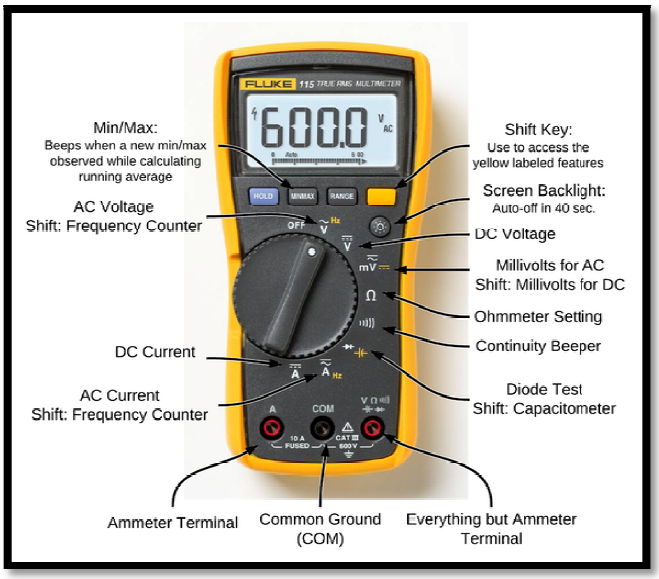


MAGNETIC SPEED SENSOR

B. CALIBRATION INSTRUMENTS REQUIRED IN POWER PLANT:-

1. Digital Multimeter

A **digital multimeter** (DMM) is a test tool used to measure two or more electrical values—principally voltage (volts), current (amps) and resistance (ohms). It is a standard diagnostic tool for technicians in the electrical/electronic industries.



2. Process meter

For industrial Process control instruments, It is used for analog 4–20 mA and 10–50 mA current loops are commonly used for analog signaling and sourcing for calibration.

3. *Pressure calibrator*

Pressure calibrator is used for calibration of transmitter and switches .It give the regulated variable pressure for calibration.

4. *HART*

The HART Communications Protocol (Highway Addressable Remote Transducer) is an early implementation of Field bus, a digital industrial automation protocol. Its most notable advantage is that it can communicate over legacy 4-20 mA analog instrumentation wiring, sharing the pair of wires used by the older system.

5. *Vacuum & Pressure hand pump*

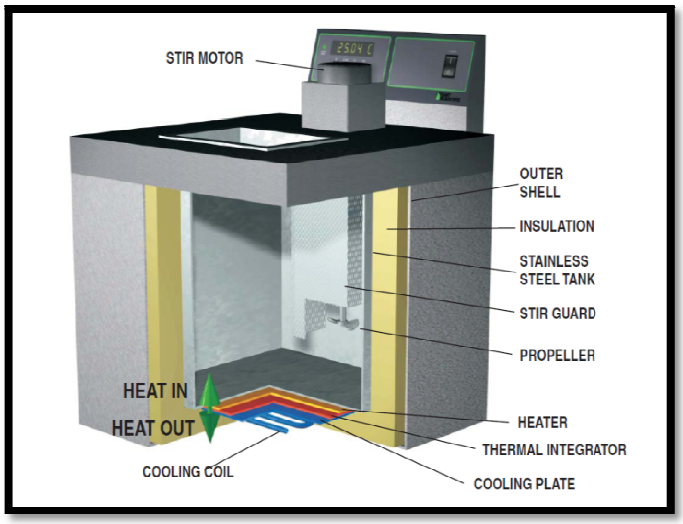
Vacuum & pressure hand pump is also use for calibration of transmitter and switch. It is used for create vacuum or pressure.

Pressure Pump

Vacuum Pump

6. *Temperature Bath*

Temperature bathe is used for calibration of temperature gauge & switch, finding the temperature response for Thermocouple & RTD.

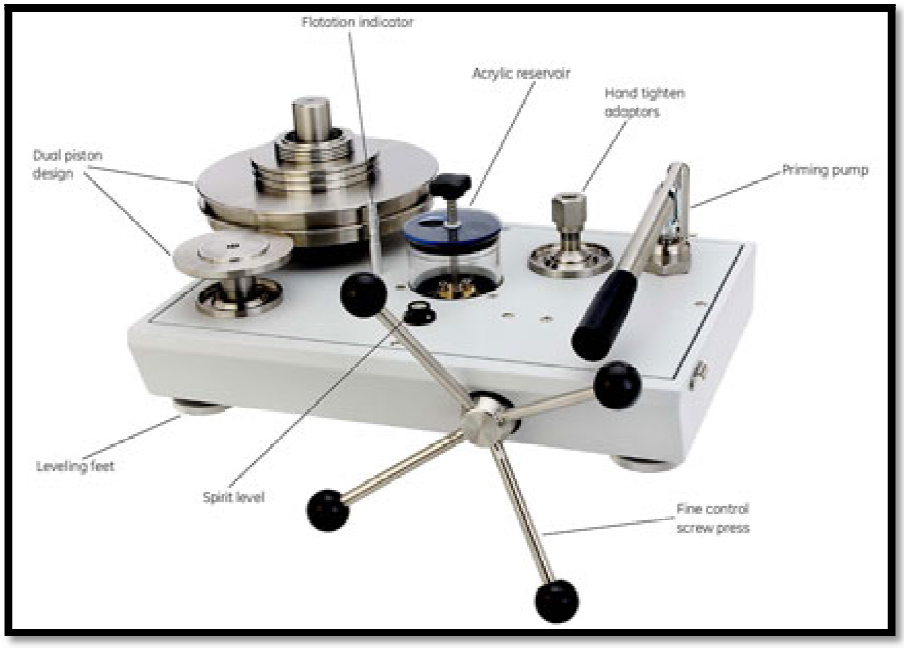


7. *Temperature calibrator(RTD&T/C)*

Temperature calibrator use for simulate and calibrate the temperature transmitter for Thermocouple and RTD.

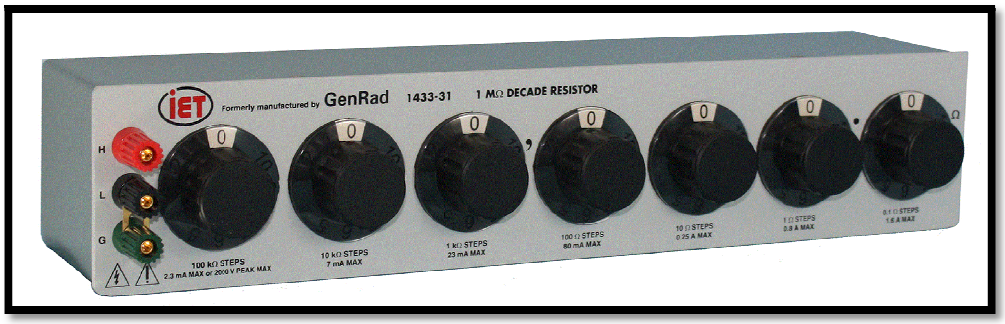
8. *Dead weight tester*

Dead weight tester is used for providing variable pressure for calibrating the pressure sensing instrument in I&C laboratory.



9. *Decade Resistor Box*

Decade resistor box is used for providing variable resistance in calibration purpose for different type of instruments.



C. CALIBRATION PROCEDURE FOR DIFRENT TYPE OF FIELD INSTRUMENTS:-

1. Calibration Procedure for DP TYPE FLOW TRANSMITTER:-

A. **Purpose - To follow the work instruction for carrying out calibration work of instruments.**
B. **Scope –These work instructions shall be applicable to calibration of all type of DP type of flow transmitter.**

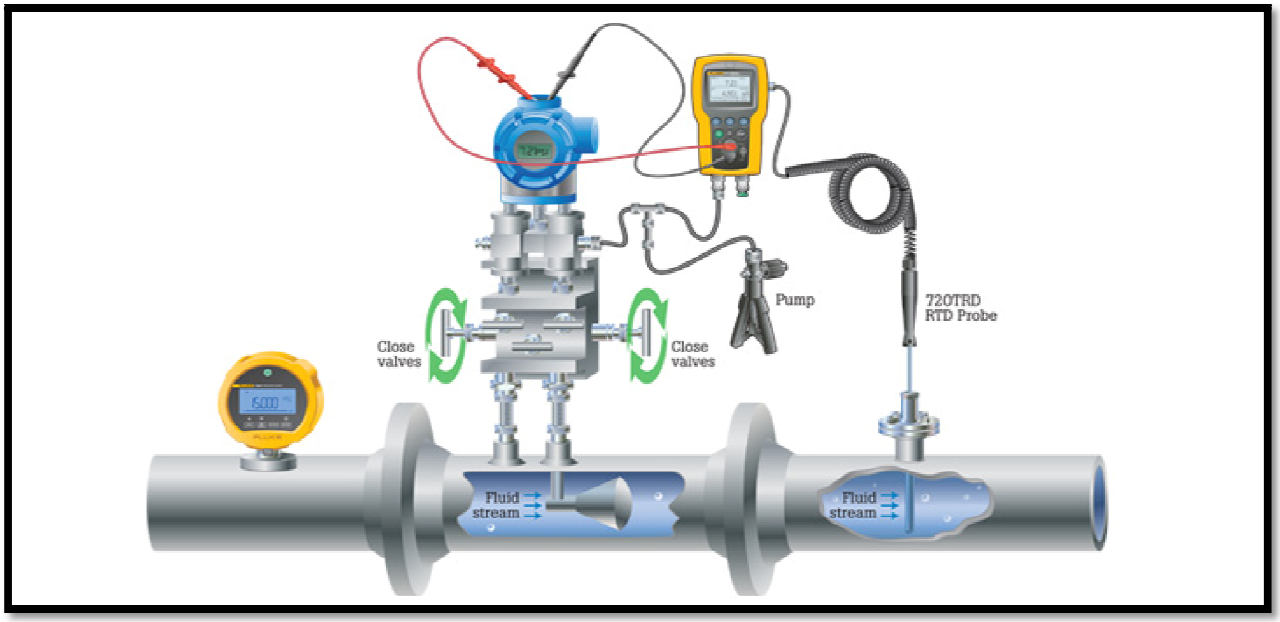
C. **PRE- REQUISITES:**

1. **Basic Qualification –**
   - **Technician-**
   - **Jr. Technician-**
2. **Trade Training – Instrument Maintainer**
   Basic Safety Training –Tool Box Talk.
3. **Mandatory PPEs – Helmet, Hand Gloves, Goggles, Ear muff, Safety shoes, oxygen meter.**
4. **Tools / Equipments –**
   - **Multi meter**
   - **Screw driver set / Spanner set**
   - **Allen key Set**
   - **Pressure calibrator**

D. **Calibration steps :-**

1. **Work permit must be taken with all safety arrangements.**
2. **Safety precautions should be followed with proper safety equipment.**
3. **Note the range of the transmitter.**
4. **Mark the 'High' and 'Low' side of transmitter and ensure that inlet side tapping of flow element (Orifice, Flow nozzle, Aerofoil) should be connected with High side and outlet tapping with low side of the transmitter.**
5. **Apply the specified equal pressure from to the high and low side of the transmitter and check for 'ZERO' value i.e. 4 mA signal measured by multimeter of master inst. If 'ZERO' is not proper, adjust it by 'ZERO' pot.**

6. Then apply the maximum specified pressure to the high side of the transmitter by using pressure pump and check for span i.e. 20 mA. If span is not proper, adjust it by 'span' pot or HEART.
7. Divide the span into 4 equal divisions and check mA o/p on each of the 4 divisions and o/p should be 8mA, 12mA, 16mA and 20mA respectively for linearity.
8. If any error is observed in the above step adjust zero or span as per error. For Conventional transmitter this adjustment is to be done by potentiometer and for Smart transmitters do this adjustment by hand held terminal.
9. Calculate the % accuracy of the transmitter from above readings. If it is within the acceptable limit, then calibration is o.k.



10. Configuration using HART calibrator
    I. Check the resistance across the pressure transmitter; it should be more than 250 Ώ, if it is not so then connect a resistance of 250 Ώ in series with the supply.
    II. Connect HART calibrator in parallel to the transmitter and switch it on.
    III. Go to the basic parameters and then enter the LRV and URV.
    IV. Select the SQUARE ROOT mode
    V. In diagnosis select loop testing and check the value at 4mA and 20mA on DCS.
11. Clear the work permit & take trial run.
12. After trials ensure that there is no abnormality.

2. Calibration Procedure for DIFF. PR. TRANSMITTER

A. Purpose - To follow the work instruction for carrying out maintenance work of instruments.

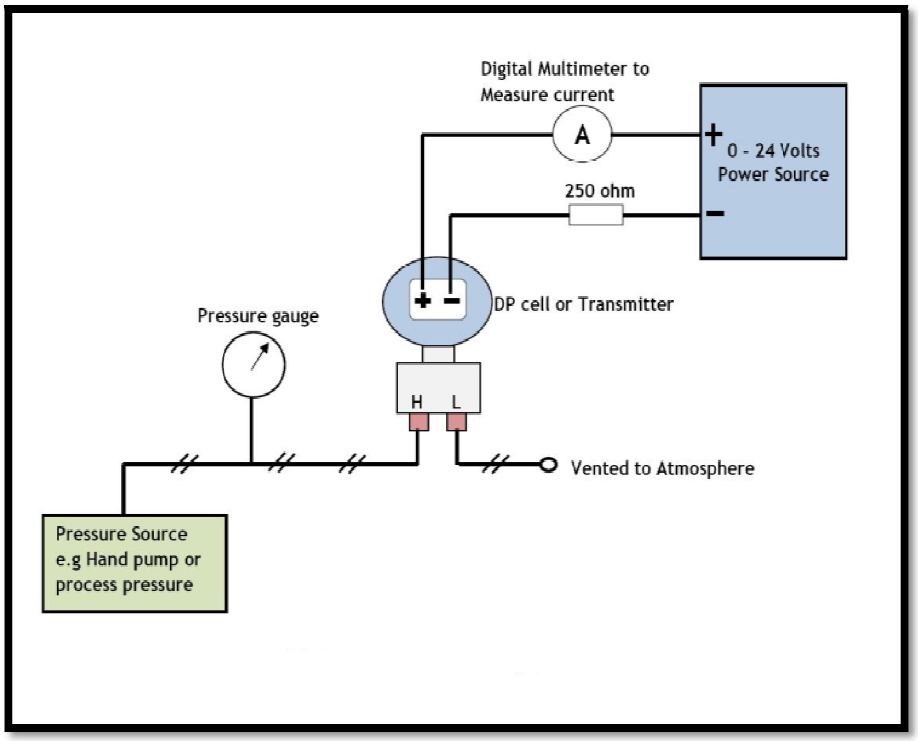
B. Scope – These work instructions shall be applicable to calibration of all type of DP type of pressure transmitter.

