INDUSTRIAL PROCESS MEASUREMENT

PART-1

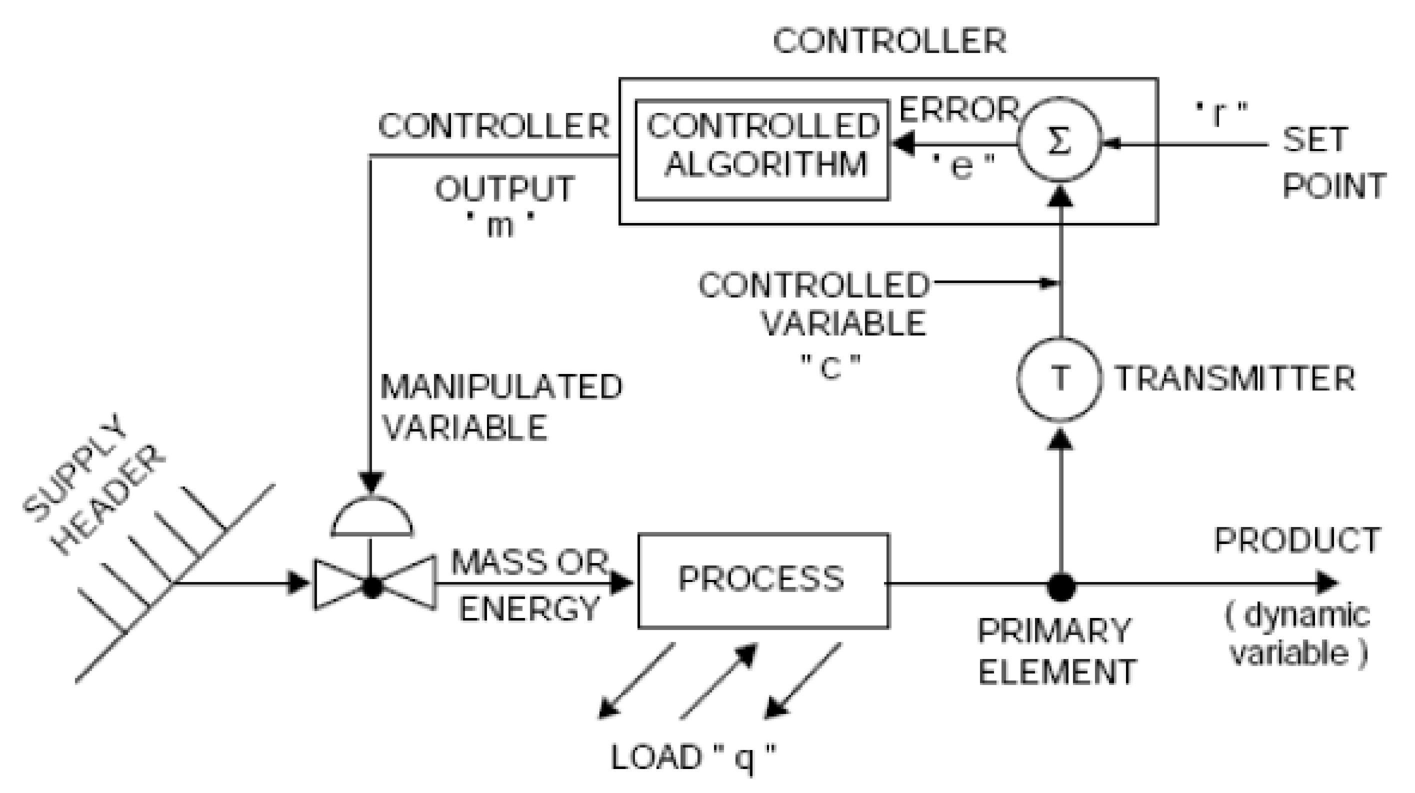
ENG / ISLAM DEIF

CONTENTS

MEASUREMENT FUNDAMENTALS

MEASUREMENT FUNDAMENTALS

Basic Control loop



MEASUREMENT FUNDAMENTALS

What Is Measurement

A measurement is simply an exact comparison of physical quantity to some definite standard or measure of dimension called a unit

UNITS

Example:

The SPEED of the train : kilometers per hour.

The TEMPERATURE in the furnace: Deg. C

The PRESSURE : psi

The WEIGHT of the parcel: kgs.

The LEVEL in the tank: meters

The AREA of the plot: Sq. Feet

The FLOW of water in the pipeline: lts/hr.(LPH)

MEASUREMENT FUNDAMENTALS

SI Units

Quantity	Unit	Symbol
Length	Meter	m
Mass	Kilogram	kg
Time	Second	s
Electric current	Ampere	A
Temperature	Kelvin	K
Luminous intensity	Candela	cd
Amount of substance	Mole	mol

MEASUREMENT FUNDAMENTALS

Derived SI Units

Quantity	Unit	Symbol
Area	square meter	m^2
Volume	cubic meter	m^3
Density	kg per cubic meter	$kg\ m^{-3}$
Velocity	meter per second	$m\ s^{-1}$
acceleration	meter per second per second	$m\ s^{-2}$

MEASUREMENT FUNDAMENTALS

Examples SI Units

Quantity	Unit	Explanation
Force	N	Newton = kg m s^{-2}
Pressure	Pa	Pascal = N m^{-2}
Energy	J	Joule = N.m
Electric charge	C	Coulomb = A.s
Electric potential	V	Volt = J/C
Energy	J	Joule = N.m
Electric charge	C	Coulomb = A s
Electric potential	V	I V = I J/C
Power	watt	I watt = I J/s

MEASUREMENT FUNDAMENTALS

Inferred vs. Direct Measurement

A Direct measurement looks only at the desired variable
Ex: floats, dipstick ----------→ level

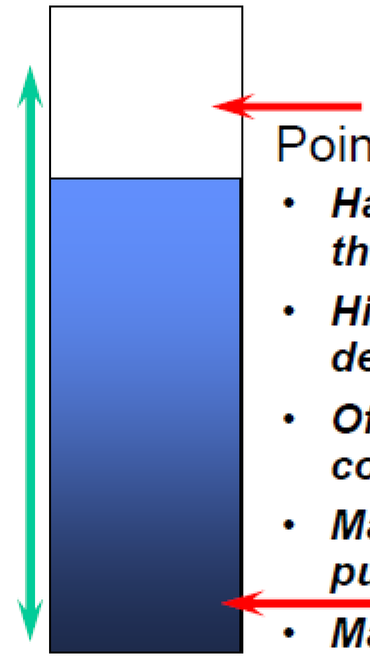
An Inferred measurement is derived from another measurement
Ex: pressure transmitter
Head Pressure / Density = Level
Mass/ Density = Level

MEASUREMENT FUNDAMENTALS

Continuous vs. Point Measurement

Continuous Measurement

- *Constant detection of product height*
- *Concerned with amount of product*
- *May be used to control addition of other components to the vessel*



Point measurement

- *Has the level reached this point?*
- *High or low level detection*
- *Often used for alarm control*
- *May start or stop pumps*
- *May open or close valves*

MEASUREMENT FUNDAMENTALS

Process variable

A *process variable* is a physical or chemical property quantity or other condition which can be changed.

flow rate
pressure
level
temperature

Basic Process Variables

PH
Density
Viscosity
Vibration

Advanced Process Variables

MEASUREMENT FUNDAMENTALS

Basic measuring instrument

Sensor - senses the parameter being monitored and
converts the magnitude of the parameter to a mechanical or electrical signal.

Transducer- converts the output signal of the
detector to a signal that can be used easily. (Often the
sensor and transducer are accomplished in the same device.)

Amplifier - increases the process signal to a usable
magnitude. (In many cases, signal conditioning also
occurs in the amplifier section.

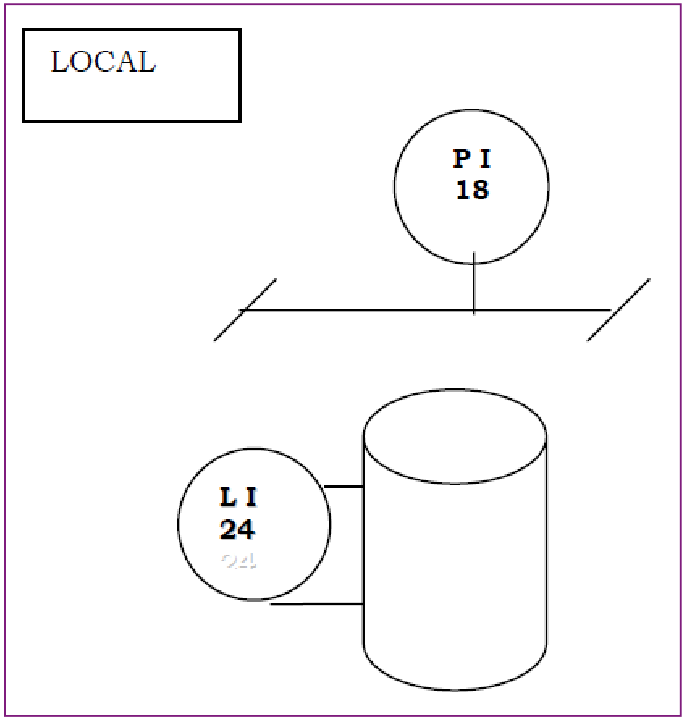
Transmitter - transmits data from one instrument
component to another when the components are physically separated.
Indicator - displays the process variable signal being measured.

MEASUREMENT FUNDAMENTALS

Instrument Location

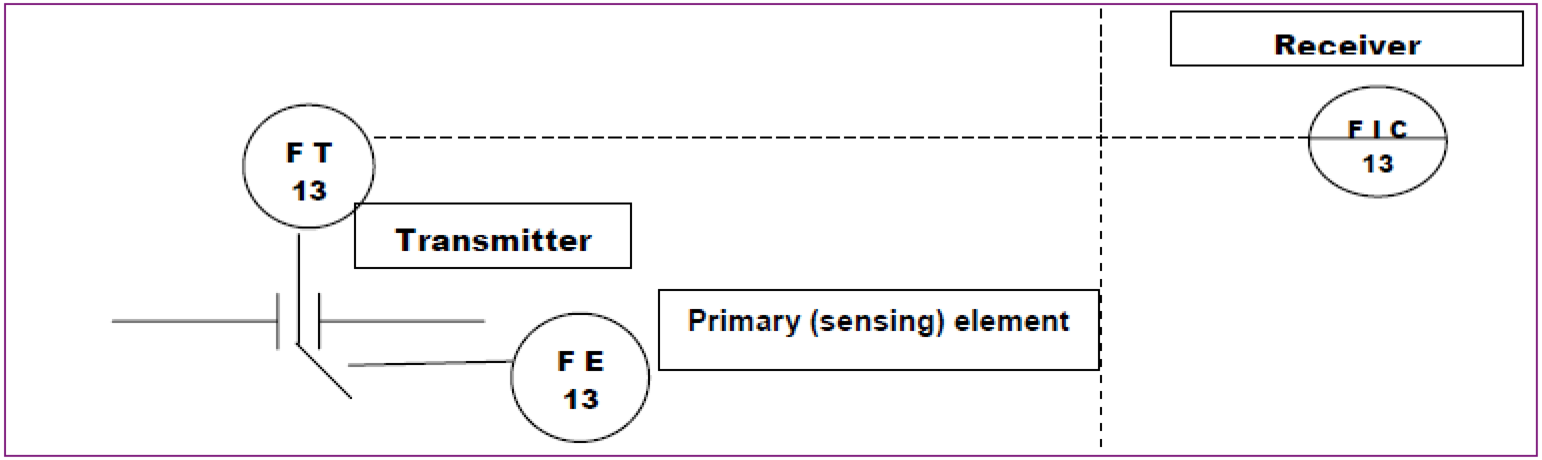
Local

When it is required to know the Pressure in the pipeline or level in the tank, one has to go to that place of installation (local) to know the values. These types of measurement are known as LOCAL MEASUREMENT.



Remote

The Parameter to be measured is sensed in the field area and the signal is transmitted to a remote place. (Central Control Room) for readable & control purpose and this type of measurement is known as **REMOTE MEASUREMENT.** Sitting in Control room, one can know the values.



MEASUREMENT FUNDAMENTALS

PLANT INSTRUMENTATION

- FIELD
  - INSTRUMENTS
    - Sensors
    - Pressure Instruments
    - Temperature Instruments
    - Flow Instruments
    - Level Instruments
    - Speed Instruments
    - Density Instruments
    - Weight Instruments
    - Analytical Instruments
    - Control Valves
    - Actuators
  - OTHER ITEMS
    - Local Panels
    - *Junction Boxes*
    - Cable trays
    - Cable duct
    - Cables
    - Impulse Lines
    - SS / Copper tubes
- CONTROL ROOM
  - DCS
  - PLC
  - SCADA
  - Industrial PC's
  - Marshalling Racks
  - UPS
  - Control Panel

BASIC DEFINITIONS

MEASUREMENT FUNDAMENTALS

Accuracy

How close a measurement is to the reference value of the process being measured.
Accuracy rating:
is a number that defines a limit that errors will not exceed when a device is used under specified operating conditions

Example
As % error over range : **± 1%** -- 20° to 120°C
OR
Units over range : **± 1°C** -- between limits

MEASUREMENT FUNDAMENTALS

Example

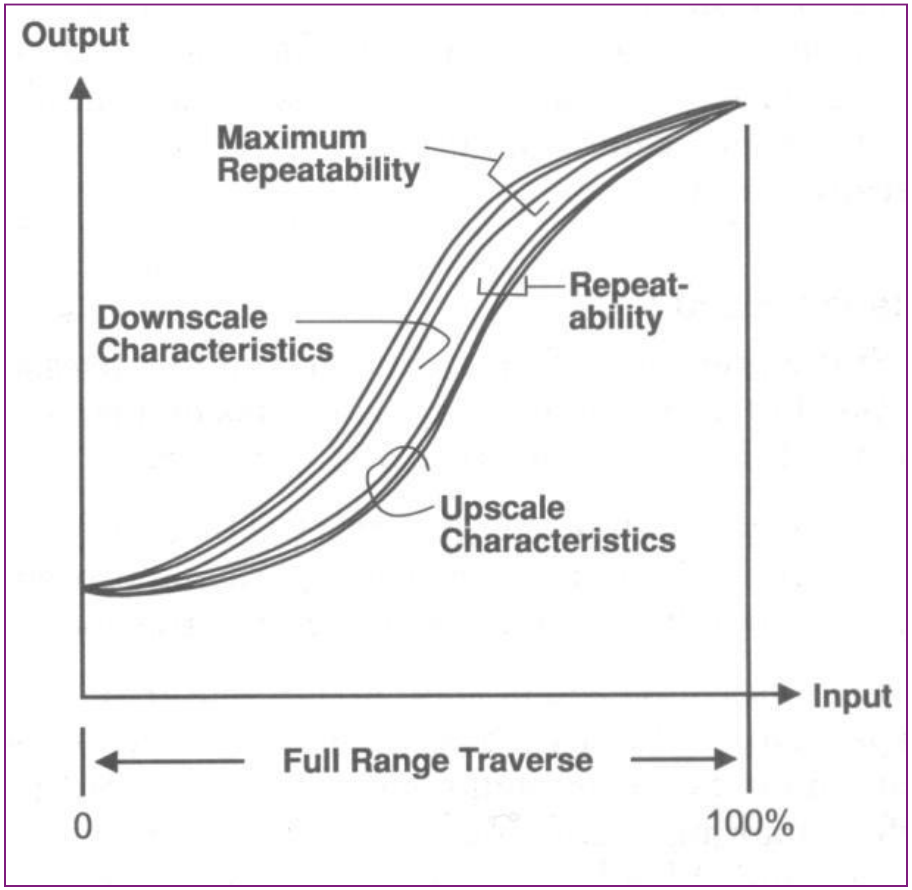
A temperature-measuring instrument produces an output with a range of 180°F to 320°F.
Express the accuracy of this meter in the four ways if the accuracy is 2% absolute.

Expressed in terms of **measured variable**:
Accuracy = ±2°F
Expressed in terms of percent of **span**:
Accuracy = ±2% of Span = (0.02 x 140°F) = ±2.8°F
Expressed in terms of percent of **upper-range** value:
Accuracy = ±2% of upper-range value = (0.02 x 320°F) = ±6.4 F
Expressed In terms of percent of **actual reading**:
Accuracy = ±2% of actual reading (mid-range) = (0.02x 250°F) = ±5F
observing a device.

MEASUREMENT FUNDAMENTALS

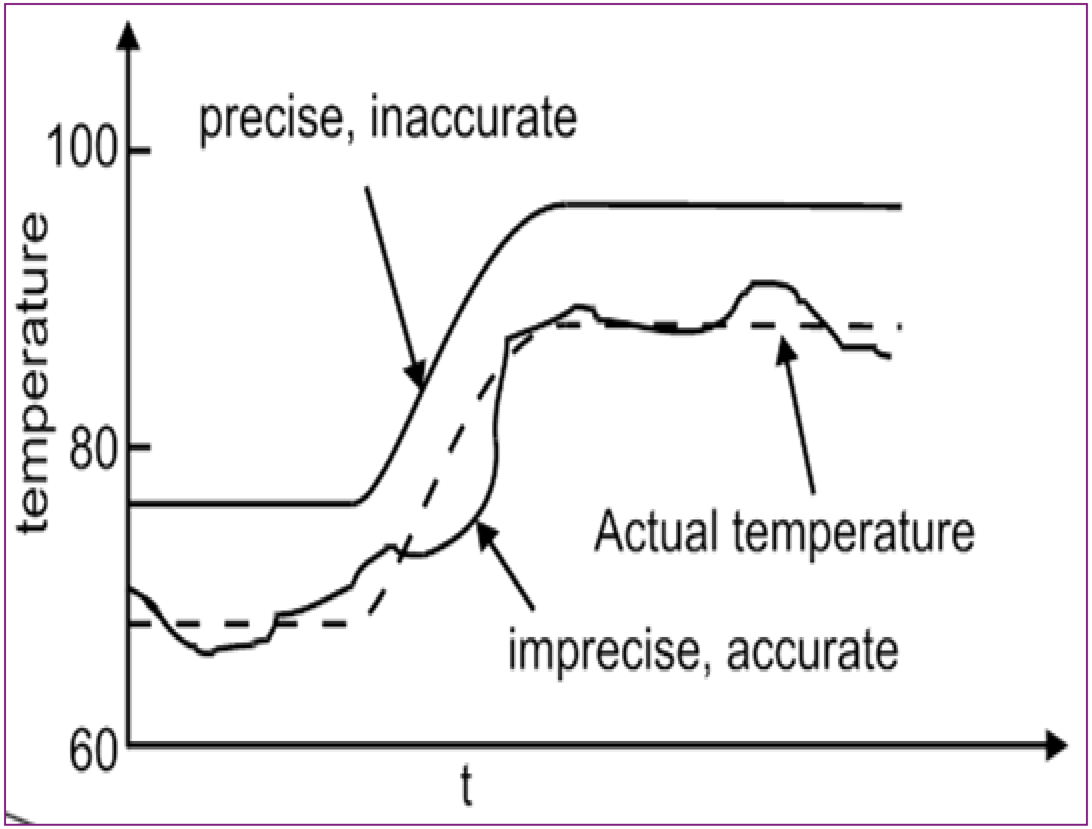
Repeatability (precision)

If two or more measurements are made of a Process Variable at the same identical state, repeatability indicates how close the measurements will be together.

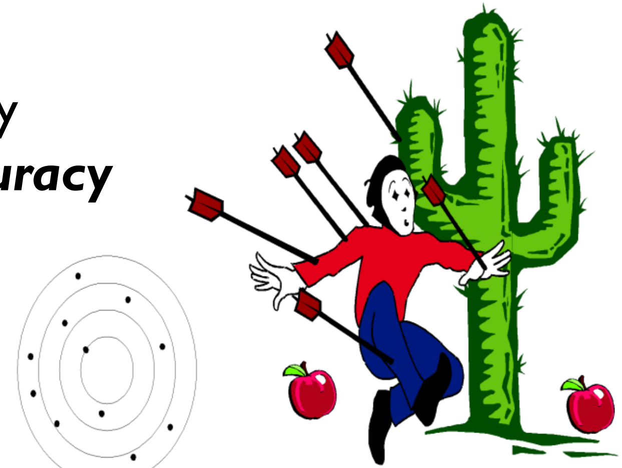


MEASUREMENT FUNDAMENTALS

Accuracy Vs Precision

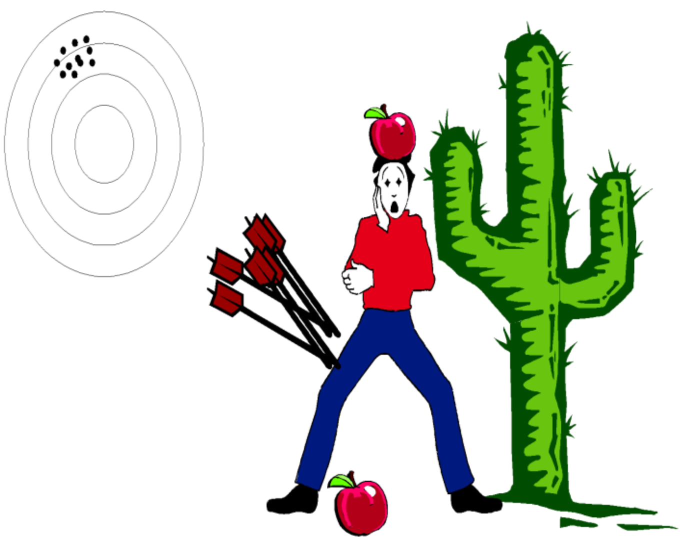


MEASUREMENT FUNDAMENTALS



Poor repeatability
means poor accuracy
Low precision, low accuracy

Good repeatability does
not necessary means good accuracy
High precision, low accuracy