C. PRE- REQUISITES:

1. **Basic Qualification –**
   - **Technician-**
   - **Jr. Technician-**
2. **Trade Training – Instrument Maintainer**
   Basic Safety Training –Tool Box Talk.
3. **Mandatory PPEs – Helmet, Hand Gloves, Goggles, Ear muff, Safety shoes, oxygen meter.**
4. **Tools / Equipments –**
   - **Multi meter**
   - **Screw driver set / Spanner set**
   - **Allen key Set**
   - **Pressure calibrator**

D. Calibration steps :-

1. **Work permit must be taken with all safety arrangements.**
2. **Safety precautions should be followed with proper safety equipment.**
3. **Note the range of the transmitter**
4. **Mark the 'High' and 'Low' side of transmitter.**
5. **Apply the specified minimum pressure from pressure calibrator to the Low side of the transmitter and check or '0' i.e. 4 mA with multimeter of master inst. List If '0' is not proper, adjust it by '0' pot.**
6. **Then apply the maximum specified pressure to the high side by using pressure calibrator to the transmitter and check for span i.e.20 mA. If span is not proper, adjust it by 'span' pot.**
7. **Divide the span into 4 equal divisions and check mA o/p on each of the 4 divisions and o/p should be 8mA, 12mA, 16mA and 20mA respectively for linearity.**
8. **If any error is observed in the above step adjust zero or span as per error. For conventional transmitter this adjustment is to be done by potentiometer and for smart transmitters do this adjustment by HART.**
9. **Calculate the % accuracy of the transmitter from above readings. If it is within the acceptable limit, then calibration is o.k.**



Percent of range	Input pressure	Output current (ideal)	Output current (measured)	Error (percent of span)
0%	0 PSI	4.00 mA	3.99 mA	-0.0625 %
25% ↑	50 PSI	8.00 mA	**7.98 mA**	**-0.125 %**
50% ↑	100 PSI	12.00 mA	11.99 mA	-0.0625 %
75% ↑	150 PSI	16.00 mA	15.99 mA	-0.0625 %
100% ↑	200 PSI	20.00 mA	20.00 mA	0 %
75% ↓	150 PSI	16.00 mA	16.01 mA	+0.0625 %
50% ↓	100 PSI	12.00 mA	12.02 mA	+0.125 %
25% ↓	50 PSI	8.00 mA	**8.03 mA**	**+0.188 %**
0% ↓	0 PSI	4.00 mA	4.01 mA	+0.0625 %

Configuration using HART calibrator

1. **Check the resistance first across the pressure transmitter, as it should be more than 250 Ώ, if it is not so then connect a resistance of 250 Ώ in series with the supply.**
2. **Connect HART calibrator in parallel to the transmitter and switch it on.**
3. **Go to the basic parameters and then enter the LRV and URV.**
4. **Select the 'LINEAR' mode.**
5. **In diagnosis select loop testing and check the value at 4mA and 20mA on DCS.**

1. **Clear the work permit & take trial run.**
2. **After trials ensure that there is no abnormality.**

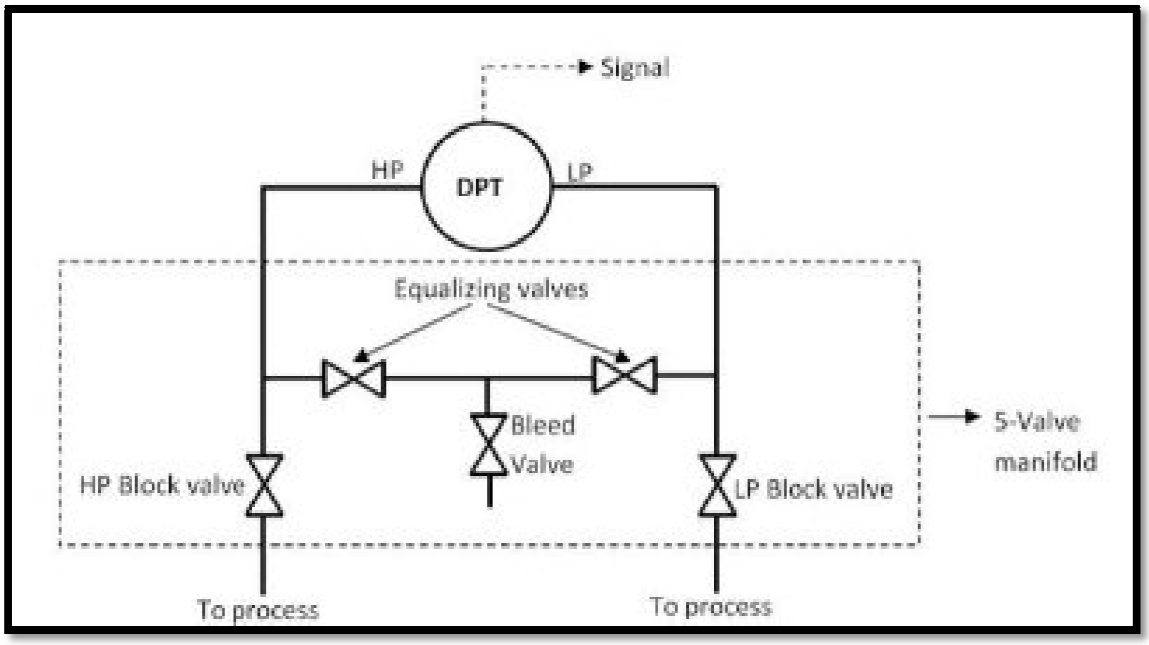
3. Calibration Procedure for PRESSURE TRANSMITTER

A. **Purpose - To follow the work instruction for carrying out maintenance work of instruments.**
B. **Scope – These work instructions shall be applicable to calibration of all type of pressure transmitter.**
C. **PRE- REQUISITES:**

1. **Basic Qualification –**
   - **Technician-**
   - **Jr. Technician-**
2. **Trade Training – Instrument Maintainer**
   Basic Safety Training –Tool Box Talk.
3. **Mandatory PPEs – Helmet, Hand Gloves, Goggles, Ear muff, Safety shoes, oxygen meter.**
4. **Tools / Equipments –**
   - **Multi meter**
   - **Screw driver set / Spanner set**
   - **Allen key Set**
   - **Pressure calibrator**

D. **Calibration steps :-**

1. **Work permit must be taken with all safety arrangements.**
2. **Safety precautions should be followed with proper safety equipment.**
3. **Note calibration range from Inst data sheet.**
4. **Apply the max pressure through master Pressure Calibrator. List to the transmitter to be calibrated and check the span with multi meter of master inst.**
5. **Release the pressure up to 0 Kg/cm2 (Atmospheric) and check the output 4 mA for Pressure Transmitter & 7.20 mA for Compound Pressure Transmitter.**
6. **Divide the full calibration range into four parts such as - 25 %, 50 %, 75% & 100 % or into five parts such as - 20%, 40%, 60%, 80% & 100%. However, for Compound Pressure Transmitter, since the absolute vacuum of –1 Kg/cm2 is not possible to achieve, therefore one reading at maximum possible vacuum (>= 700 mmHg absolute should be taken).**
7. **Check the mA o/p on each of the above pressure.**
8. **If any error is observed in the above step adjust zero or span as per error. For conventional transmitter this adjustment is to be done by potentiometer and for smart transmitters do this adjustment by hand held terminal.**
9. **Calculate the % accuracy of the transmitter from above readings. If it is within the acceptable limit, then calibration is o.k.**



Configuration using HART calibrator

1. **Check the resistance first across the pressure transmitter, as it should be more than 250 Ω, if it is not so then connect a resistance of 250 Ω in series with the +ve supply.**
2. **Connect HART calibrator in parallel to the transmitter and switch it on.**
3. **Go to the basic parameters and then enter the LRV and URV.**
4. **In diagnosis select loop testing and check the value at 4mA and 20mA on DCS.**
5. **Clear the work permit & take in line.**
6. **After taken in line ensure that there is no abnormality.**

4. Calibration Procedure for ULTRASONIC LEVEL TRANSMITTER

A. Purpose - To follow the work instruction for carrying out maintenance work of instruments.

B. Scope –These work instructions shall be applicable for ultrasonic type level transmitter.

C. PRE- REQUISITES:

1. Basic Qualification –

- **Technician-**
- **Jr. Technician-**

2. Trade Training – Instrument Maintainer
Basic Safety Training –Tool Box Talk.

3. Specialized training –Use of gas monitors, Breathing apparatus, Confined Space.

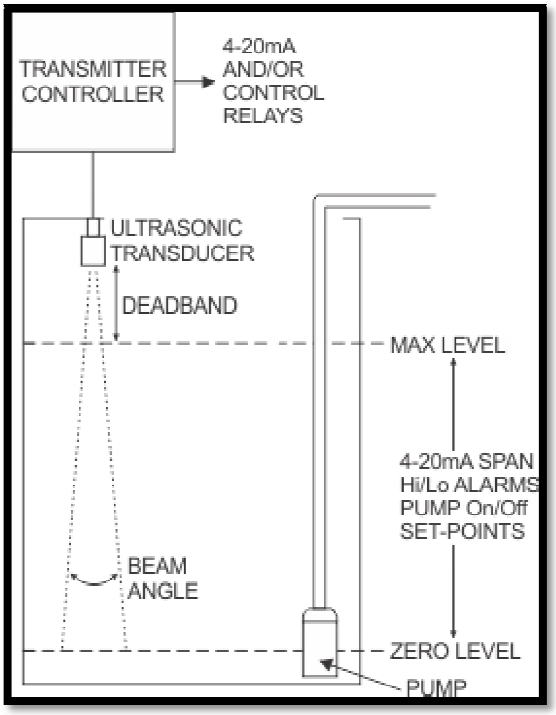
4. Mandatory PPEs – Helmet, Hand Gloves, Goggles, Ear muff, Safety shoes, oxygen meter.

Tools / Equipments –

- **Multi meter**
- **Screw driver set / Spanner set**

D. CALIBRATION STEPS:-

1. **Ensure that no filling in silo or bunker is going on. If the system is running then stop the system before removing the sensor.**
2. **Remove the ultrasonic level sensor from its mounting position.**
3. **Clean the sensor part by soft cloth.**
4. **Make the connections tight for power cable, signal cable.**
5. **Put the sensor in front of any plate or object just near to sensor. It will show the Zero (means Silo is Full).**
6. **Now put the sensor direction in open atmosphere, it will show full range of transmitter.**



Basic setup for ULTRASONIC TRANSDUCER

7. **If both the readings are as per transmitter range then check for linearity by putting object or plate at fixed distance (ex: 5 mtr).**
8. **It should show the desired value and if not then adjust the blocking distance.**
9. **Now fix back to position and see the physical level of Silo by Rope and cross check the present value of transmitter.**
10. **Close the work permit and take it on line.**

5. Calibration Procedure of Guided Wave Radar Level Transmitter:-

A. **Purpose - To follow the work instruction for carrying out maintenance work of instruments.**

B. **Scope –These work instructions shall be applicable for Guided wave radar level transmitter.**

C. **PRE- REQUISITES:**

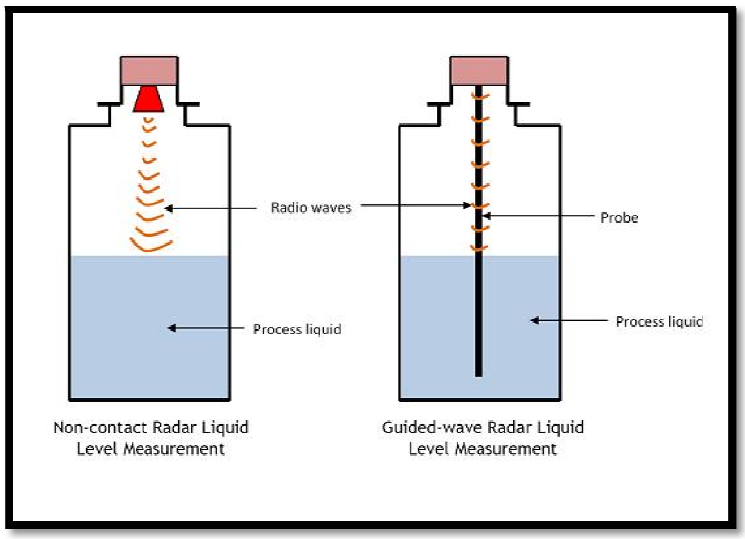
1. **Basic Qualification –**
   - **Technician-**
   - **Jr. Technician-**
2. **Trade Training – Instrument Maintainer**
   Basic Safety Training –Tool Box Talk.
3. **Specialized training –Use of gas monitors, Breathing apparatus, Confined Space.**
4. **Mandatory PPEs – Helmet, Hand Gloves, Goggles, Ear muff, Safety shoes, oxygen meter.**

Tools / Equipments –

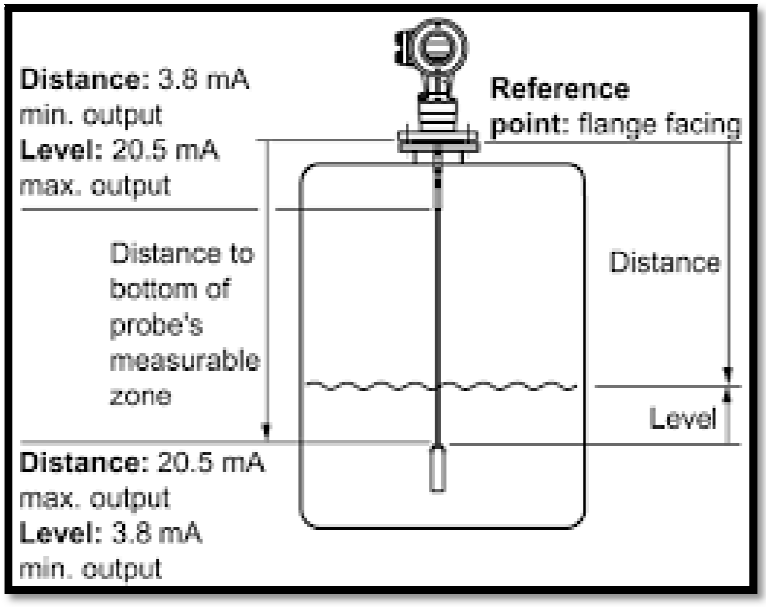
- **24 VDC power supply**
- **Multimeter digital**
- **Water Supply Connection**
- **HART communicator**
- **Screwdriver set**
- **Wrench set**