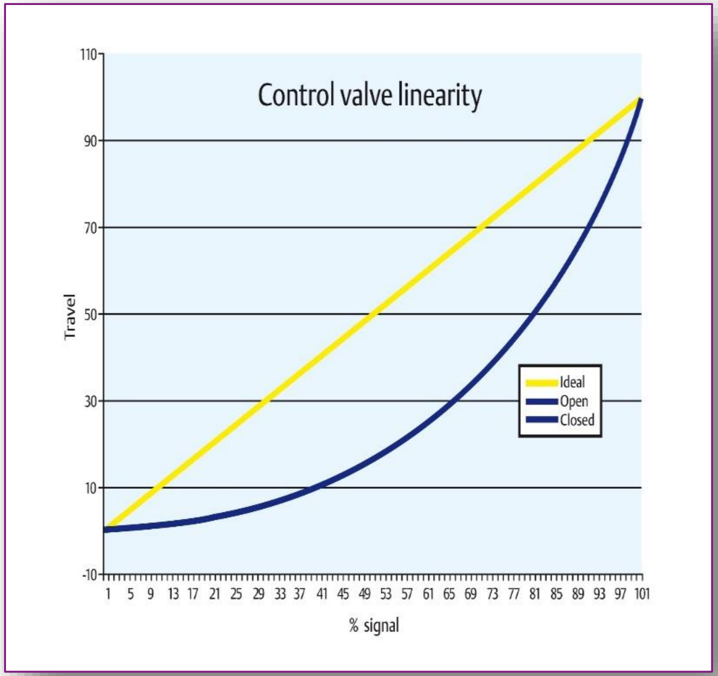


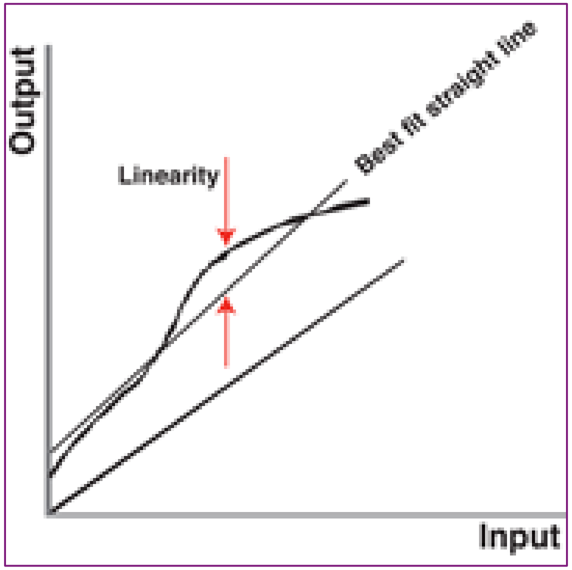
Good accuracy requires
good repeatability
High precision, high accuracy

MEASUREMENT FUNDAMENTALS

LINEARITY

The closeness to which a curve relating to two variables approximates a straight line. (Linearity also means that the same straight line will apply for both upscale and downscale directions





MEASUREMENT FUNDAMENTALS

LINEAR AND SQUARE ROOT CALIBRATION TABLE:

TRANSMITTER OUTPUT			READING		MEASURED VALUE
mA	psi	Kg/ cm2	LINEAR SCALE	SQUARE ROOT SCALE	FLOW (m3 / Hr.)
4	3	0.2	0%	0%	0
8	6	0.4	25%	50%	100
12	9	0.6	50%	70.71%	200
16	12	0.8	75%	86.60%	300
20	15	1	100%	100%	400

MEASUREMENT FUNDAMENTALS

Sensitivity

Amount of change in the output signal from a transducer to a specified change in the input physical parameter.

examples

Thermocouples: 5 mV per °C

Resolution

Smallest change in input causing significant change in output.

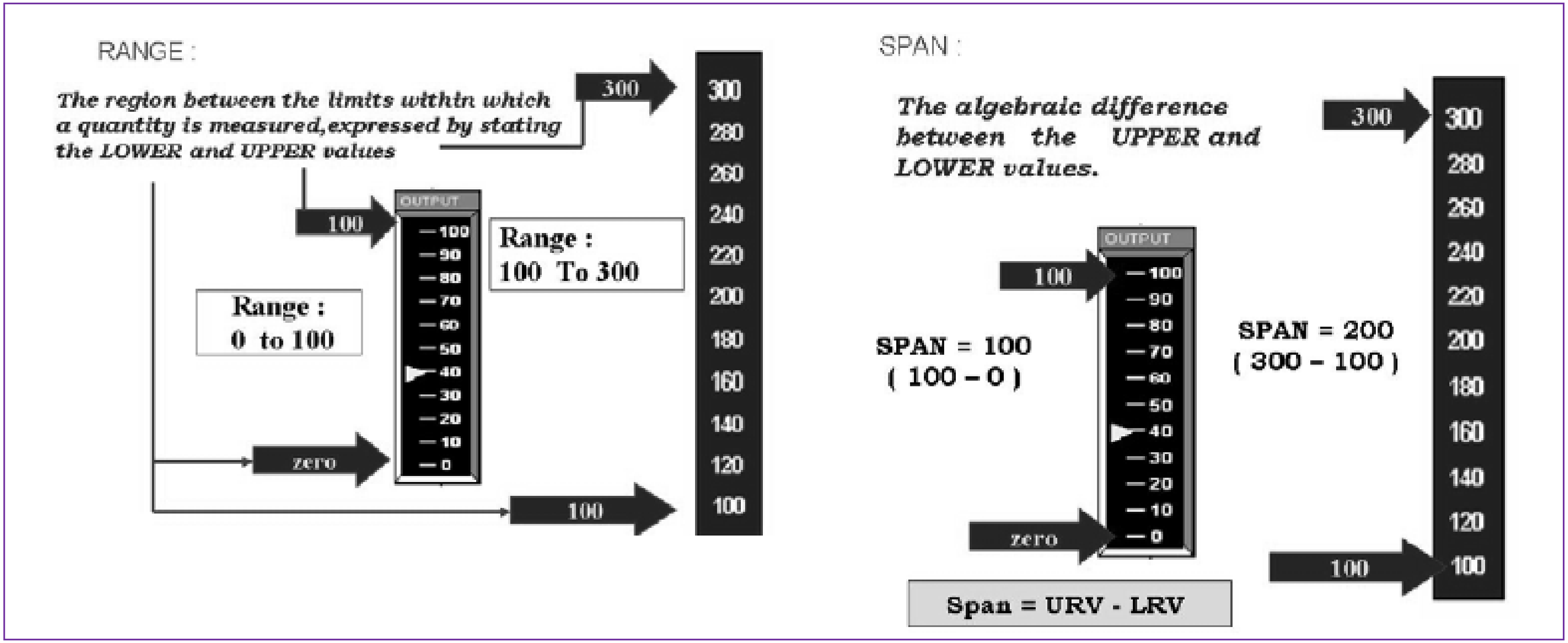
MEASUREMENT FUNDAMENTALS

Range and Span

Minimum and maximum measurable values of a PV between which the defined limits of the specifications are met.

Range: -10° C to +65°C

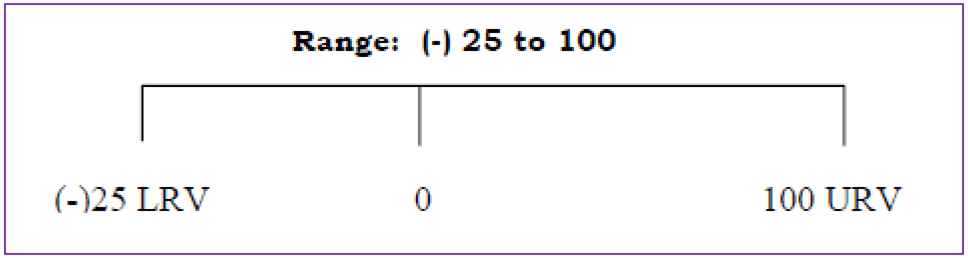
Span: 75° C



MEASUREMENT FUNDAMENTALS

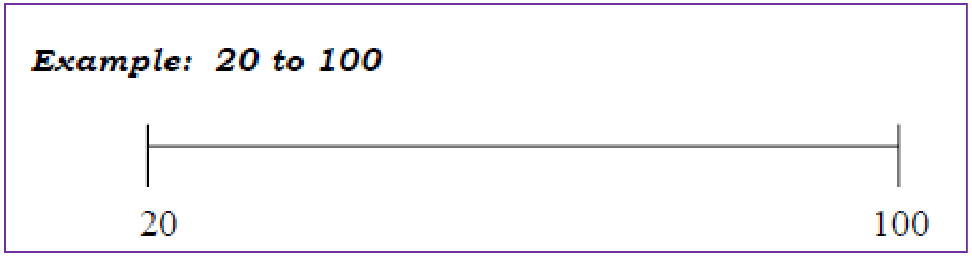
Elevated Zero

A range where the zero value of the measured signal is greater than the lower range value. Zero lies between LRV and URV



Suppressed Zero

A range where the zero value of the measured signal is less than the lower range value. Zero does not appear in the scale.



MEASURED VARIABLE & MEASURED SIGNAL

TYPICAL RANGES	TYPE OF RANGE	RANGE	LOWER RANGE VALUE	UPPER RANGE VALUE	SPAN
THERMOCOUPLE 0 2000 °F TYPE K T/C	Measured Variable	0 to 2000°F	0° F	2000° F	2000° F
-0.68 +44.91mV	Measured Signal	-0.68 to +44.91mV	-0.68mV	+44.91mV	45.59mV
FLOWMETER 0 10,000Ib/h	Measured Variable	0 to 10,000Ib/h	0 Ib/h	10,000Ib/h	10,000 Ib/h
0 100in H2O	Measured Signal	0 to 100 in H2O	0in H2O	100in H2O	100in H2O
TACHOMETER 0 500 rpm	Measured Variable	0 to 500 rpm	0 rpm	500 rpm	500 rpm
0 5V	Measured Signal	0 to 5V	0 V	5V	5V

MEASUREMENT FUNDAMENTALS

HYSTERESIS

The hysteresis is the difference between the
upscale and the downscale output values of the device for the same input.

It is not necessary to traverse over 0% to 100% to
see the hysteresis. At time the input stops and
changes direction, the effect of hysteresis is felt.

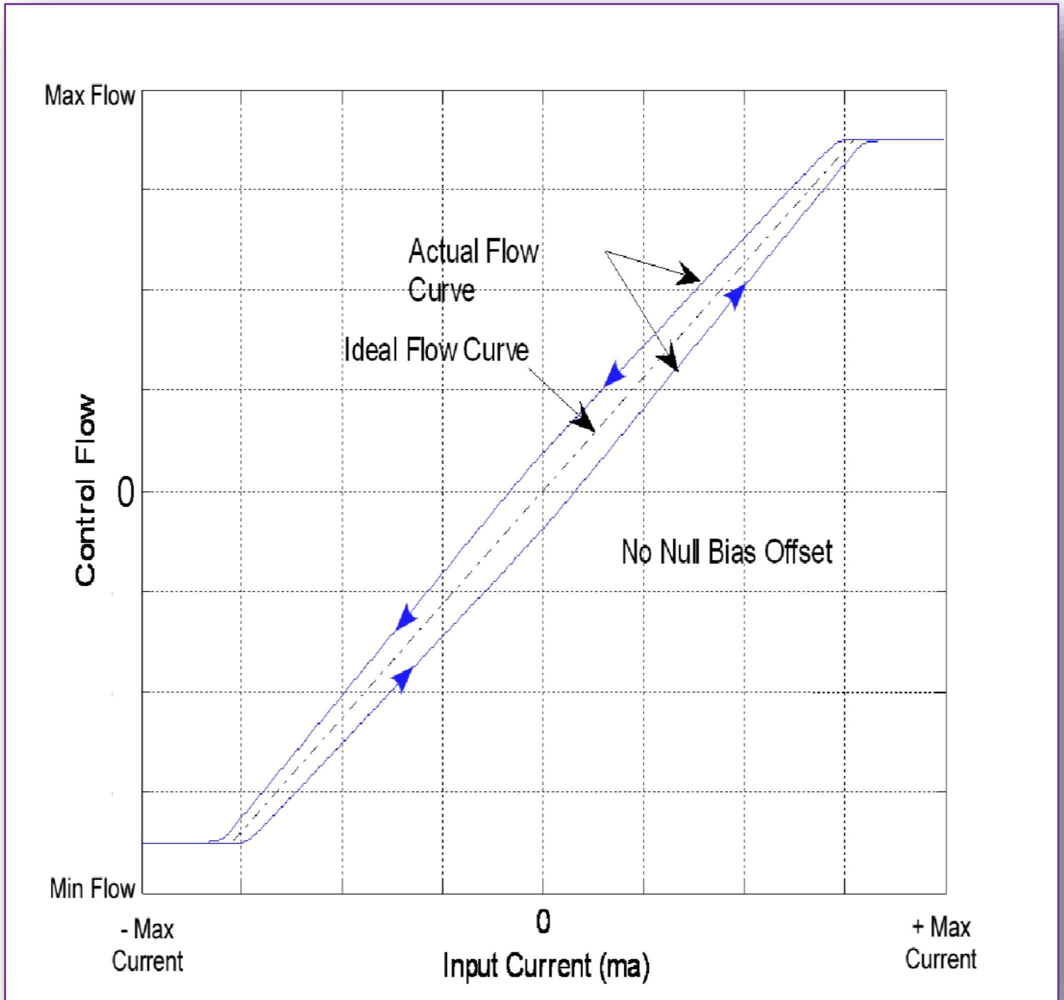
This means simply that the output values
obtained while increasing the input will be
different from the output values obtained while decreasing the input.

Hysteresis is based on inherent physical
characteristics of the materials used to construct the instrument.

Hysteresis can be mechanical or magnetic.

MEASUREMENT FUNDAMENTALS

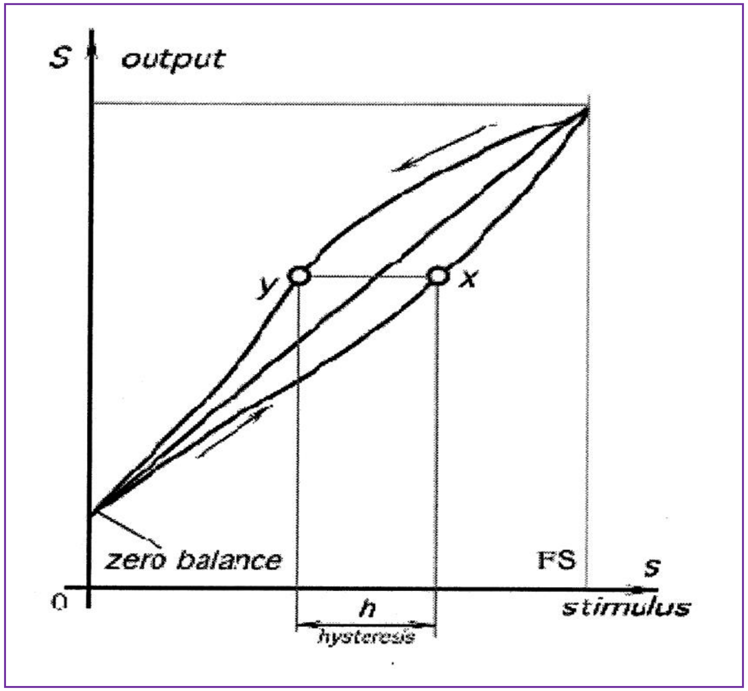
HYSTERESIS



Example

A displacement sensor when the object moves from left to right at a certain point produces a voltage which differs by 20 mV from that when the object moves from right to left.

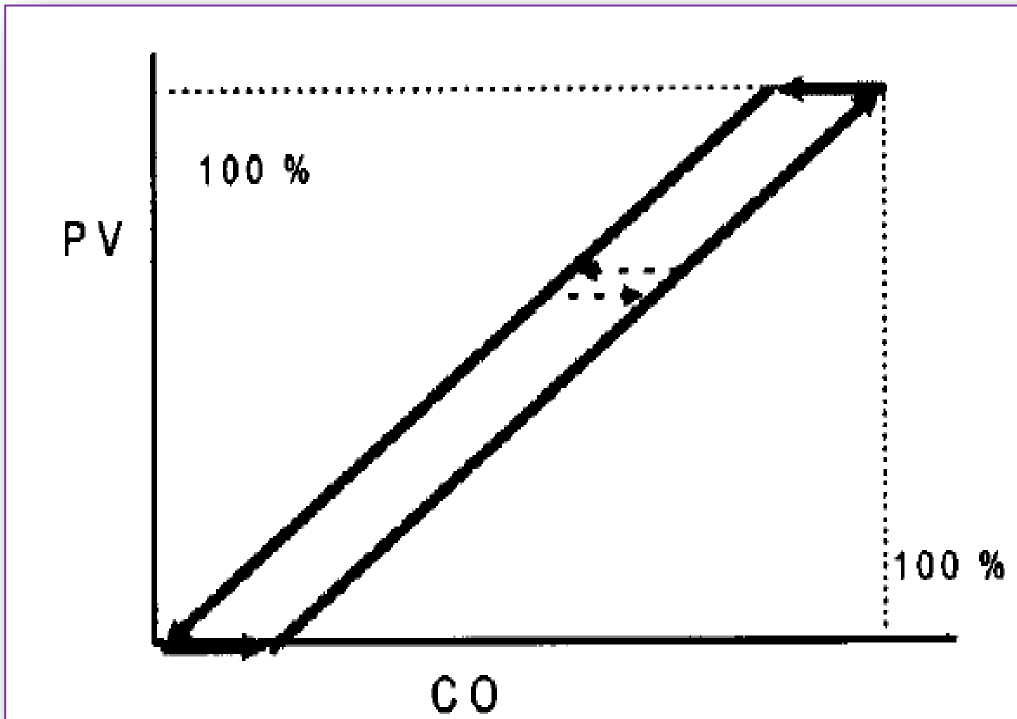
If the sensitivity of the sensor is 10 mV/mm, the hysteresis error in terms of displacement units is 2 mm.



MEASUREMENT FUNDAMENTALS

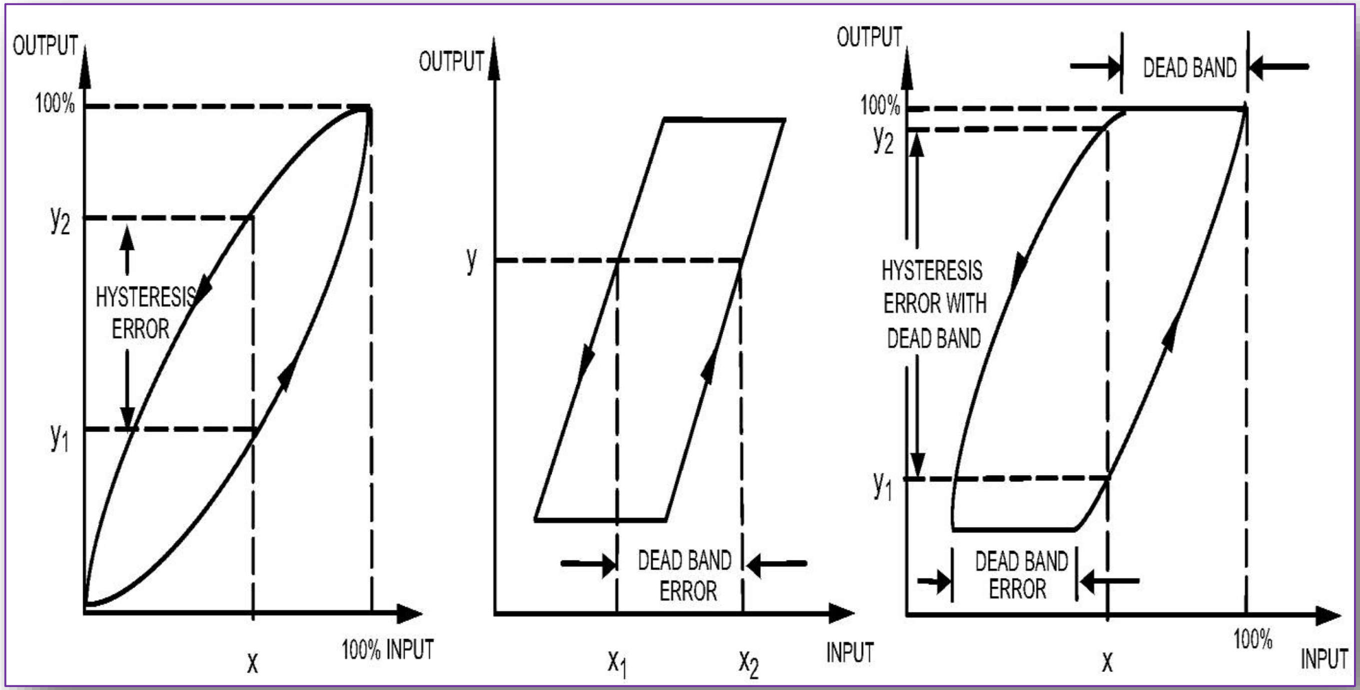
DEAD BAND (BACKLASH)

The range through which an input signal can be varied, upon reversal of direction, without initiating an observable change in the output signal. Dead band is the name given to a general phenomenon that can apply to any device.



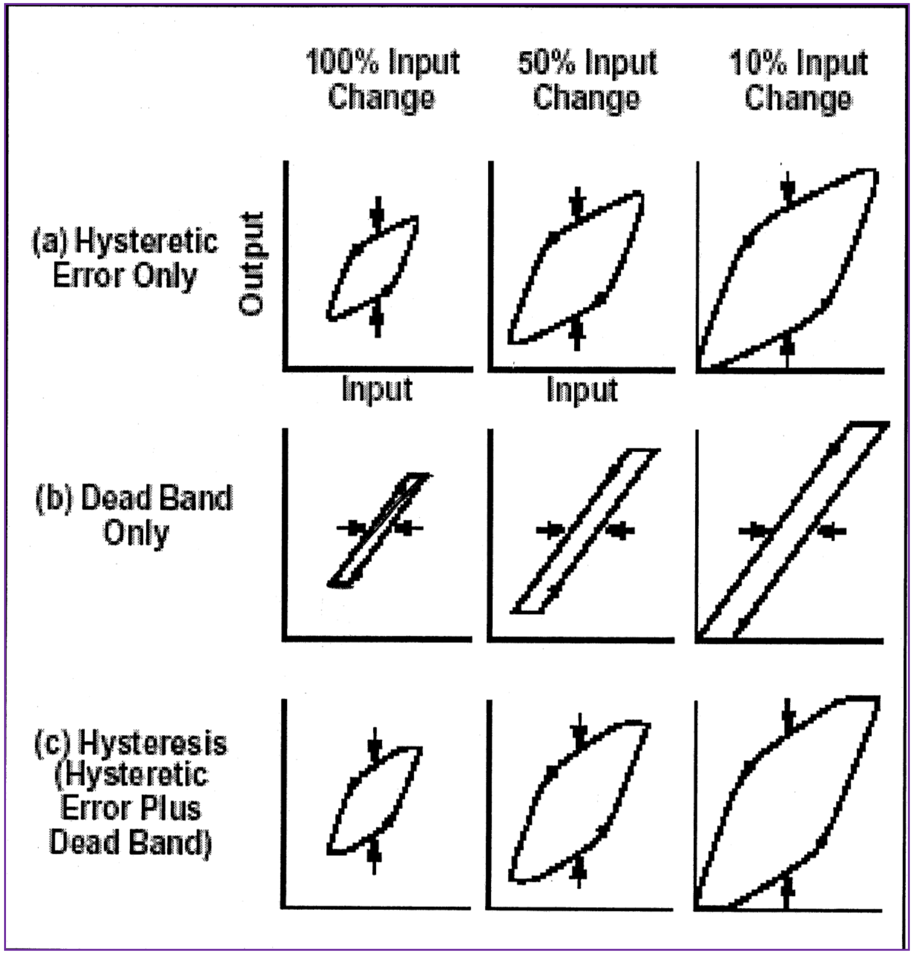
MEASUREMENT FUNDAMENTALS

HYSTERESIS & DEAD BAND EFFECTS



MEASUREMENT FUNDAMENTALS

HYSTERESIS & DEAD BAND EFFECTS



MEASUREMENT FUNDAMENTALS

Rangeability (Turndown)

Turndown ratio is also commonly referred to as Rangeability. It indicates the range in which a flow meter or controller can accurately measure the fluid. In other words, it's simply the high end of a measurement range compared to the low end, expressed in a ratio and is calculated using a simple formula.