D. **CALIBRATION STEPS:-**

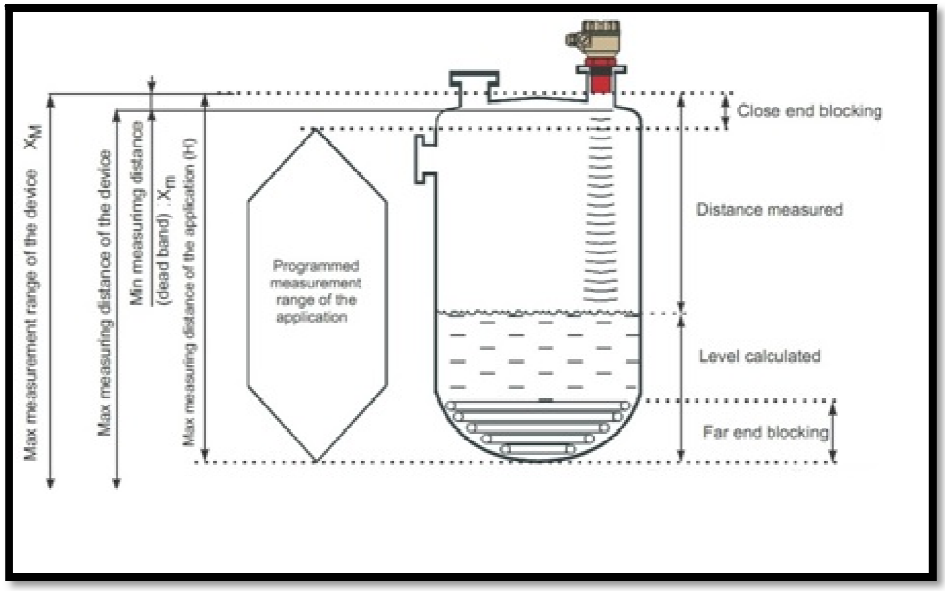
1. **Set up the guided wave radar level transmitter, HART communicator, power supply, and the multimeter as below (see below calibration setup file).**
2. **Check the configuration of the lower range value (0% level, 4 mA) and high range value (100% level, 20 mA). Make sure that the inputted data is as per datasheet. For example, the lower range value is 10 inch and the high range value is 35 inch (both of it are measured from the bottom of level transmitter probe)**
3. **Fill the level transmitter chamber with water up to the 0% level. Read the level measurement in the transmitter LCD (or in the HART communicator). Set this condition as 0% level through HART communicator.**
4. **Read the mA output of the transmitter by using a multimeter. Adjust (if any) through the HART communicator so that the output of the transmitter (on multimeter) is 4 mA.**



Non-Contact & Guided wave Radar liquid Level Measurement



Guided wave Radar Liquid Level Transmitter



Non contact type radar level transmitter

5. **Fill the level transmitter chamber with water up to the 100% level. Read the level measurement in the transmitter LCD (or in the HART communicator). Set this condition as 100% level through HART communicator.**
6. **Read the mA output of the transmitter by using a multimeter. Adjust (if any) through the HART communicator so that the output of the transmitter (on multimeter) is 20 mA.**
7. **Close the work permit and take it on line.**

6. Calibration Procedure of Displacer (Buoyancy) Level Transmitter:-

A. **Purpose - To follow the work instruction for carrying out maintenance work of instruments.**

B. **Scope –These work instructions shall be applicable for displacer type level transmitter.**

C. **PRE- REQUISITES:**

1. **Basic Qualification –**
   - **Technician-**
   - **Jr. Technician-**
2. **Trade Training – Instrument Maintainer**
   Basic Safety Training –Tool Box Talk.

   Specialized training –Use of gas monitors, Breathing apparatus, Confined space.
3. **Mandatory PPEs – Helmet, Hand Gloves, Goggles, Ear muff, Safety shoes, oxygen meter.**
4. **Tools / Equipments –**
   - **24 VDC power supply**
   - **Multimeter digital**
   - **Water Supply Connection**
   - **HART communicator**
   - **Screwdriver set**
   - **Wrench set**

D. **CALIBRATION STEPS:-**

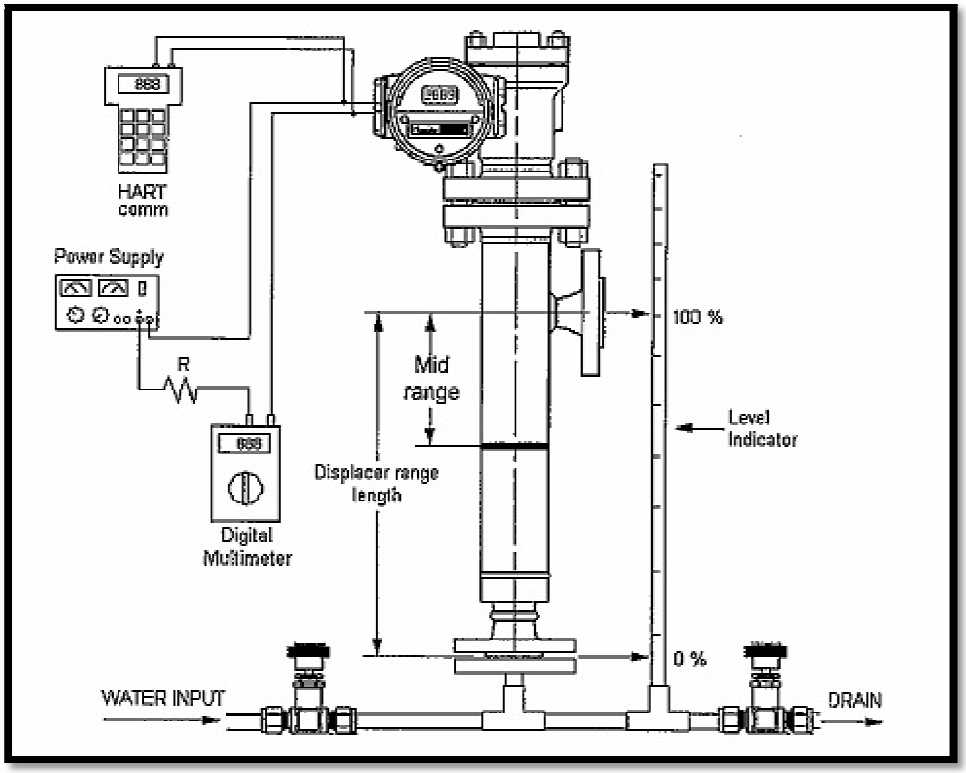
1. **Calculate the equivalence water level**
   zero level = displacer not immersed (no need certain adjustment)
   Calculate the high level using this equation:
   (Process Fluid Operating SG / Water SG)*Transmitter Level Range

2. **Set up the Displacer Level Transmitter to column or temporary support as shown in the calibration setup file below.**

3. **Fill the level transmitter chamber with water up to the centre of the lower part flange of the LIT cage as a zero level.**

4. **By using handheld HART communicator set this level as zero level (see also in the LCD display of the transmitter, it should show zero level).**
5. **Read the mA output of the transmitter by using a multimeter. Adjust (if any) through the HART communicator so that the output of the transmitter (on multimeter) is 4 mA.**

6. **Fill the level transmitter chamber with water up to the calculated equivalence high level above.**
7. **By using handheld HART communicator set this level as high level (see also in the LCD display of the transmitter, it should show high level).**
8. **Read the mA output of the transmitter by using a multimeter. Adjust (if any) through the HART communicator so that the output of the transmitter (on multimeter) is 20 mA.**



6.1. Non-Interface Displacer Level Transmitter Calibration Procedure:-

1. **Calculate the equivalence water level**
   Calculate zero level using this equation:
   (Lighter Process Fluid Operating SG / Water SG)*Transmitter Level Range
   Calculate the high level using this equation:
   (Heavier Process Fluid Operating SG / Water SG)*Transmitter Level Range

2. **Set up the Displacer Level Transmitter to column or temporary support as shown in the calibration setup file below.**

3. **Fill the level transmitter chamber with water up to the calculated equivalence zero level above.**

4. **By using handheld HART communicator set this level as zero level (see also in the LCD display of the transmitter, it should show zero level).**

5. **Read the mA output of the transmitter by using a multimeter. Adjust (if any) through the HART communicator so that the output of the transmitter (on multimeter) is 4 mA.**

6. **Fill the level transmitter chamber with water up to the calculated equivalence high level above.**

7. **By using handheld HART communicator set this level as high level (see also in the LCD display of the transmitter, it should show high level).**

8. **Read the mA output of the transmitter by using a multimeter. Adjust (if any) through the HART communicator so that the output of the transmitter (on multimeter) is 20 mA.**

6.2. Interface Displacer Level Transmitter Calibration Procedure:-

1. **Calculate the equivalence water level**
   Calculate zero level using this equation:
   (Lighter Process Fluid Operating SG / Water SG)*Transmitter Level Range
2. **Calculate the high level using this equation:**
   (Heavier Process Fluid Operating SG /Water SG)*Transmitter Level.

3. **Set up the Displacer Level Transmitter to column or temporary support as shown in the calibration setup file below.**

4. **Fill the level transmitter chamber with water up to the calculated equivalence zero level above.**

5. **By using handheld HART communicator set this level as zero level (see also in the LCD display of the transmitter, it should show zero level).**

6. **Read the mA output of the transmitter by using a multimeter. Adjust (if any) through the HART communicator so that the output of the transmitter (on multimeter) is 4 mA.**

7. **Fill the level transmitter chamber with water up to the calculated equivalence high level above.**

8. **By using handheld HART communicator set this level as high level (see also in the LCD display of the transmitter, it should show high level).**

9. **Read the mA output of the transmitter by using a multimeter. Adjust (if any) through the HART communicator so that the output of the transmitter (on multimeter) is 20 mA.**

7. Calibration procedure LEVEL SWITCH & SENSOR:-

A. **Purpose - To follow the work instruction for carrying out maintenance work of instruments.**
B. **Scope –These work instructions shall be applicable for calibration of level switch & sensor.**
C. **PRE- REQUISITES:**

1. **Basic Qualification –**
   - **Technician-**
   - **Jr. Technician-**
2. **Trade Training – Instrument Maintainer**
   Basic Safety Training –Tool Box Talk.
3. **Specialized training –Use of gas monitors, Rescue operation And Confined Space.**
4. **Mandatory PPEs – Helmet, Hand Gloves, Goggles, Ear muff, Safety shoes, oxygen meter.**

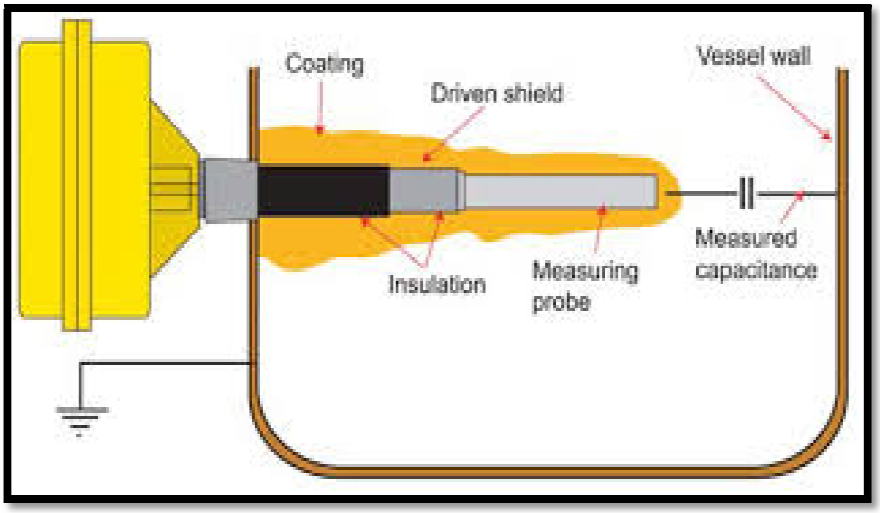
D. **Tools / Equipments –**
   - **Multi meter**
   - **Screw driver set / Spanner set**
   - **Allen key Set**

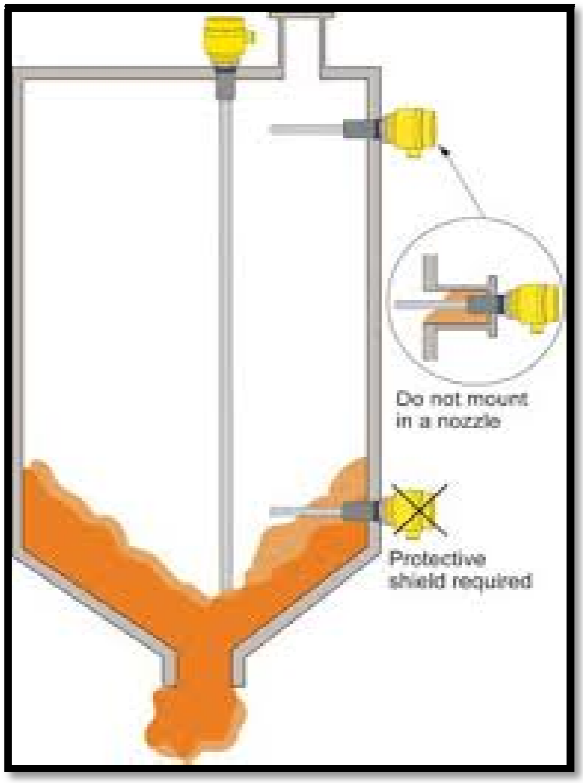
STEPS OF Calibration:-

1. **Capacitance type Level Switch**
2. **RF Type level switch**
3. **Float Type Level switch**
4. **Conductivity type Level switches**

7.1. Capacitance type Level Switch CLT-100

1. **Check the terminations of Level probe and controller end – it must be fully tight.**
2. **Check LED indications (green) of Power ON and Probe sensing.**
3. **Remove the Probe from position and clean it properly. Before removing the probe, ensure that chord of sensor should be opened to avoid the twisting/ breakage.**
4. **Take Oil pot and dip the probe it in. LED color will turn from Green to Red.**
5. **Relay contact at controller will change the contact and level normal indication will glow.**
6. **Takeout the probe from oil it will show the empty through relay contact.**
7. **If LED color and relay change contact changeover is not being take place then follow the calibration procedure.**
8. **Ensure that shield wire should not be grounded.**
9. **Self adhesive mark to be used for fixing the calibration pots.**



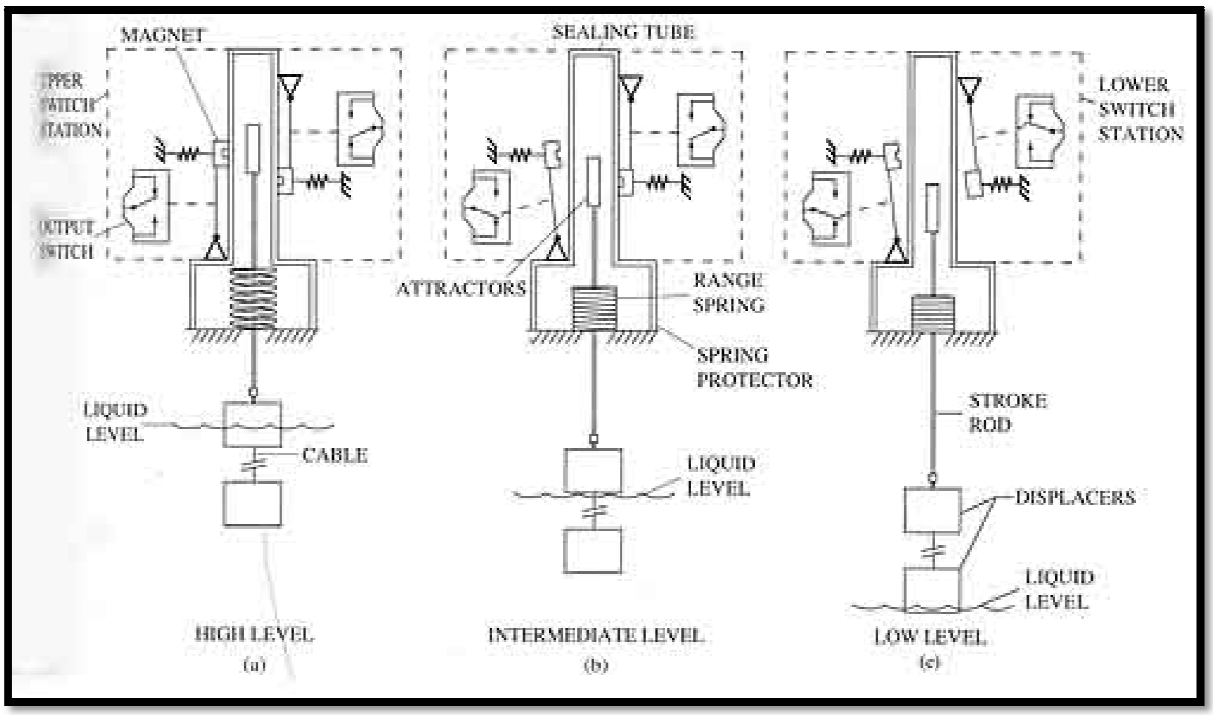


7.2. RF Type Level Sensors:-

1. Inform to field operator for isolation of Level probe.
2. Remove the probe from position and clean it properly.
3. Ensure that all termination are tightened fully.
4. In AHP, probe should be check in bucket full of ash and ensure that wire distance should be same as it is in normal use.
5. Put the probe in water or dust as per application and check the sensing of level.
6. If level sensing is not showing then adjust the sensitivity by port.
7. Controller is having three Set point option.
8. Select which one we are using for feedback. If all three are in use then adjust as per required level of sump.
9. Check the same by varying the level of water or dust and relay contact changeover.
10. Repeat two or three times and then fix the probe back to position.
11. Close the work permit and take it online.