Turndown Ratio = maximum flow / minimum flow

For example, if a given flow meter has a 50:1 turndown ratio the flow meter is capable of accurately measuring down to 1/50th of the maximum flow. So, suppose a flow meter has a full scale rating of 20 l/min the flow meter will measure down to 0.4 l/min of flow.

MEASUREMENT FUNDAMENTALS

Example

If we are using these flow meters to measure a given liquid in an application where the expected maximum flow rate is 2,400gpm then:

For the **Orifice plate meter**, minimum flow = 25% of maximum flow = 600gpm.

Since the turn down of the Orifice meter is 4:1, this means that at flow rates between 600gpm and 2,400gpm the flow meter can still meet its claimed or stated accuracy.

For the **Turbine meter**, minimum flow = 10% of maximum flow = 240gpm

For the **Coriolis meter**, minimum flow = 1.25% of maximum flow = 30gpm

Flowmeter Type	Turn Down or Operating Range	Minimum Flow
Orifice Plate	4:1	25% of Maximum flow
Turbine	10:1	10% of Maximum flow
Coriolis	80:1	1.25% of Maximum flow

MEASUREMENT FUNDAMENTALS

Deviation:

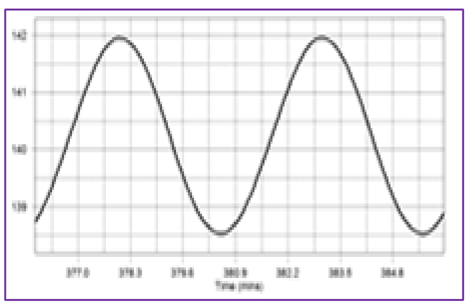
Any departure from a desired or expected value or pattern.

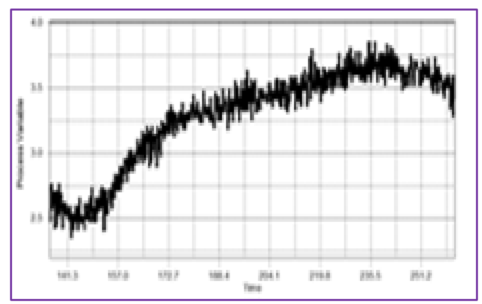
Drift:

An undesirable change in the output-input relating over a period of time.

Noise

is a variation in a measurement of a process variable that does not reflect real changes in the process variable.





MEASUREMENT FUNDAMENTALS

Sources

Noise is generally a result of the technology used to sense the process variable.

Electrical signals used to transmit instrument measurements are susceptible to having noise induced from other electrical devices.

Noise can also be caused by wear and tear on the mechanical elements of a sensor.

Noise may be uncontrolled, random variations in the process itself.

Effects

Noise reduces the accuracy and precision of process measurements.

Noise introduces more uncertainty into the measurement.

Noise also introduces errors in control systems. To a controller, fluctuations in the process variable due to noise are indistinguishable from fluctuations caused by real disturbances.

MEASUREMENT FUNDAMENTALS

Instrument error summary

Hysteresis Error

Linearity Error

Sensitivity Error

Zero Shift (null) Error

Repeatability Error

MEASUREMENT FUNDAMENTALS

Exercise

Example 1

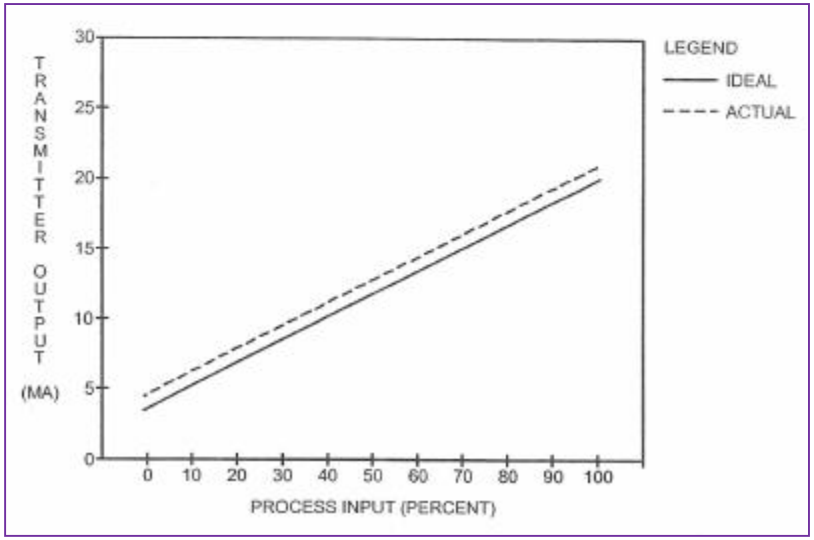
The calibration plot shows that the transmitter does need recalibration to correct for:

A. a zero error.

B. a span error.

C. both a zero and span error.

D. a linearity error.



MEASUREMENT FUNDAMENTALS

Exercise

The calibration plot indicates that the pneumatic controller has ------------ and must be calibrated.

A. a zero error

B. a span error

C. both a zero and span error

D. a linearity error

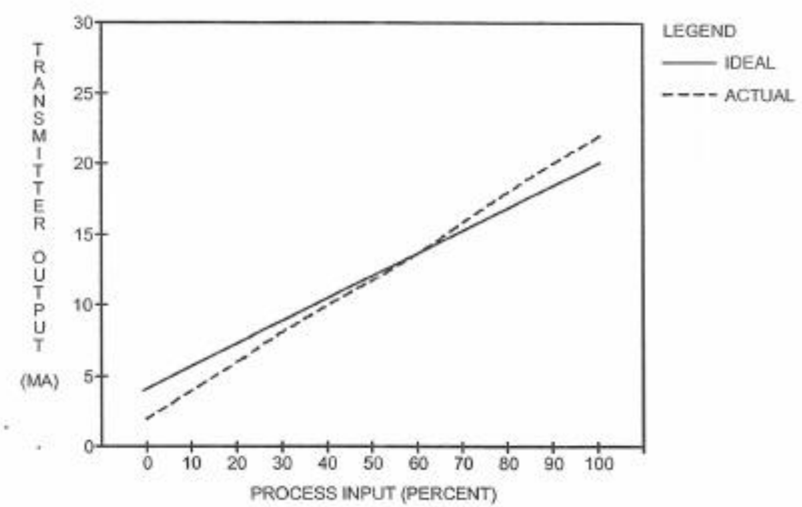


Figure 1-2

MEASUREMENT FUNDAMENTALS

Exercise

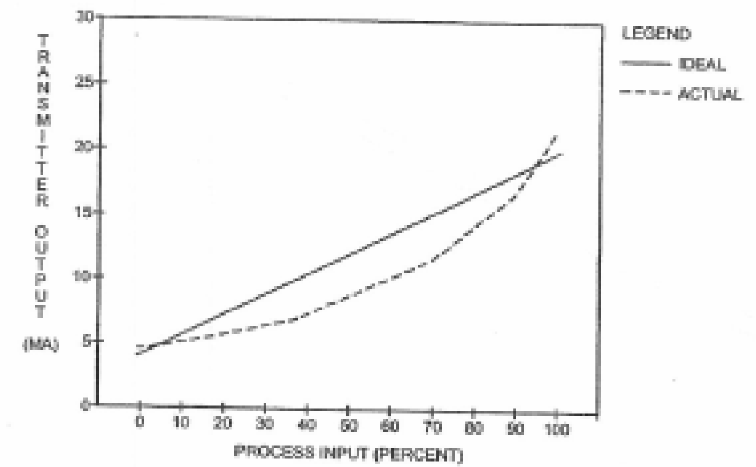
This electronic DP cell requires calibration to correct for the:

A. zero error.

B. span error.

C. zero, span and linearity errors.

D. zero and span errors.



MEASUREMENT FUNDAMENTALS

Exercise

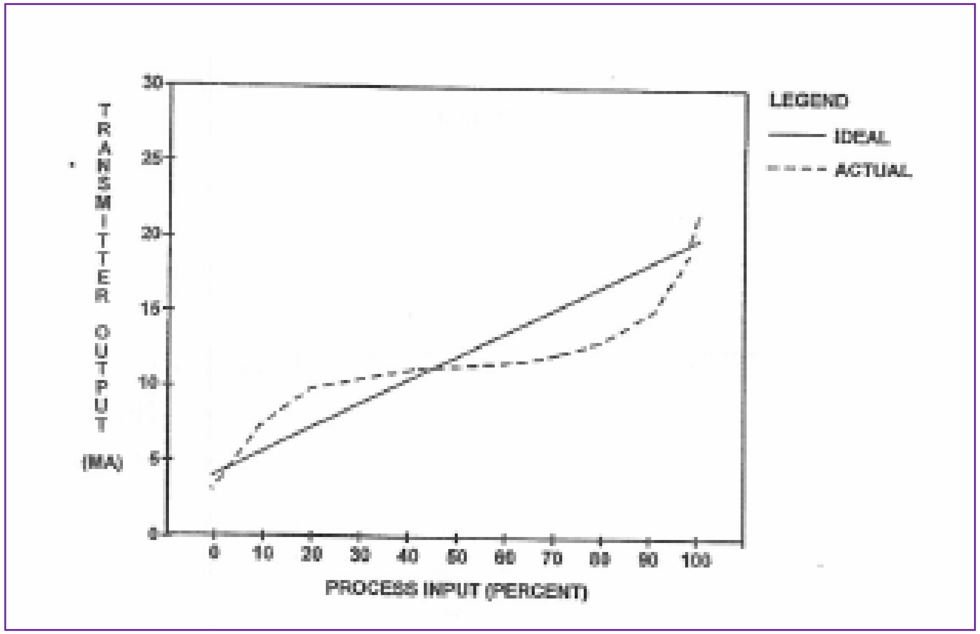
his pneumatic level transmitter has:

A. hysteresis.

B. a zero error.

C. a span error.

D. zero, span and linearity errors.



MEASUREMENT FUNDAMENTALS

Exercise

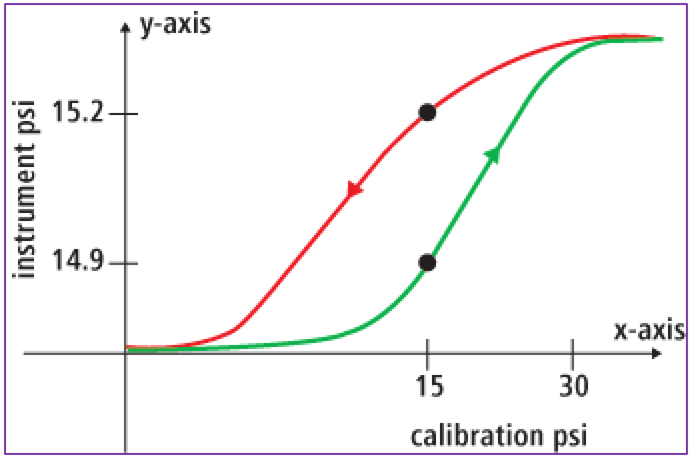
A 0-30 psig gage is undergoing calibration. Starting at 0 psi, the technician applies a pressure of 15 psi. The gage reads 14.9 psi. Then the technician applies 30 psi of pressure. The technician then reduces the calibration pressure to 15 psi. The gage reads 15.2 psig. What type of error do these readings suggest?