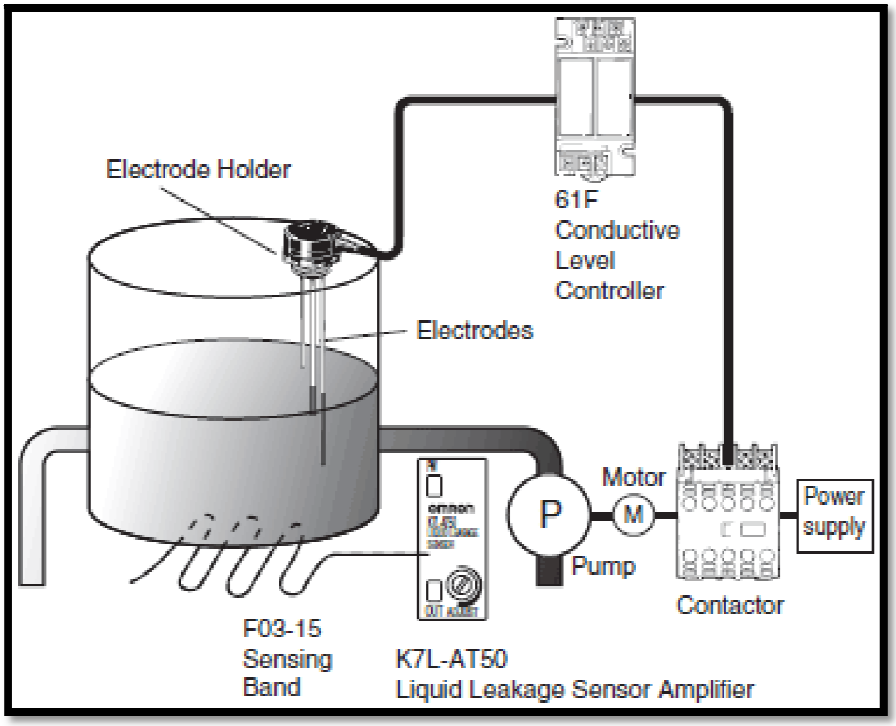
7.3. Float Type Level Sensors:-

1. Inform to field operator for isolation of Level probe.
2. Remove the probe from position and clean it properly.
3. Ensure that all terminations are tightened fully.
4. Put the probe in liquid media as per application and check the sensing of level. (Low and high).
5. Micro switch will change contact at both the level. If not then check the micro Switch contacts. By sliding float from up to down.
6. Repeat two or three times and then fix the probe back to position.
7. Close the work permit and take it online.



7.4. Conductivity Type Level Sensors:-

1. Inform to field operator for isolation of Level switch.
2. Remove the Switch electrode (reference and measuring) from position and clean it properly.
3. Ensure that all terminations are tightened fully.
4. Put the Electrode in liquid media and check the sensing LED and relay contact changeover. (Low medium and high).
5. If not then check the power supply to controller. And check controller functions by making sort contact in each terminal of various Levels (low, Medium, & High) one by one.
6. All three level LED or contacts will change the status at output.
7. Check the level by varying water level in Sump.
8. Assemble the instrument and close the permit.



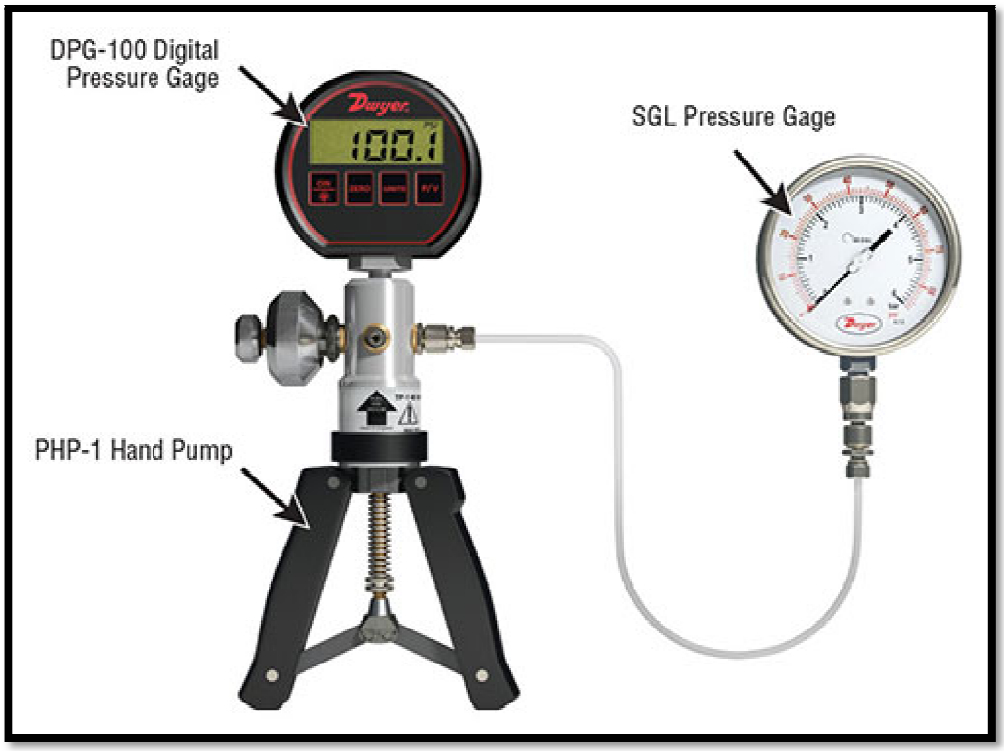
8. Calibration procedure FOR PRESSURE GAUGE:-

A. **Purpose - To follow the work instruction for carrying out calibration work of instruments.**

B. **Scope –These work instructions shall be applicable for pressure gauge.**

C. **PRE- REQUISITES:**

1. **Basic Qualification –**
   - **Technician-**
   - **Jr. Technician-**
2. **Trade Training – Instrument Maintainer**
   Basic Safety Training – Tool Box Talk.
3. **Specialized training –Use of gas monitors, and Confined Space.**
4. **Mandatory PPEs – Helmet, Hand Gloves, Goggles, Ear muff, Safety shoes.**
   Tools / Equipments –
   - **Multi meter**
   - **Screw driver set / Spanner set**
   - **Pointer puller**
   - **Hand pump**
   - **Master pressure gauge**
5. **Calibration Activities:-**
   1. **Work permit must be taken with all safety arrangements with local isolation.**
   2. **Safety precautions should be followed with proper safety equipment.**
   3. **Before applying any pressure to the gauge, check the zero of the gauge if it is not so, adjust**
   4. **The zero of the gauge.**
   5. **Note the range of particular gauge.**
   6. **Apply the Pressure of [25%] , [50%] , [75%] and [100%] of range from Test Inst. (Pressure pump) of master Inst. List.**
   7. **Check the span of the gauge with standard gauge value. If there is no matching then adjust the span of the burden of pressure gauge.**
   8. **After adjusting the span again check and set the zero of the gauge and after this check the span value.**



Gauge calibration general arrangement

9. Note the related reading and errors for the above positions.
    a. Confirm the error as linear or non-linear.
    b. If the error is linear, adjust with zero & span of burden.
    c. If the error is non linear, adjust with pointer tension screw and make it linear.
    d. Then adjust with zero & span of burden.
    e. Measure the% accuracy, if it is within the acceptable limit, then calibration is o.k.
10. Clear the work permit & take trial run.
11. After trials ensure that there is no abnormality

9. Calibration procedure FOR PRESSURE SWITCH

A. Purpose - To follow the work instruction for carrying out calibration work of instruments.

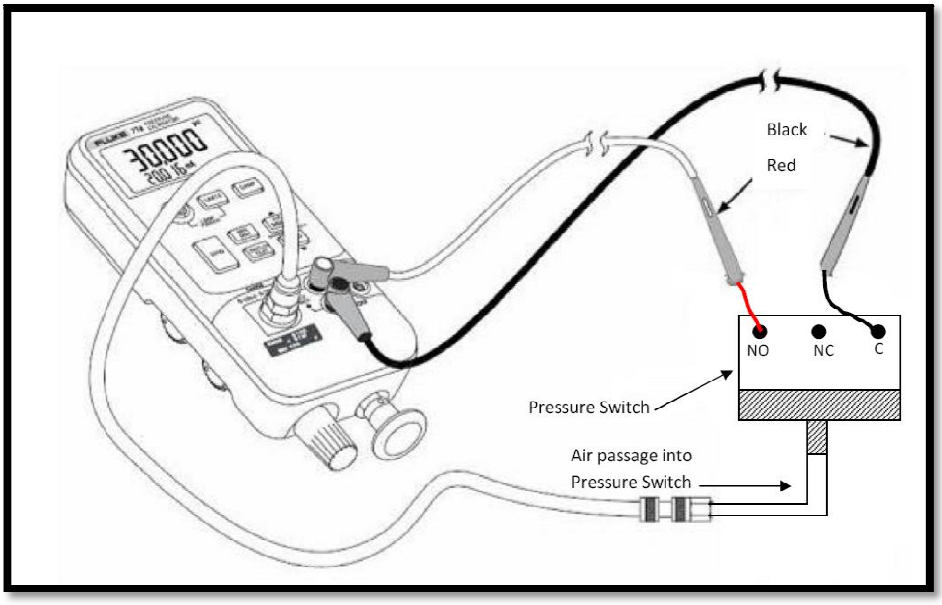
B. **Scope –These work instructions shall be applicable for pressure switch.**

C. PRE- REQUISITES:

1. **Basic Qualification –**
   - **Technician**
   - **Jr. Technician**
2. **Trade Training – Instrument Maintainer**
   Basic Safety Training – Tool Box Talk.
3. **Specialized training –Use of gas monitors, Confined Space.**
4. **Mandatory PPEs – Helmet, Hand Gloves, Goggles, Ear muff, Safety shoes, oxygen meter.**
   Tools / Equipments –
   - **Multi meter**
   - **Screw driver set / Spanner set**
   - **Allen key Set**
   - **Dead Weight Tester**
   - **Master pressure gauge**

E. Calibration Activities :

1. **Work permit must be taken with all safety arrangements.**
2. **Safety precautions should be followed with proper safety equipment.**
3. **Work permit must be taken with all safety arrangements.**
4. **Safety precautions should be followed with proper safety equipment.**
5. **Check the NO & NC contacts of the pressure switch in off-line condition.**
6. **Mount the Pressure switch vertically with process connection facing down.**
7. **Adjust the pressure setting at desired value.**
8. **Apply the pressure slightly less than desired pressure through process connection port by dead Weight tester.**



General arrangement of pressure switch calibration

9. **Raise the pressure gradually up to desired level and then adjust the fine setting so that Pressure Switch gets operated.**
10. **Now check the contacts by the help of multimeter, Both the contacts should be change over from NO & NC to NC & NO.**
11. **Release the pressure and repeat the process two –three times to observe that switch is operated at desired Pressure.**
12. **Clear the work permit & take trial run.**
13. **After trials ensure that there is no abnormality.**

10. Calibration procedure for I/P CONVERTOR

A. Purpose - To follow the work instruction for carrying out maintenance work of instruments.

B. Scope –These work instructions shall be applicable for I/P convertor.

C. Measurable/Control/KPI – Adequate light.

D. PRE- REQUISITES:-

1. Basic Qualification –

- **Technician-**
- **Jr. Technician-**

2. Trade Training – Instrument Maintainer

Basic Safety Training – Tool Box Talk.

3. Specialized training –Use of gas monitors, Rescue operation And Confined Space.

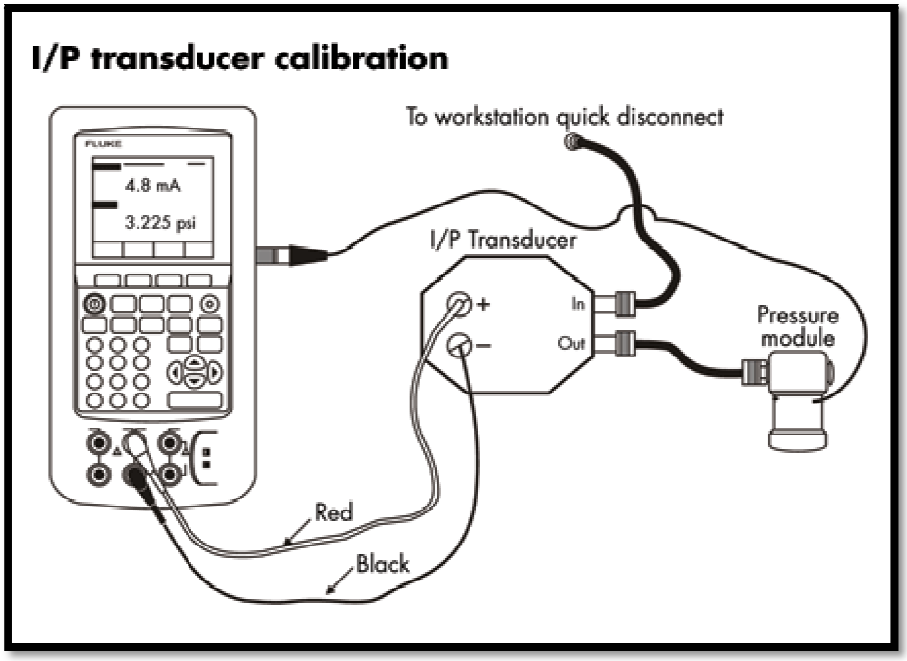
4. Mandatory PPEs – Helmet, Hand Gloves, Goggles, Ear muff, Safety shoes, Breathing apparatus, oxygen meter.

Tools / Equipments –

- **Multi meter**
- **Screw driver set / Spanner set**
- **Allen key Set**

E. Calibration Activities :

1. **Work permit must be taken with all safety arrangements.**
2. **Safety precautions should be followed with proper safety equipment.**
3. **Note the range of the transmitter**
4. **Mark the 'High' and 'Low' side of transmitter.**
5. **Apply the specified minimum pressure from pressure calibrator to the Low side of the transmitter and check or '0' i.e. 4 mA with multimeter of master inst. List If '0' is not proper, adjust it by '0' pot.**
6. **Then apply the max specified pressure to the high side of the transmitter and check for span i.e.20 mA. If span is not proper, adjust it by 'span' pot.**
7. **Divide the span into 4 equal divisions and check mA o/p on each of the 4 divisions and o/p should be 8mA, 12mA, 16mA and 20mA respectively for linearity.**
8. **If any error is observed in the above step adjust zero or span as per error. For conventional transmitter this adjustment is to be done by potentiometer and for smart transmitters do this adjustment by HART.**
9. **Calculate the % accuracy of the transmitter from above readings. If it is within the acceptable limit, then calibration is o.k.**



Configuration using HART calibrator

I. **Check the resistance first across the pressure transmitter, as it should be more than 250 Ώ, if it is not so then connect a resistance of 250 Ώ in series with the supply.**
II. **Connect HART calibrator in parallel to the transmitter and switch it on.**
III. **Go to the basic parameters and then enter the LRV and URV.**
IV. **Select the 'LINEAR' mode.**
V. **In diagnosis select loop testing and check the value at 4mA and 20mA on DCS.**

F. **Clear the work permit & take trial run.**
G. **After trials ensure that there is no abnormality.**

11. Calibration procedure for THERMOCOUPLE

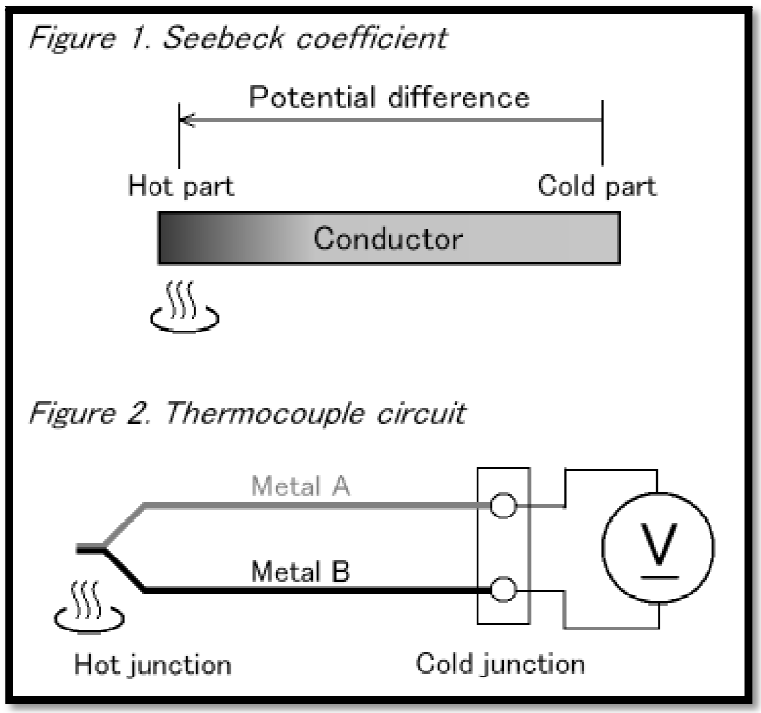
A. **Purpose - To follow the work instruction for carrying out calibration work of instruments.**
B. **Scope –These work instructions shall be applicable for calibration of Thermocouple transmitter.**
C. **PRE- REQUISITES:**

1. **Basic Qualification –**
   - **Technician**
   - **Jr. Technician**
2. **Trade Training – Instrument Maintainer**
   Basic Safety Training – Tool Box Talk.
3. **Specialized training –Use of gas monitors, Confined Space.**
4. **Mandatory PPEs – Helmet, Hand Gloves, Goggles, Ear muff, Safety shoes.**
5. **Tools / Equipments –**
   - **Multi meter**
   - **Screw driver set / Spanner set**
   - **Thermocouple simulator**
   - **Thermometer.**
6. **Calibration Activities:**

1. **Work permit must be taken with all safety arrangements.**
2. **Safety precautions should be followed with proper safety equipment.**

7. **PROCEDURE:**

1. **Work permit must be taken with all safety arrangements.**
2. **Safety precautions should be followed with proper safety equipment.**
3. **Ensure that the T/C is in any control logic or not for plant operation safety.**
4. **Check the thermocouple by standard multimeter. T/C should not be short or open with its Thermo well.**
5. **First of all, short the T/C wire then indicator will display ambient temp. If indicator reading is not corresponding to that temperature, then adjust the zero pot for matching with ambient Temperature.**



Thermocouple principal

6. **Now span calibration of indicator, mV corresponding to full scale range is fed by T/C Simulator. At this stage indicator will display max. Value of range in deg.cent. If indicator Reading is not in the span range then adjust the span by span pot of indicator**
7. **Check 25%, 50%, 75% & 100% of span value indication by simulating corresponding mV.**
8. **NO & NC relay contacts will be checked, if available.**
9. **Results are recorded in the calibration report format.**
10. **Clear the work permit & take trial run.**
11. **After trials ensure that there is no abnormality.**

12. Calibration procedure for RTD

A. Purpose - To follow the work instruction for carrying out calibration work of instruments.

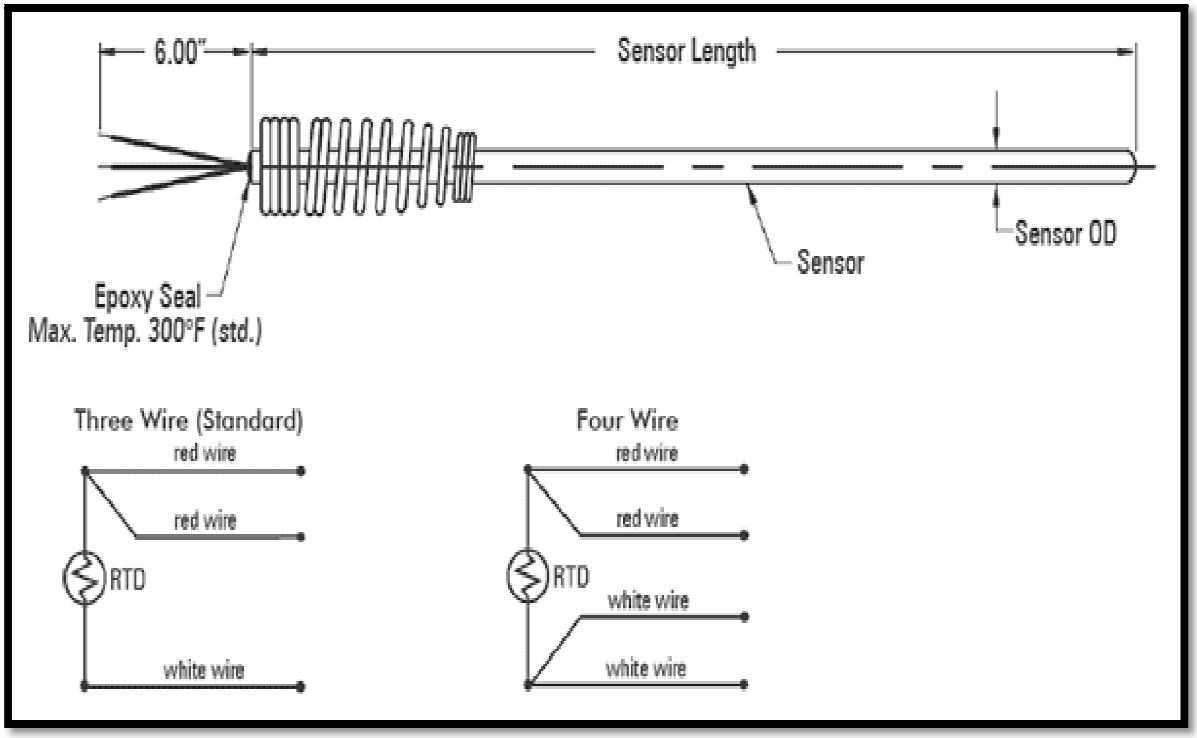
B. Scope –These work instructions shall be applicable for calibration of RTD.

C. PRE- REQUISITES:

1. Basic Qualification –
   - Technician
   - Jr. Technician
2. Trade Training – Instrument Maintainer
   Basic Safety Training – Tool Box Talk.
3. Specialized training –Use of gas monitors, Breathing apparatus, Rescue operation And Confined Space.
4. Mandatory PPEs – Helmet, Hand Gloves, Goggles, Ear muff, Safety shoes.
5. Tools / Equipments –
   - Multi meter
   - Screw driver set / Spanner set
   - RTD
   - Standard Thermometer.

D. Calibration Activities:

1. Work permit must be taken with all safety arrangements.
2. Safety precautions should be followed with proper safety equipment.
3. Ensure that the RTD is in any control logic or not for plant operation safety.
4. Check whether the thermo well is properly inserted in the medium and also check RTD element is inserted in thermo well.
5. Connect the RTD's wire to the indicator and note down the value.
6. If it is not matching with desired temperature, then check the wire connections in indicator side as well as RTD side and tight the wire.



General arrangement for RTD

7. **Clear the work permit & take trial run.**
8. **After trials ensure that there is no abnormality.**

13. Calibration procedure for POSITION F/B TRANSMITTER

A. **Purpose - To follow the work instruction for carrying out maintenance work of instruments.**
B. **Scope –These work instructions shall be applicable for position F/B transmitter.**
C. **PRE- REQUISITES:**

1. **Basic Qualification –**
   - **Technician**
   - **Jr. Technician**
2. **Trade Training – Instrument Maintainer**
   Basic Safety Training – Tool Box Talk.
3. **Specialized training –Use of gas monitors And Confined Space.**
4. **Mandatory PPEs – Helmet, Hand Gloves, Goggles, Ear muff, Safety shoes,oxygen meter.**
5. **Tools / Equipments –**
   - **Multi meter**
   - **Screw driver set / Spanner set**

D. **Calibration Activities :**

1. **Work permit must be taken with all safety arrangements.**
2. **Safety precautions should be followed with proper safety equipment.**
3. **Connect the link of transmitter with the valve stem.**
4. **Connect the wire and ON the 24VDC power supply. Connect the Multimeter in series.**
5. **Apply 4 mA signals by mA source of master instrument list and check for 0% opening of valve. Now check the output of position transmitter which shall be 4mA.**
6. **If it is not so then adjust by ZERO pot of position transmitter.**
7. **Apply 20 mA signals with mA source and check for 100 % opening. Then output of position transmitter shall be 20mA.If it differs from the reference, adjust it by positioner span adjustment.**
8. **Apply 8 mA, 12mA and 16mA signal by mA source to the valve and check for 25 % 50%and 75% respectively opening of valve.**
9. **Check the output of position transmitter which should be 8mA, 12mA and 16 mA respectively.**
10. **Adjust the 0 to 45 degree angle of lever, if linearity not found.**
11. **Check with reverse cycle response of position transmitter.**
12. **Clear the work permit & take trial run.**
13. **After trials ensure that there is no abnormality.**

14. Calibration procedure for Vibration Sensor/Proximeter

A. Purpose - To follow the work instruction for carrying out calibration work of instruments.

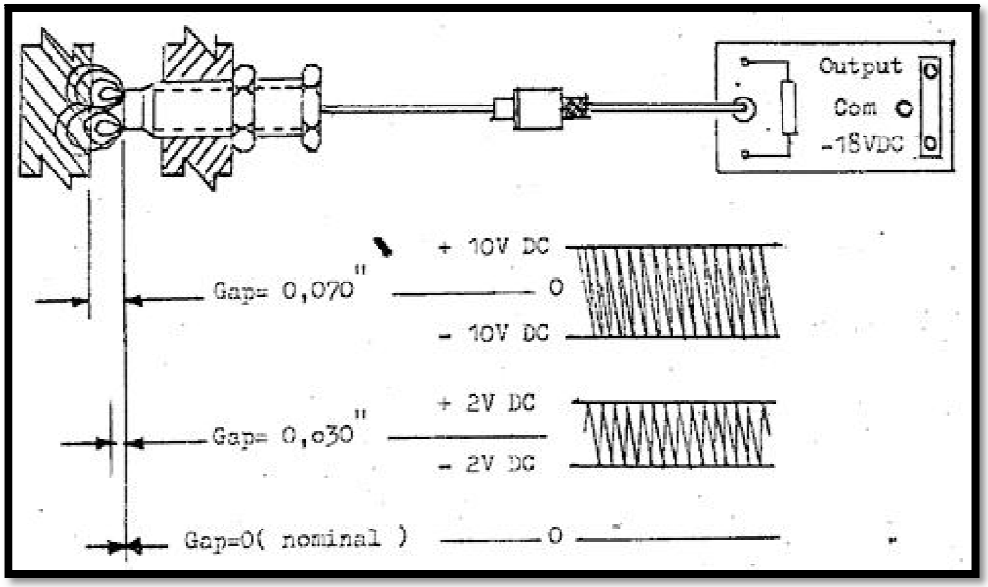
B. Scope –These work instructions shall be applicable for vibration & proximeter.