A. hysteresis error

B. span error

C. zero shift error

D. linearity error



BASIC DEFINITIONS

INSTRUMENT CALIBRATION

Calibration and ranging

Every instrument has at least one input and one output. For a pressure sensor, the input would be some fluid pressure and the output would be an electronic signal.

Calibration and ***Ranging*** are two tasks associated with establishing an accurate correspondence between any instrument's input signal and its output signal.

Calibration assures the instrument accurately senses the real-world variable it is supposed to measure or control.

Ranging establishes the desired relationship between an instrument's input and its output.

INSTRUMENT CALIBRATION

Calibration versus re-ranging

To **calibrate** an instrument means to check and adjust its response so the output accurately corresponds to its input throughout a specified range. The instrument is exposed to an actual input stimulus of precisely known quantity. For a pressure gauge, indicator, or transmitter, this would mean subjecting the pressure instrument to known fluid pressures and comparing the instrument response against those known pressure quantities.

To **range** an instrument means to set the lower and upper range values so it responds with the desired sensitivity to changes in input. For example, a pressure transmitter set to a range of 0 to 200 PSI (0 PSI = 4 mA output ; 200 PSI = 20 mA output) could be re-ranged to respond on a scale of 0 to 150 PSI (0 PSI = 4 mA ; 150 PSI = 20 mA).

INSTRUMENT CALIBRATION

Zero and span adjustments

$$y = mx + b$$

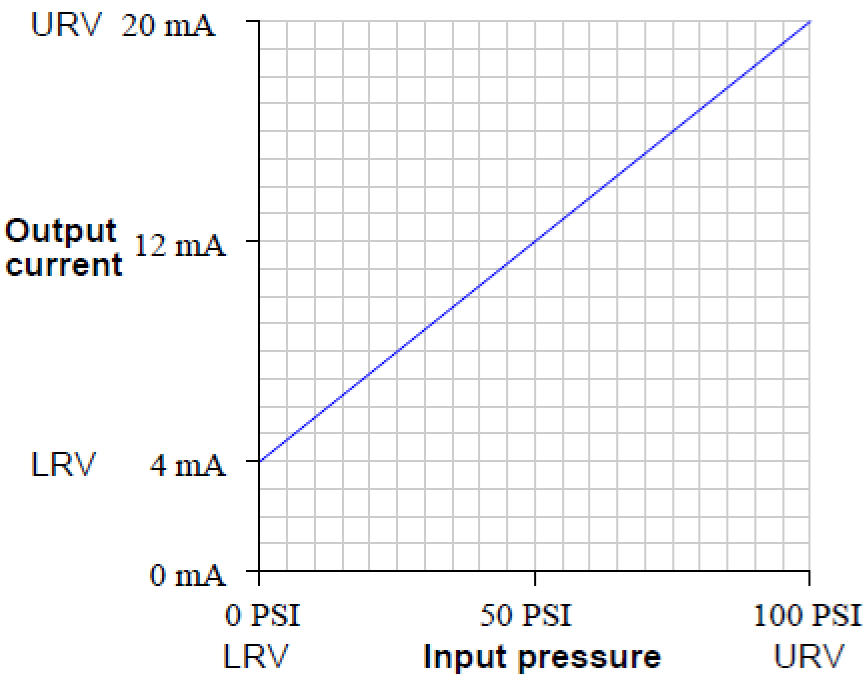
Where,

y = Vertical position on graph

x = Horizontal position on graph

m = Slope of line

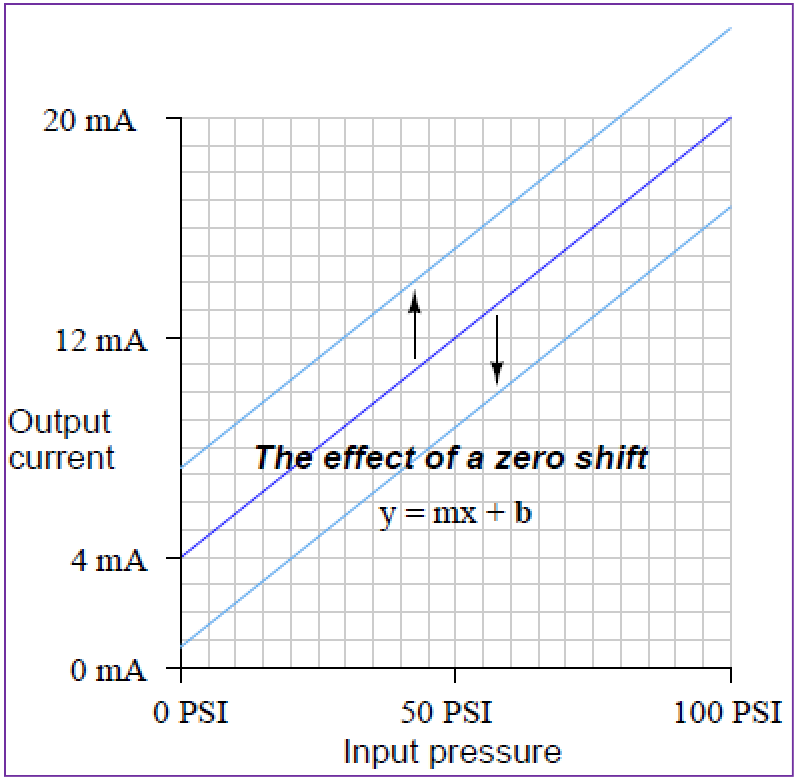
b = Point of intersection between the line and the vertical (y) axis



INSTRUMENT CALIBRATION

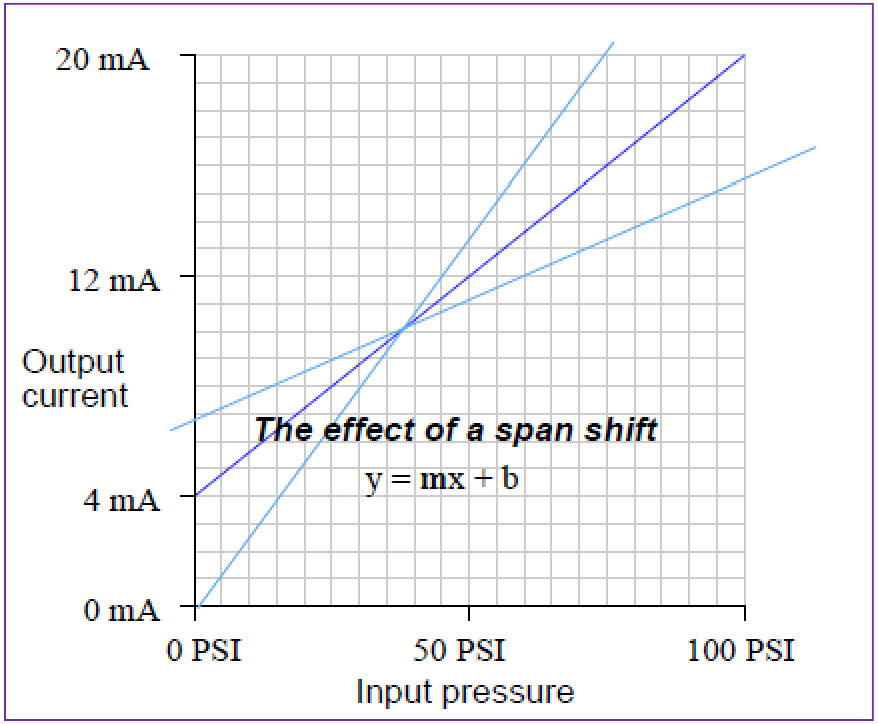
Typical calibration errors

Zero shift calibration error



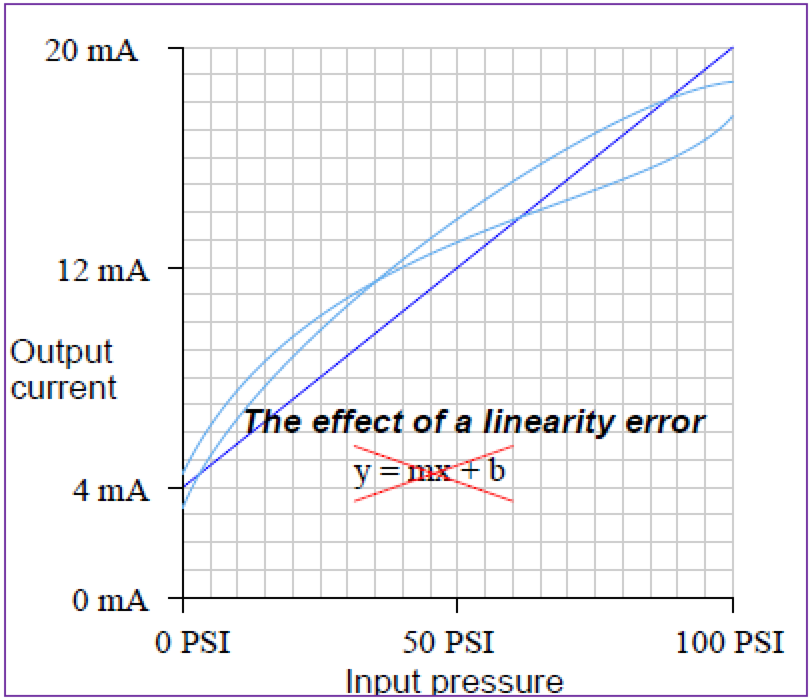
INSTRUMENT CALIBRATION

Span shift calibration error



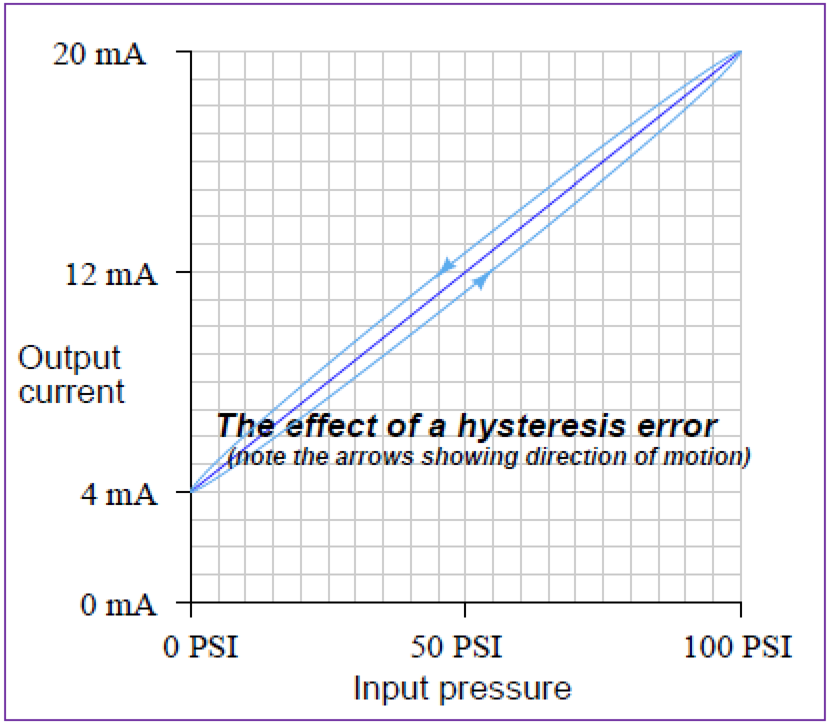
INSTRUMENT CALIBRATION

Linearity calibration error



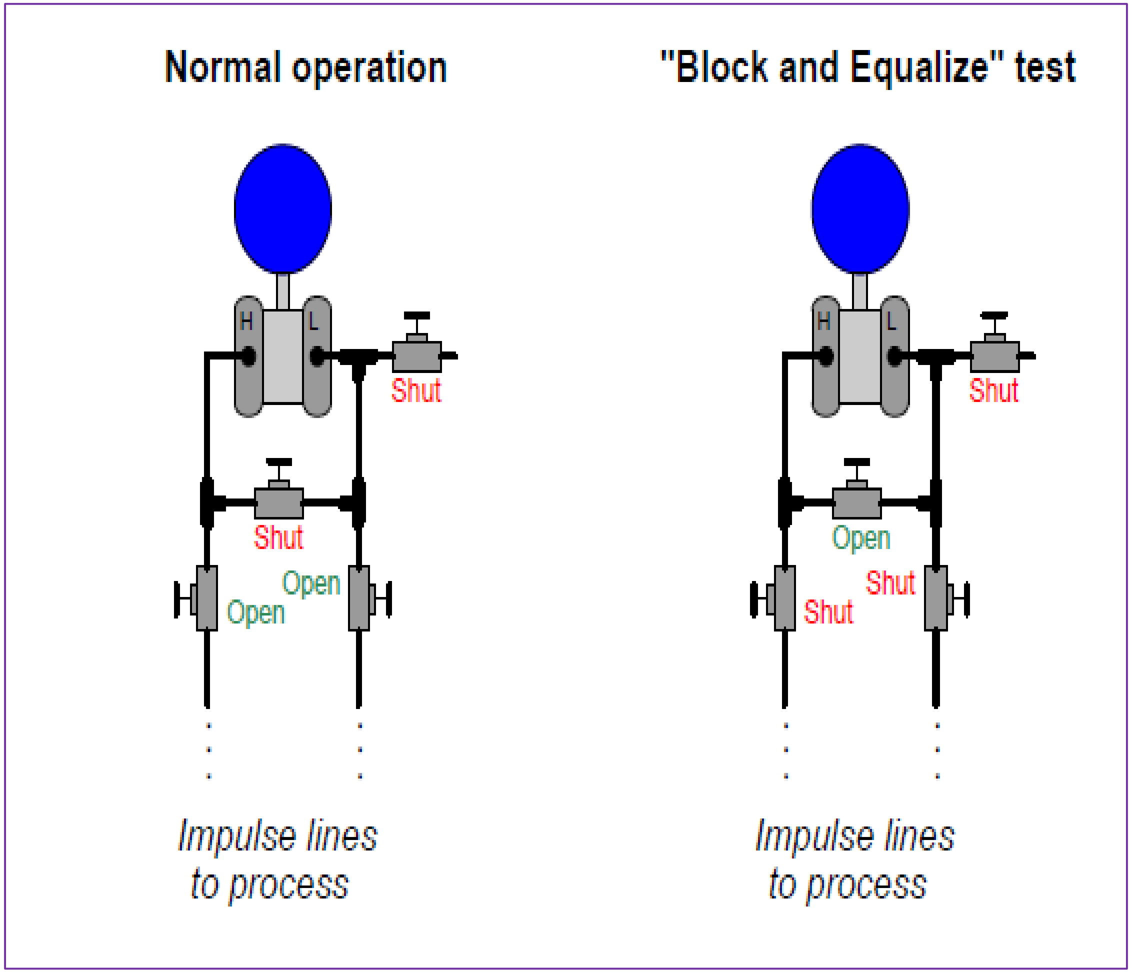
INSTRUMENT CALIBRATION

Hysteresis calibration error



INSTRUMENT CALIBRATION

Single-point test Calibration



INSTRUMENT CALIBRATION

As-found and as-left documentation

An important principle in calibration practice is to document every instrument's calibration as it was found and as it was left after adjustments were made. The purpose for documenting both conditions is to make data available for calculating instrument drift over time.

Percent of range	Input pressure	Output current (ideal)	Output current (measured)	Error (percent of span)
0%	0 PSI	4.00 mA		
25%	50 PSI	8.00 mA		
50%	100 PSI	12.00 mA		
75%	150 PSI	16.00 mA		
100%	200 PSI	20.00 mA		

INSTRUMENT CALIBRATION

Up-tests and Down-tests

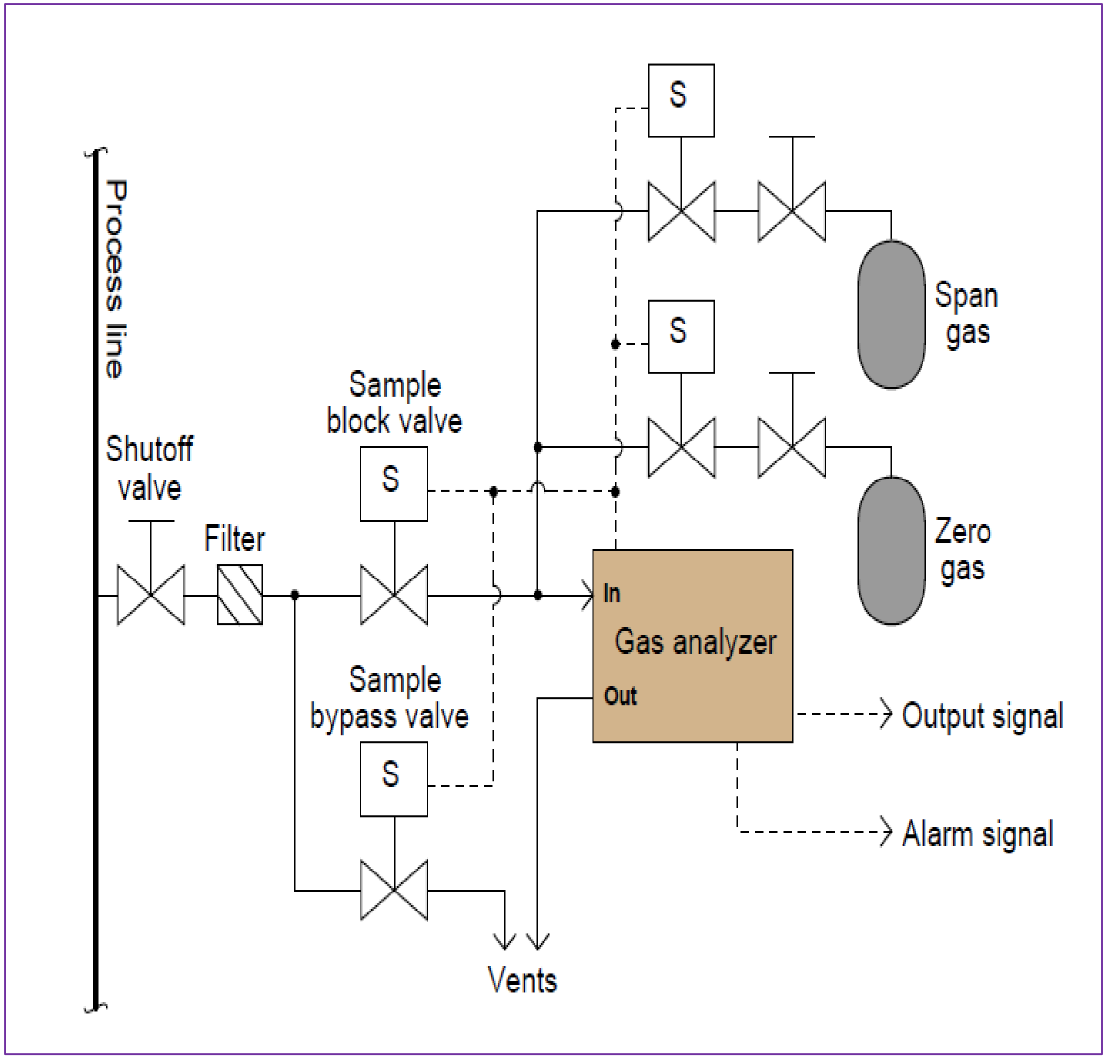
It is not uncommon for calibration tables to show multiple calibration points going up as well as going down, for the purpose of documenting hysteresis and deadband errors.

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 %

INSTRUMENT CALIBRATION

Automatic Calibration

Example 1 : Analyzer



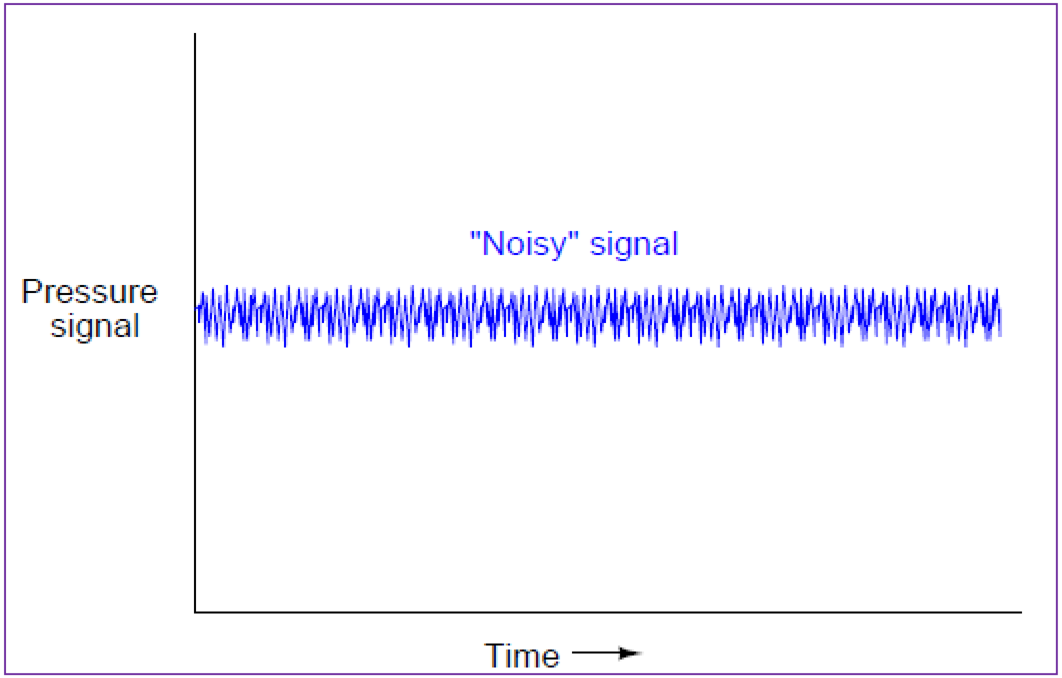
INSTRUMENT CALIBRATION

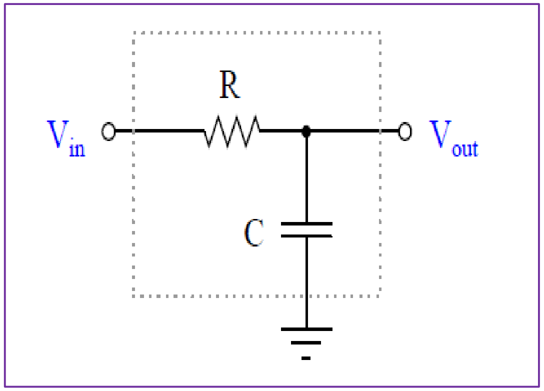
Example 2 : Smart Positioner DVC 6000 Series

INSTRUMENT CALIBRATION

Damping

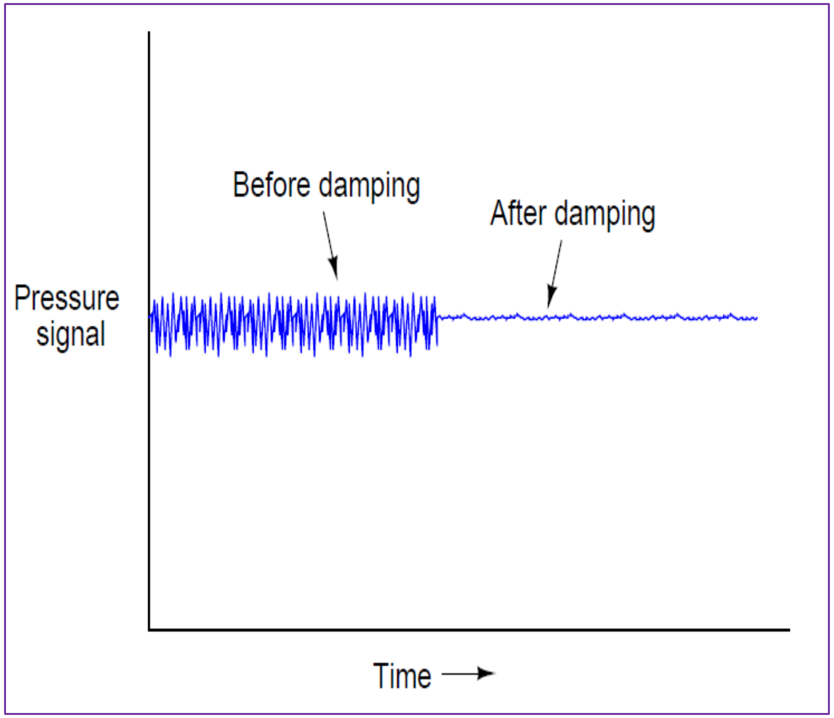
The vast majority of modern process transmitters (both analog and digital) come equipped with a feature known as damping. This feature is essentially a low-pass filter function placed in-line with the signal, reducing the amount of process "noise" reported by the transmitter.