C. PRE- REQUISITES:

1. **Basic Qualification –**
   - **Technician**
   - **Jr. Technician**
2. **Trade Training – Instrument Maintainer**
   Basic Safety Training – Tool Box Talk.
3. **Specialized training –Use of gas monitors And Confined Space.**
4. **Mandatory PPEs – Helmet, Hand Gloves, Goggles, Ear muff, Safety shoes, oxygen meter, safety belt.**
5. **Tools / Equipments –**
   - **Multi meter**
   - **Screw driver set / Spanner set**
   - **Allen key Set**

D. Calibration Activities :

1. **Work permit must be taken with all safety arrangements.**
2. **Safety precautions should be followed with proper safety equipment.**
3. **Insert the sensor at the confined place given on the casing of the turbine or on the movable rotor.**
4. **Connect the multimeter at the proxy meter terminal and put the multimeter pot at VDC point.**
5. **Now do the setting of vibration sensor by the help of spanner set.**



Vibration Sensor mounting arrangement

6. **Sensor adjusting range is from -9.5 to -10.5 VDC and Set the sensor at -9.9 VDC or -10VDC by continuously watching the multimeter reading and Vibration Display unit or DCS. When this value will show on multimeter and Vibration Display unit or DCS showing "Zero" fix the sensor by tightening the nut.**
7. **If multimeter value is deflecting after tightening the sensor, then again do the setting of sensor until above output value will not achieve after tightening the sensor.**
8. **Clear the work permit & take trial run.**
9. **After trials ensure that there is no abnormality.**

15. Calibration procedure for Oxygen Analyzer

A. Purpose - To follow the work instruction for carrying out calibration work of instruments.

B. **Scope –These work instructions shall be applicable for oxygen analyzer.**

C. PRE- REQUISITES:

1. Basic Qualification –

- **Technician**
- **Jr. Technician**

2. Trade Training – Instrument Maintainer
Basic Safety Training – Tool Box Talk.

3. **Specialized training –Use of gas monitors & Confined Space.**

4. Mandatory PPEs – Helmet, Hand Gloves, Goggles, Ear muff, Safety shoes, oxygen meter.

5. Tools / Equipments : –

- **Multi meter**
- **Screw driver set / Spanner set**
- **Allen key Set**
- **Sample oxygen cylinder of 8.0% O2 / 0.3 % O2**

D. **Calibration Activities :-**

i. Work permit must be taken with all safety arrangements.

ii. Safety precautions should be followed with proper safety equipment.

A. Auto calibration with Air (20.95%).

B. Two Point calibration with standard gas.

6.1 Work permit must be taken with all safety arrangements.

6.2 Safety precautions should be followed with proper safety equipment.

6.3 Connect the analyzer transmitter with the O2 sensor probe.

6.4 Ensure that Pneumatic connections are correct and tight. And check Ref Air flow and pressure, it must be 5~40 l/Hr and pressure: 1 Bar max.

6.5 Switch ON the power supply and wait till temperature increased up to 840°c, which is shown on the transmitter display.

6.6 Go to system menu and select single point calibration.

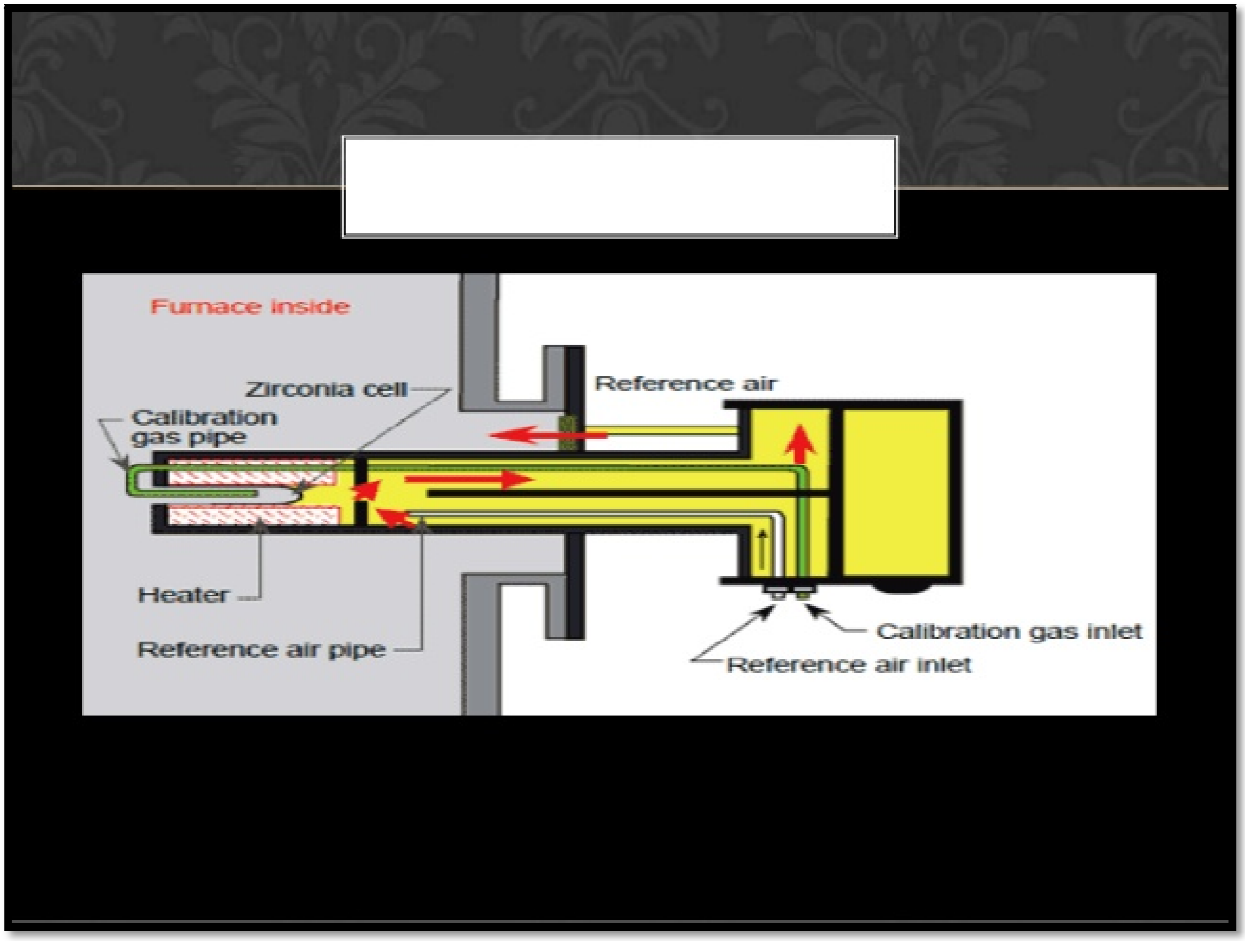
A. Auto calibration with Air (20.95%)

A.1 Select single point calibration from system menu.

A.2 Open the manual test Air Port in ambient. Supply test air (Ambient Air) with flow 5 l/h min.

A.3 Start calibration by pressing start button and wait till calibration complete message comes.

A.4 Go to main screen and see the display, it should be 20.95. If not then follow the two point calibration method.



B. Two Point calibration with standard gas

B.1 Select single point calibration from system menu.

B.2 Connect the Sample oxygen cylinder of 0.3% O2 at test gas supply port and adjust the flow rate of test Gas 1.

B.3 Start calibration by pressing start button and wait till calibration complete message comes.

B.4 Start calibration by pressing start button and wait till calibration complete message comes. NO manual interference should be there during the calibration.

B.5 After completion of step-1, system will start step-2 automatically.

B.6 Now disconnects the test gas-1 and connect test gas-2 with min 5l/h flow rate.

B.7 Time bar will start increasing and it will take two minutes app.

B.8 After completion of calibration process *"calibration completed successfully"* message will appear.

B.9 See the result of test value at display. If any error comes during calibration process then refer the operation manual of O2 Analyzer.

B.10 Disconnect the test gas cylinder.

B.11 Clear the work permit & take inline.

B.12 If accuracy is within acceptable limit then calibration is ok.

B.13 After trials ensure that there is no abnormality.

16. Calibration procedure for CONTROL VALVE / DAMPER DRIVE

A. **Purpose - To follow the work instruction for carrying out calibration work of instruments.**
B. **Scope –These work instructions shall be applicable for control valves & damper drive.**
C. **PRE- REQUISITES:**
   1. **Basic Qualification –**
      - **Technician-**
      - **Jr. Technician**
   2. **Trade Training – Instrument Maintainer**
      Basic Safety Training – Tool Box Talk.
   3. **Specialized training –Use of gas monitors, And Confined Space.**
   4. **Mandatory PPEs – Helmet, Hand Gloves, Goggles, Ear muff, Safety shoes, oxygen meter.**
   5. **Tools / Equipments –**
      - **Multi meter**
      - **Screw driver set / Spanner set**
      - **Allen key Set**

D. **Calibration Activities:**
   1. **Work permit must be taken with all safety arrangements with local isolation.**
   2. **Ensure that Control Loop is in manual mode.**
   3. **During Local isolation, ensure that inlet and outlet line is depressurized by opening drain valve.**
   4. **Safety precautions should be followed with proper safety equipment.**
   5. **Check working air pressure for the control valve. Adjust correct pressure from Pressure regulator.**
   6. **Without applying any external signal or pressure to the I/P adjust the scale Indicator of control valve opening at 0% exactly.**
   7. **Apply 4 mA signals by mA source of master instrument and check for 0 % opening of valve. Also check the output of I/P which shall be 0.2 kg /cm2.**
   8. **Check valve passing, adjust the positioner for full closing of valve. Even after this there is assign found at 0% opening, remove the valve from Position and do the lapping of the Plug & Seat using lapping compound (with the help of mechanical department.**
   9. **Again put the valve in Position and confirm that valve is fully closed and no passing at 0.2kg/cm2 input to positioner.**
   10. **Apply 20 mA signal with mA source and check for 100 % opening. The output of I/P which should be 1.0 kg/cm2. Check the full stroke (travel) of the valve stem.**
   11. **If it differs from the reference, adjust it by positioner span adjustment.**

12. **Apply 8 mA, 12mA and 16mA signal by mA source and check for 25 %, 50% and 75%.**
13. **Respectively opening of valve. Check the output of I/P which should be 0.4, 0.6 and 0.8 Kg /cm² respectively.**
14. **If any error is observed during the above steps, adjust with zero / span of Positioner.**
15. **Check and calibrate with reverse cycle response of control valve (100% to 0%).**
16. **Results are recorded in history register kept at respective section.**
17. **Results are recorded in history register kept at respective section.**
18. **Clear the work permit & take trial run.**
19. **After trials ensure that there is no abnormality.**
20. **Then take the control Loop in Auto mode.**

17. Calibration procedure for PH ANALYZER

A. **Purpose - To follow the work instruction for carrying out calibration work of instruments.**
B. **Scope – This work instruction shall be applicable to PH Analyzer (SWAS).**
C. **PRE- REQUISITES:**

1. **Basic Qualification –**
   - **Technician**
   - **Jr. Technician**
2. **Trade Training – Instrument Maintainer**
   Basic Safety Training – Tool Box Talk.
3. **Specialized training –Use of gas monitors.**
4. **Mandatory PPEs – Helmet, Hand Gloves, Goggles, Ear muff, Safety shoes, oxygen meter.**
5. **Tools / Equipments –**
   - **Multi meter**
   - **Screw driver set / Spanner set**
   - **Allen key Set**
   - **4PH, 7PH & 9PH Standard solution**

D. **Calibration Activities:**

1. **Work permit must be taken with all safety arrangements.**
2. **Safety precautions should be followed with proper safety equipments.**
3. **Inform to operations department for isolation of the process.**
4. **Ensure physically that isolation has been done with proper LOTO system.**

STEPS OF MAINTENANCE

Daily

I. **Check the following:**
II. **Sample Temperature < 45 Degree C**
III. **Sample flow 10 to 15LPH**
IV. **Sample pressure 0.5 to 6 Bar**

Weekly

I. **Check for any deposition on pH probe.**
II. **If yes clean with DM water or Immerse pH electrode in 0.1.N HCL for 10 min followed by cleansing with DM water & dipping in 0.1.N. NaOH for 10 min.**
III. **Rinse again in DM water for 30 min. & put back electrode in service.**
IV. **Check the response of analyzer & calibrate analyzer with pH buffers close to sample pH.**

Monthly

I. **Check response of analyzer, if sluggish follow weekly schedule Pl.**
II. **See above If do not succeed follow the following step carefully:**
III. **Put electrode overnight in 0.1.N. HCL followed by rinsing in DM water for 30 min. & then performs the calibration procedure.**
IV. **In case of reference junction is clogged follow following:**
V. **Dip electrode in 0.1.M KCL (heated to 80 degree C) for 10 min Followed by dipping in cool KCL for another 10 min & then rinsing with DM water, calibrate after doing this.**

18. Calibration procedure for SILICA ANALYZER

A. **Purpose - To follow the work instruction for carrying out maintenance work of instruments.**
B. **Scope –These work instructions shall be applicable for silica analyzer.**
C. **PRE- REQUISITES:**

1. **Basic Qualification –**
   - **Technician**
   - **Jr. Technician**
2. **Trade Training – Instrument Maintainer**
   Basic Safety Training – Tool Box Talk.
3. **Specialized training –Use of gas monitors, And Confined Space.**
4. **Mandatory PPEs – Helmet, Hand Gloves, Goggles, Ear muff, Safety shoes, oxygen meter.**
5. **Tools / Equipments –**
   - **Multi meter**
   - **Screw driver set / Spanner set**
   - **Allen key Set**

D. **Calibration Activities:-**

i. **Work permit must be taken with all safety arrangements.**
ii. **Safety precautions should be followed with proper safety equipment.**
iii. **Inform to operations department for isolation of the process. Ensure physically that isolation has been done with proper LOTO system.**

STEPS OF MAINTENANCE

i. **Check the leakage from the fittings.**
ii. **Check level of conditioning reagent- Amino acid, Citric acid, molybdate replenish if low.**
iii. **Check the level of standard Solution replenish if low.**
iv. **Clean the strainer.**
v. **Check the sample cell for cleaning.**
vi. **Check the alarm (for sample pressure regent pressure low) take corrective action & reset alarm.**

Checking Regent Pressure:

i. **Reagent supply pressure must be between 8 and 18 psi for proper operation. Pressurize and check the reagent supply system as follows:**
ii. **Supply an external pressure source i.e. instrument air with regulator, and adjust output pressure between 8 to 18 psi.**
iii. **Make sure the door to the reagent compartment is closed and turn the reagent pressure interlock valve to the ON position.**

iv. **Press the TEST key to call up the test menu:**

ALARM TEST NEXT OR ENTER

v. **Use the NEXT key to advance:**

REAGENT PRESSURE NEXT OR ENTER

vi. **Press the ENTER key .The display shows the actual reagent system pressure:**

REAG P =8 TO 18 PSI CLEAR TO CANCEL

vii. **Pressure is below 8 psi, check the leakage from fitting and arrest it.**

Setting Sample Pressure:

i. **Sample must be supplied to the**
ii. **Press the TEST key:**

ALARM TEST NEXT OR ENTER

iii. **Use the NEXT key to advance to:**

SAMPLE PRESSURE NEXT OR ENTER

iv. **Press the ENTER key to display actual sample Pressure:**

SMP P=2 TO 8 psi CLEAR TO CANCEL

v. **Sample pressure display responds to any change in sample pressure. Adjust sample pressure to achieve a sample pressure reading near 5-6 psi.**

vi. **Press the CLEAR key to return normal operation.**

CALIBRATION Steps:

i. **Before starting calibration check the level of standard solution in bottle.**

ii. **If level ok, then Press CALIB. Key to call up the Calibration Menu:**

CALIB STARTED NEXT OR CLEAR

iii. **Press the ENTER key to select auto calibration:**

AUTO-CALIBRATION NEXT OR ENTER

iv. **Press the ENTER key to start calibration:**

CALIB STARTED NEXT OR CLEAR

v. **Press the CLEAR key to exit calibration Menu. Display indicates the calibrating. When calibration complete, the value of the measured standard is displayed. The gain (slop) is corrected to give the expected result.**

19. Calibration procedure for DO ANALYZERS

A. Purpose - To follow the work instruction for carrying out calibration work of instruments.

B. **Scope –These work instructions shall be applicable for DO analyzers.**

C. PRE- REQUISITES:

1. **Basic Qualification –**
   - **Technician**
   - **Jr. Technician**
2. **Trade Training – Instrument Maintainer**
   Basic Safety Training – Tool Box Talk.
3. **Specialized training –Use of gas monitors, Rescue operation And Confined Space.**
4. **Mandatory PPEs – Helmet, Hand Gloves, Goggles, Ear muff, Safety shoes, Breathing apparatus, oxygen meter.**
   Tools / Equipments –
   - **Multi meter**
   - **Screw driver set / Spanner set**
   - **Allen key Set**

H. Activities :

1. **Work permit must be taken with all safety arrangements.**
2. **Safety precautions should be followed with proper safety equipment.**
3. **Inform to operations department for isolation of the process.**

STEPS OF MAINTENANCE:

1. **Check that sample temperature should be <45 degree C.**
2. **Sample pressure should be in the range 1-3 kg/cm2 (At deaerator outlet wet panel).**
3. **Sample flow inlet (at wet panel) and sample flow outlet (at dry panel) should be in the range 10-15 LPH.**
4. **Check for air bubbles in samples. It will deteriorate the response of analyzer & give higher readings.**
5. **Tighten all fittings/tubing's (SS) which leads to analyzer flow through the assembly. If bubbles are created in the incoming line, check for correctness.**
6. **Check the instrument readings, if it is found OK, do not disturb the analyzer settings**
7. **If there are deviations, do zero or slope (Process) calibration.**

MANUAL CALIBRATION:

1. **Remove the sensor from the sample line.**
2. **Rinse the sensor head with clean water.**
3. **Wipe the sensor head with a clean soft tissue to remove any excess moisture,**
   Flow the sample through the flow chamber with pressure reducer the maximum allowable inlet pressure.
4. **Configure and start the calibration as described in zero calibration or high level adjustment depending on the preferred calibration method.**

ZERO CALIBRATION:

1. **The sensor should be removed from the sample and exposed to pure N2 gas.**
2. **Press Start to start the calibration.**
3. **A screen is displayed showing the measured values and length of the time the sensor has been under calibration. These values are continually refreshed.**
4. **The value %last calibration –the message will display which is the difference between current and previous sensor calibration.**
5. **The Signal within range and stability reached boxes indicate whether the calibration is within acceptable limits. When both the boxes indicate YES, press finish to accept the new calibration.**

SENSOR MAINTENANCE:

1. **The sensor spot needs to be replaced about once a year.**
2. **Open the sensor spot with the maintenance tool delivered with the sensor only. Also change the O-ring supplied with the new sensor spot.**

D.FEMILIZATION OF CONTROL SYSTEMS :-

Process control system consists of four basic elements:-

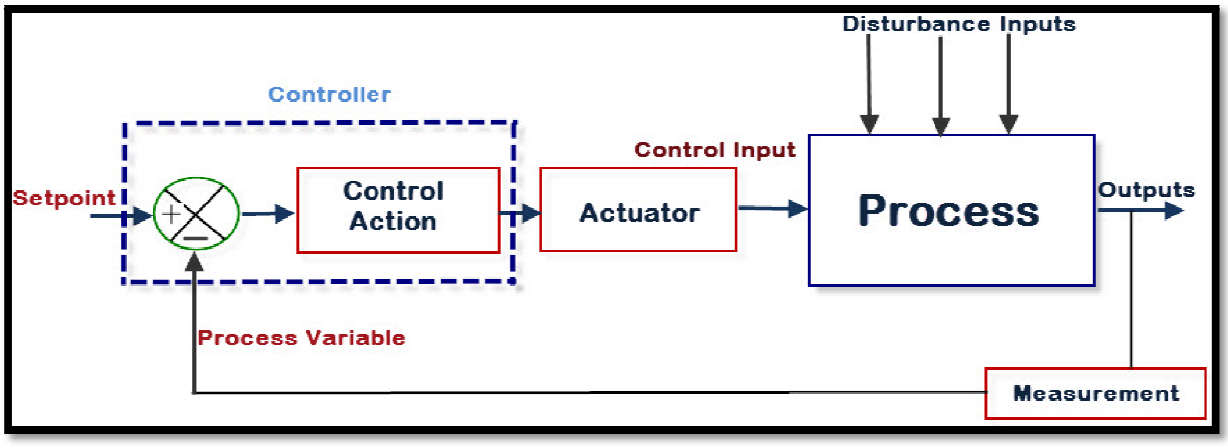
1. A measurement to know the status of the condition of a process
2. A controller to take action by considering the set value and measured value
3. An output signal to manipulate the process that results from the controller
4. The process itself that reacts to the signal (Input or output)

The two most important signals considered in industrial control systems are:

- Process Variable (PV)
- Manipulating Variable (MV)

Process variable (PV) is an input signal to the automated controller, which is measured by field devices. Depending on this value, the controller action is decided by either the operator manually or through the automatic controller.

The manipulating variable (MV) is a variable to be manipulated in order to have control over the process variable. Suppose, for a particular flow control operation, the flow control valve position is the manipulated variable to control the flow rate (process variable PV).



Nature of Industrial Control System

The nature of the industrial control system is shown in the above figure wherein the process is controlled through sensory, controller and actuator systems. The controller gets the input signals from the process measurement devices like sensors. These values are compared with the set point values in the controller and the resultant is used to control the actuator in order to produce control input to control the process as shown in the figure.

Basic Control Strategies Used in Industrial Control System

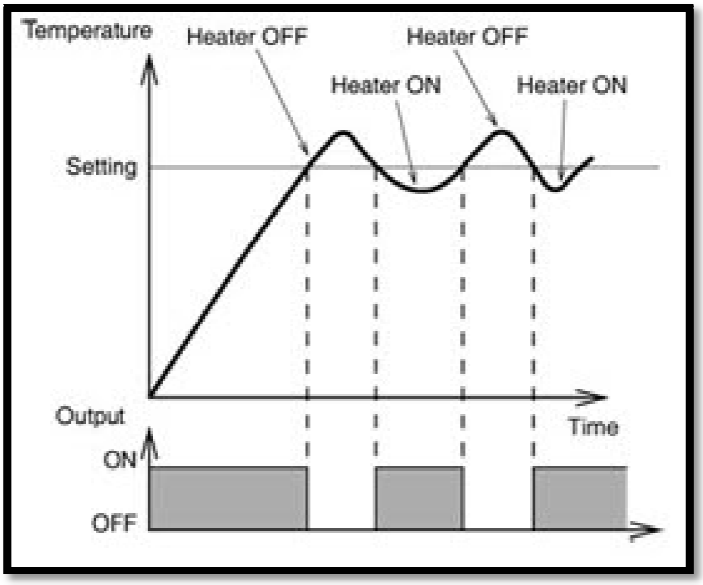
How well the process parameters are controlled depends on the control strategy implemented for that process. Basic control strategies used in most of the industries are

- **ON – OFF Control**
- **Open-Loop Control**
- **Feed- Forward Control**
- **Closed-Loop control**

1. ON – OFF Control:-

It is also called as two- position control system that has only two states fully on and fully off. It is the oldest type of control strategy that gives simple on- off mechanism for the set limits. When the process variable (PV) or measurement is below the set limit, then the controller is switched ON and the manipulated variable (MV) changes to maximum value. Similarly, if the PV is above the set limit, then the controller gets turned OFF and the MV changes to minimum value.

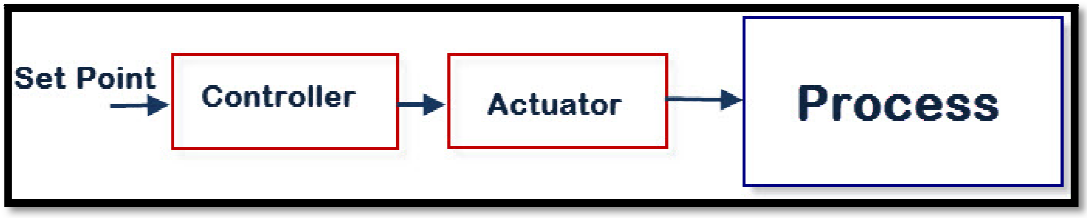
But, practically ideal on-off controller is not recommended since it is subject to process disturbances and other electrical interferences. To prevent this, on –off hysteresis or differential is added to the control function.



ON – OFF Control

2. Open-Loop Control:-

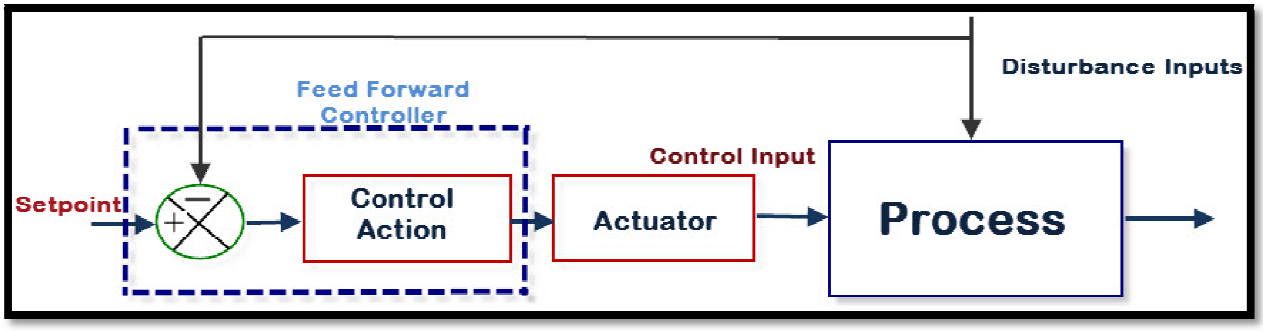
In this control structure, control action is not a function of process variable or any load changes. This is also not a self-correcting one. This control scheme independently calculates control output needed to the actuator to produce the desired response. But this system never knows the status of actuator output or process condition and also controller doesn't consider any disturbance inputs in the process. That's why this is limited for most of the applications.



Open Loop Control

3. Feed-Forward Control:-

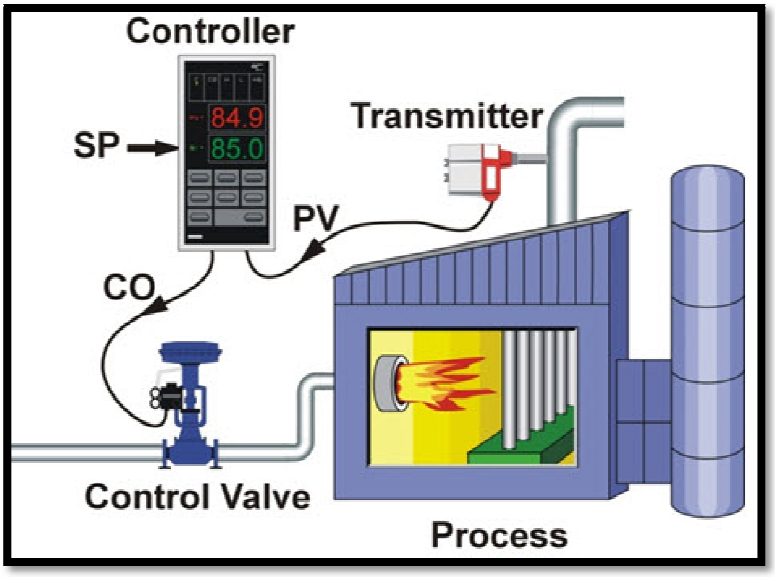
This control scheme is implemented to reduce the effect of input disturbance on process. A sensor in this system detects the disturbances or any load changes in the process, and then controller calculates the necessary signal to the actuator. This allows the controller to take corrective action before the disturbance effect the process. But this control scheme is more expensive and complicated and requires a better understanding of the process to implement control logic.



Feed Forward Control

4. Closed-Loop Control:-

Closed-loop control scheme is widely implemented in many of the industrial control applications. It uses the output measurement as feedback signal; and, it is compared with desired or set-point value. The difference between these actual and desired output is called error. Thus, the controller gives the control input to the actuator till the error gets minimized so that the output is maintained at the desired value as shown in the figure. Most of the closed loop control systems are implemented with PID controller for accurate and reliable control.

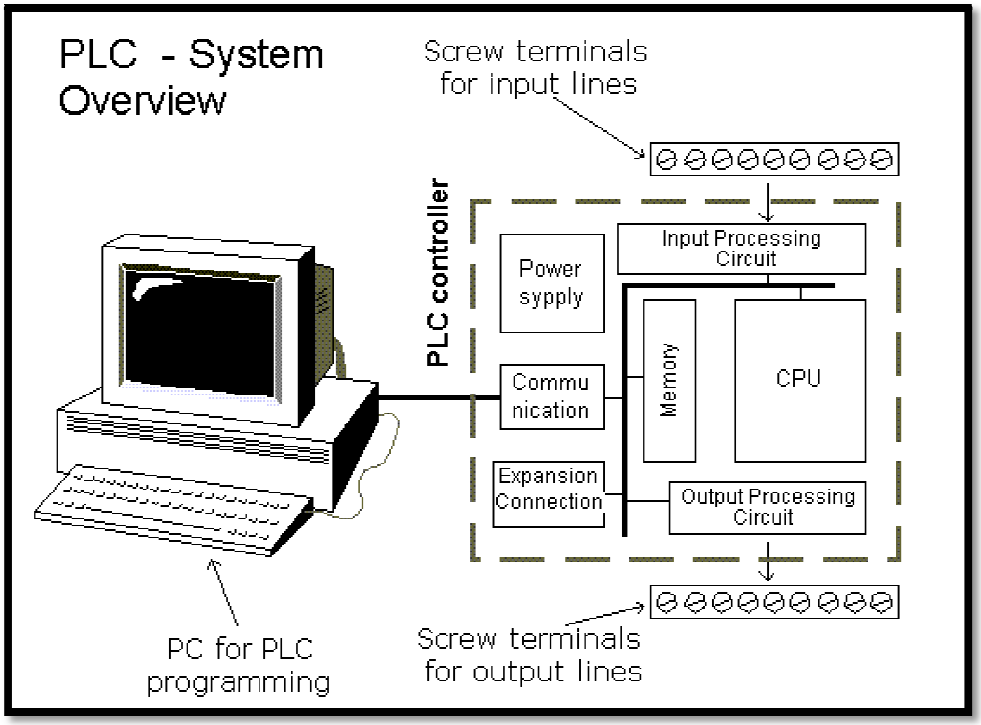


Closed Loop Control

Types of Industrial Control systems Depending on the functionality and complexity of the control action, industrial control systems are differentiated into several types, but most commonly and widely used control systems are of three types:

1. **Programmable Logic Controllers (PLCs)**
2. **Distributed Control Systems (DCS)**
3. **Supervisory control and Data Acquisition (SCADA)**

Programmable Logic Controllers (PLCs)



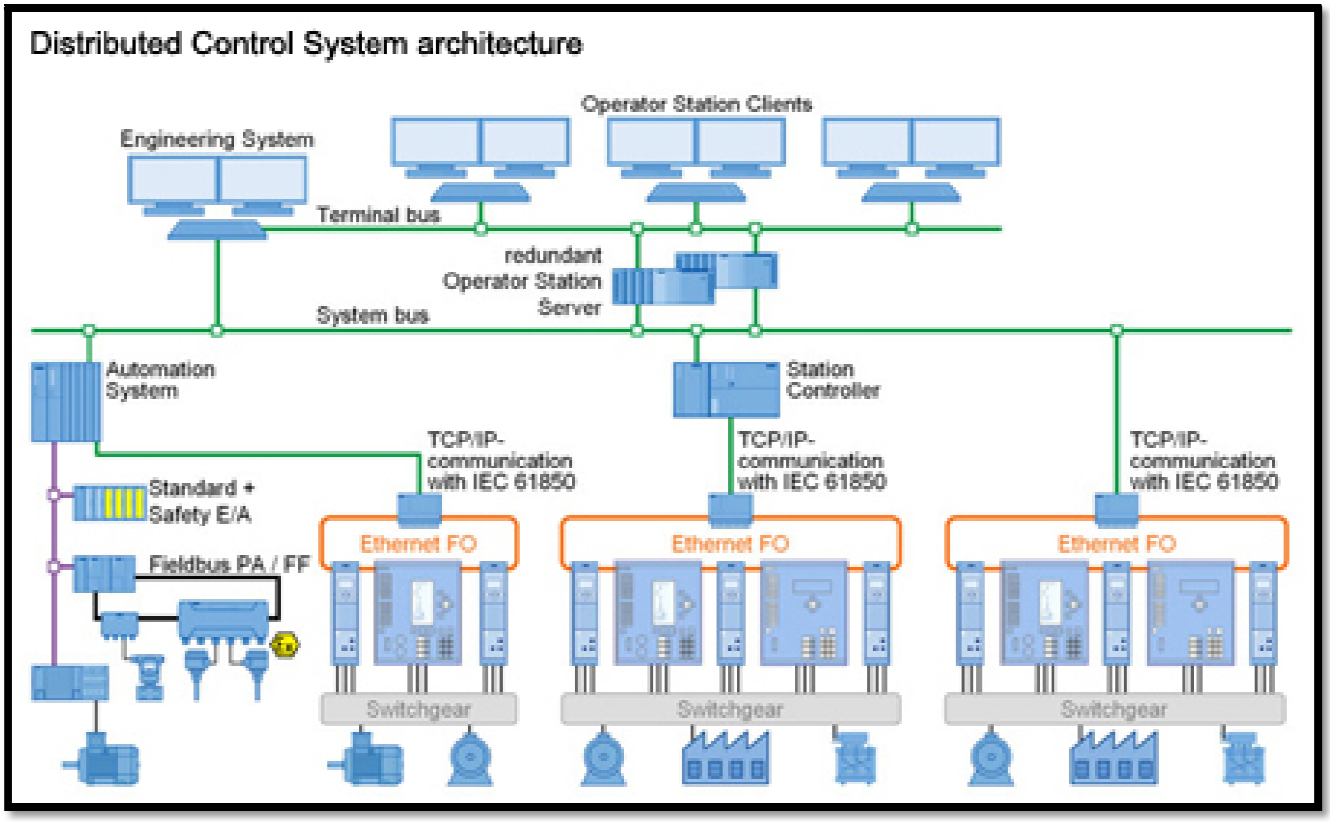
Programmable Logic Controllers (PLCs)

As an industrial computer, Programmable Logic controller (PLC) is capable of being programmed to perform various industrial control applications. PLC is built with modules like CPU, power supply, I/O modules (both digital and analog) and communication modules. These PLCs can be modular or integrated types. A modular type PLC is fixed and compact one with limited I/O functionalities whereas an integrated PLC is capable to extend I/O modules based on the required I/O functionalities.

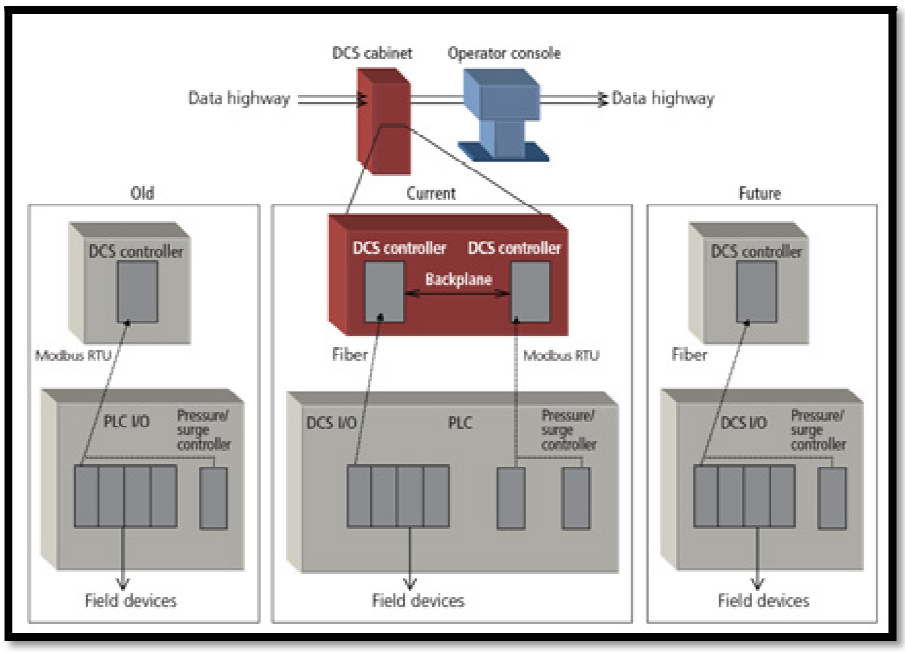
The sensors are connected to the input module and output devices or actuators to the output module of the PLC. The CPU of the PLC continuously reads the inputs from the sensors and according to the program; it produces the outputs to operate the actuators.

Distributed Control Systems (DCS)

Distributed Control System is a specially designed industrial control system which is used to control complex and geographically distributed applications. As the name implies, these controllers are distributed in the entire plant area. The discrete field devices such as actuators and sensors are connected to these controllers and also maintains the continuous communications with operating PCs through a high speed communication network or bus.



General Architecture of DCS

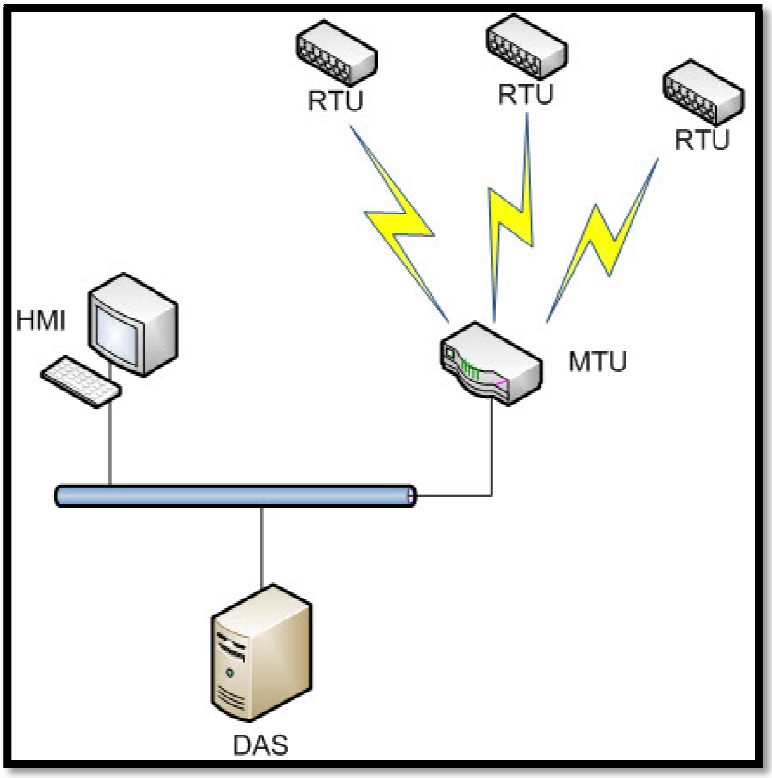


Distributed Control Systems (DCS)

The basic elements in the DCS control systems is an engineering PC controls all the distributed controllers, which controls the all the field devices connected to it. The HMI operating station used to monitor the field parameters graphically and to log the data and communication media to establish data transfer between the controllers and operating stations. DCS facilitates the human machine interface (HMI), trend display and face plates for the effective monitoring of industrial processes.

Supervisory Control and Data Acquisition (SCADA)

A SCADA system is a type of industrial process automation system that collects data from various instruments which are located in plant area or even at remote sites. This data is further processed at a central location for monitoring and controlling purpose. Based on the information from various remote stations, automated supervisory commands are sent back to these remote stations to control the field devices. Thus the remote control operation of equipments is possible with this SCADA.



Supervisory Control and Data Acquisition (SCADA)

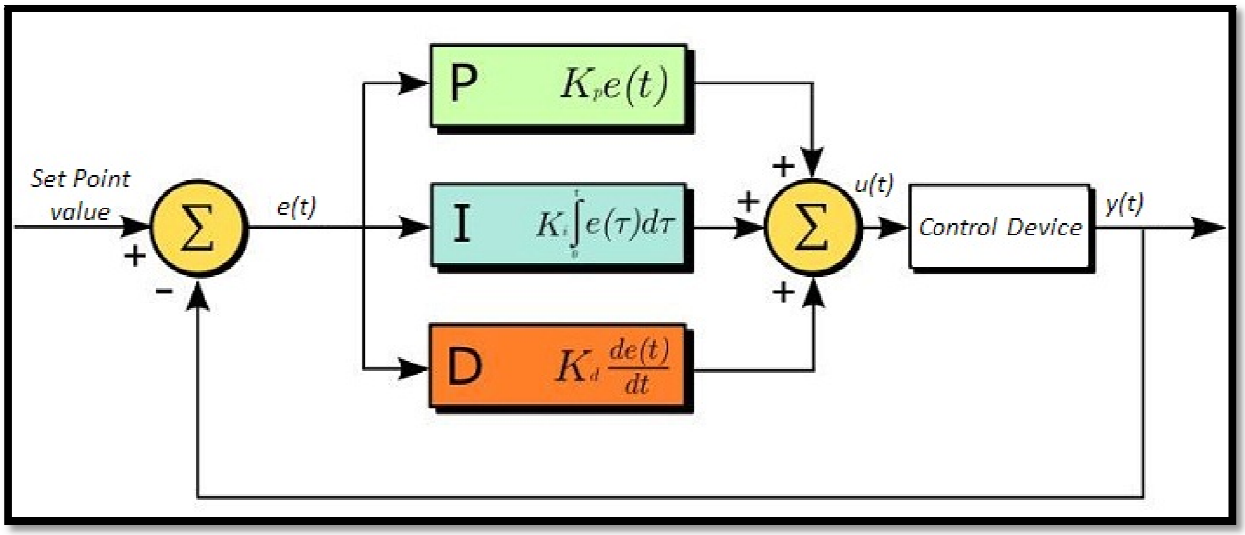
SCADA gathers data using both hardware and software systems. It consists of Remote Terminal Unit (RTU) and Communication Terminal Unit (CTU) or Master Terminal Unit as hardware devices. The RTU is nothing but a programmable logic controller which collects the data from various field instruments and sends it to the CTU to transfer to remote location as shown in the figure. At receiving side, CTU with SCADA HMI software displays all these parameters statuses and allows the user to send control signals to plant area. Apart from the industrial applications, SCADA is also popularly used in power transmission systems.

Hence the industrial control system is a multi-discipline system, which deals with disciplines like control systems, communication, instrumentation, electronics and electrical systems. Apart from the discussed control strategies some more advanced-control strategies are also used like cascade and

ratio-control schemes. For any further discussions on this topic, you can leave a comment in the comment section.

PID CONTROLLER:-

PID controller A Proportional-Integral-Derivative controller (PID controller) is a generic controller widely used in industrial control systems. PID controllers can be used to regulate flow, temperature, pressure, level, and many other industrial process variables. PID controller describes the mathematic calculations that are applied to calculate the error between the current result and the desired set-point. PID control equation involves three separate parameters; the Proportional, Integral and Derivative terms. – Proportional term responds instantaneously to the current error (providing instantaneous response). – Integral term (past errors) responds to the accumulation of errors in the form of average (providing a slow response that drives the steady-state error towards Zero). – Derivative term (future errors) responds to the rate at which the error is changing (providing some anticipatory response).



Example: Temperature Control using a Digital PID controller

A typical PID temperature controller application could be to continuously vary a regulator which can alter a process temperature. This may be a pulsed switching device for electrical heaters or by opening and closing a gas valve. A heat only PID temperature controller uses a reverse output action, i.e. more power is applied when the temperature is below the set point and less power when above. PID control for injection and extrusion applications often employ additional cooling control outputs and usually require multiple controllers.

A PID controller (sometimes called a three term controller) reads the sensor signal, normally from a thermocouple or RTD, and converts the measurement to engineering units e.g. Degrees C. It then subtracts the measurement from a desired set point to determine an error.

The error is acted upon by the three (P, I & D) terms simultaneously:

Proportional (Gain)

The error is multiplied by a negative (for reverse action) proportional constant P, and added to the current output. P represents the band over which a controller's output is proportional to the error of the system.

Example: - **For a heater, a controller with a proportional band of 10 deg C and a set point of 100 deg C would have an output of 100% up to 90 deg C, 50% at 95 Deg C and 10% at 99 deg C. If the temperature overshoots the set point value, the heating power would be cut back further. Proportional only control can provide a stable process temperature but there will always be an error between the required set point and the actual process temperature.**

Integral (Reset)

The error is integrated (averaged) over a period of time, and then multiplied by a constant I, and added to the current control output. I represent the steady state error of the system and will remove set point / measured value errors. For many applications Proportional + Integral control will be satisfactory with good stability and at the desired set point.

Derivative (Rate)

The rate of change of the error is calculated with respect to time, multiplied by another constant D, and added to the output. The derivative term is used to determine a controller's response to a change or disturbance of the process temperature (e.g. opening an oven door). The larger the derivative term, the more rapidly the controller will respond to changes in the process value.