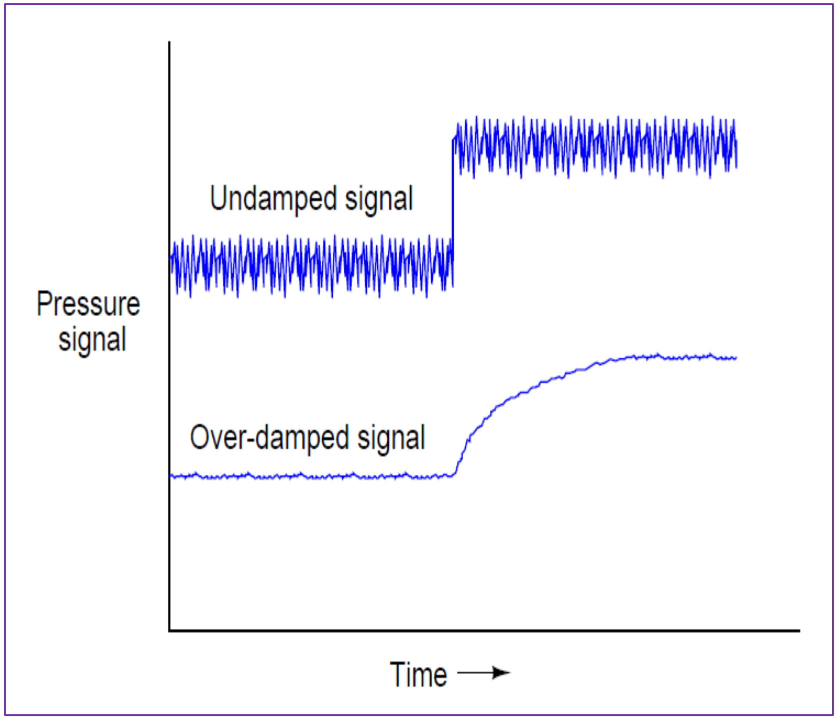




INSTRUMENT CALIBRATION

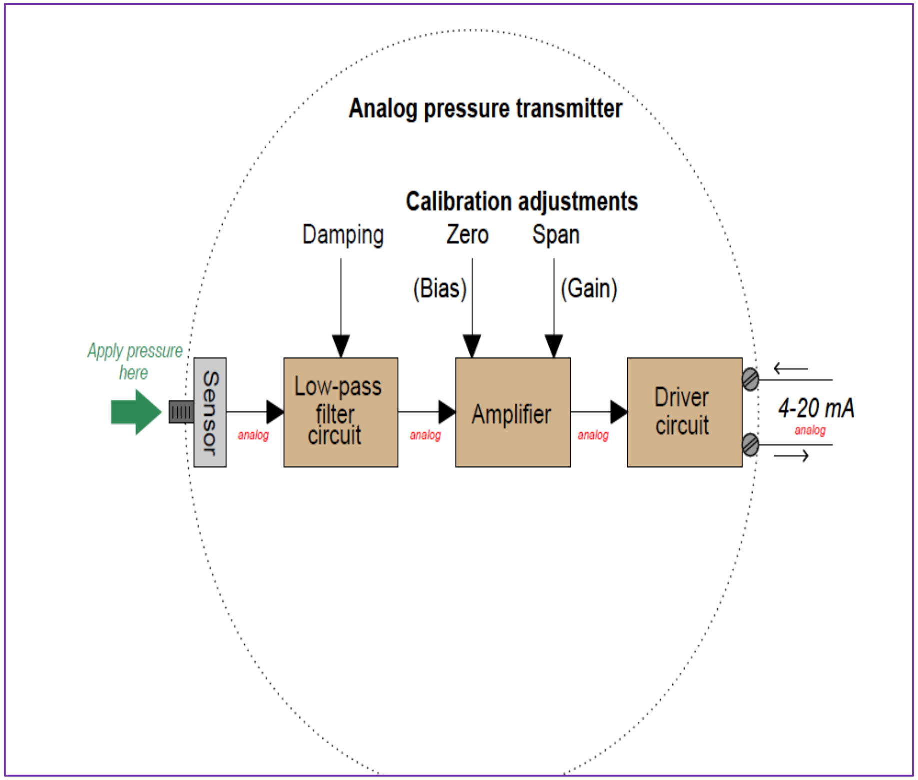
Damping Effect

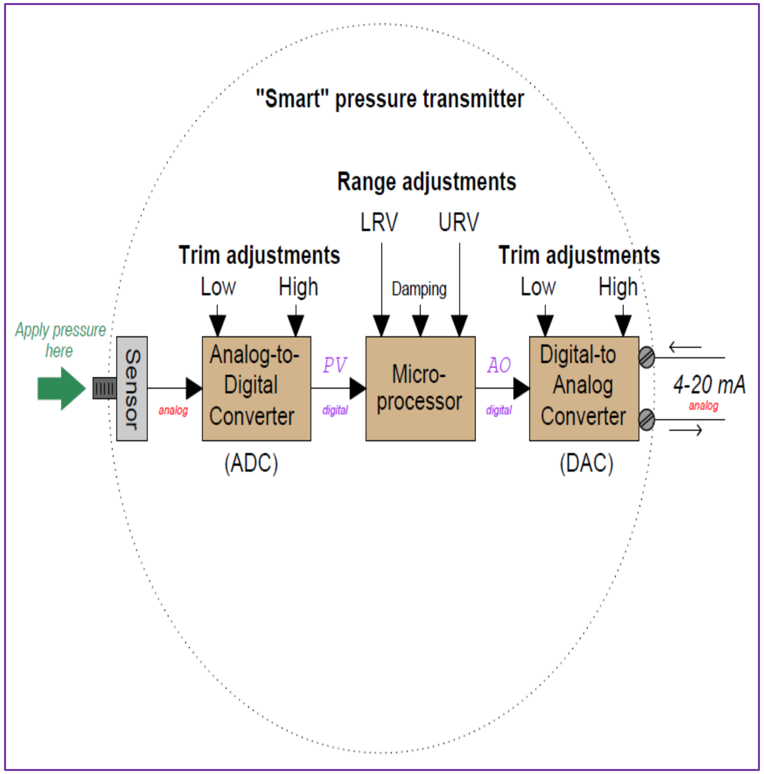




INSTRUMENT CALIBRATION

Analogue and Digital transmitters





INSTRUMENT CALIBRATION

Calibration Procedure

The only way we can know that an instrument's output accurately corresponds to its input over a continuous range is to subject that instrument to known input values while measuring the corresponding output signal values. This means we must use trusted standards to establish known input conditions and to measure output signals.

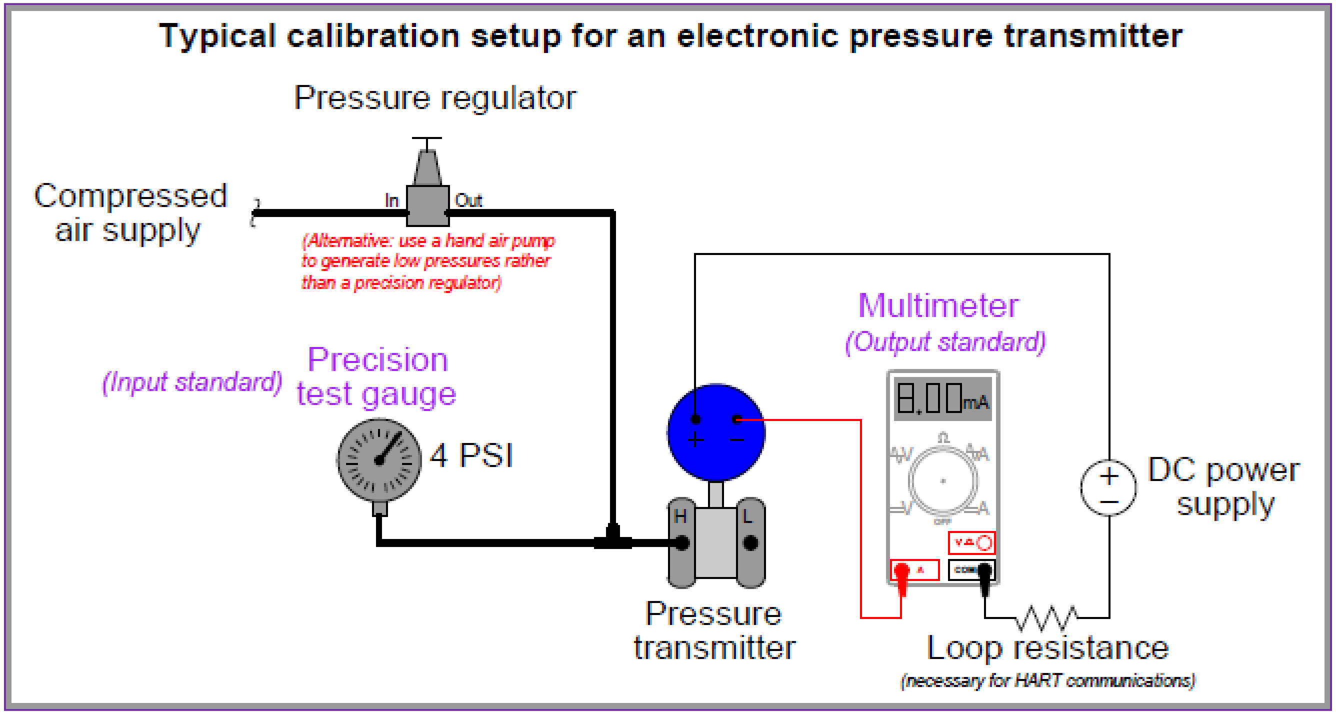
Five-point calibration

The instrument is checked at 0% (LRV), 25%, 50%, 75%, and 100% (URV) of range.

Another improvement over the basic five-point test is to check the instrument's response at five calibration points decreasing as well as increasing. Such tests are often referred to as Updown calibrations. The purpose of such a test is to determine if the instrument has any significant hysteresis: a lack of responsiveness to a change in direction.

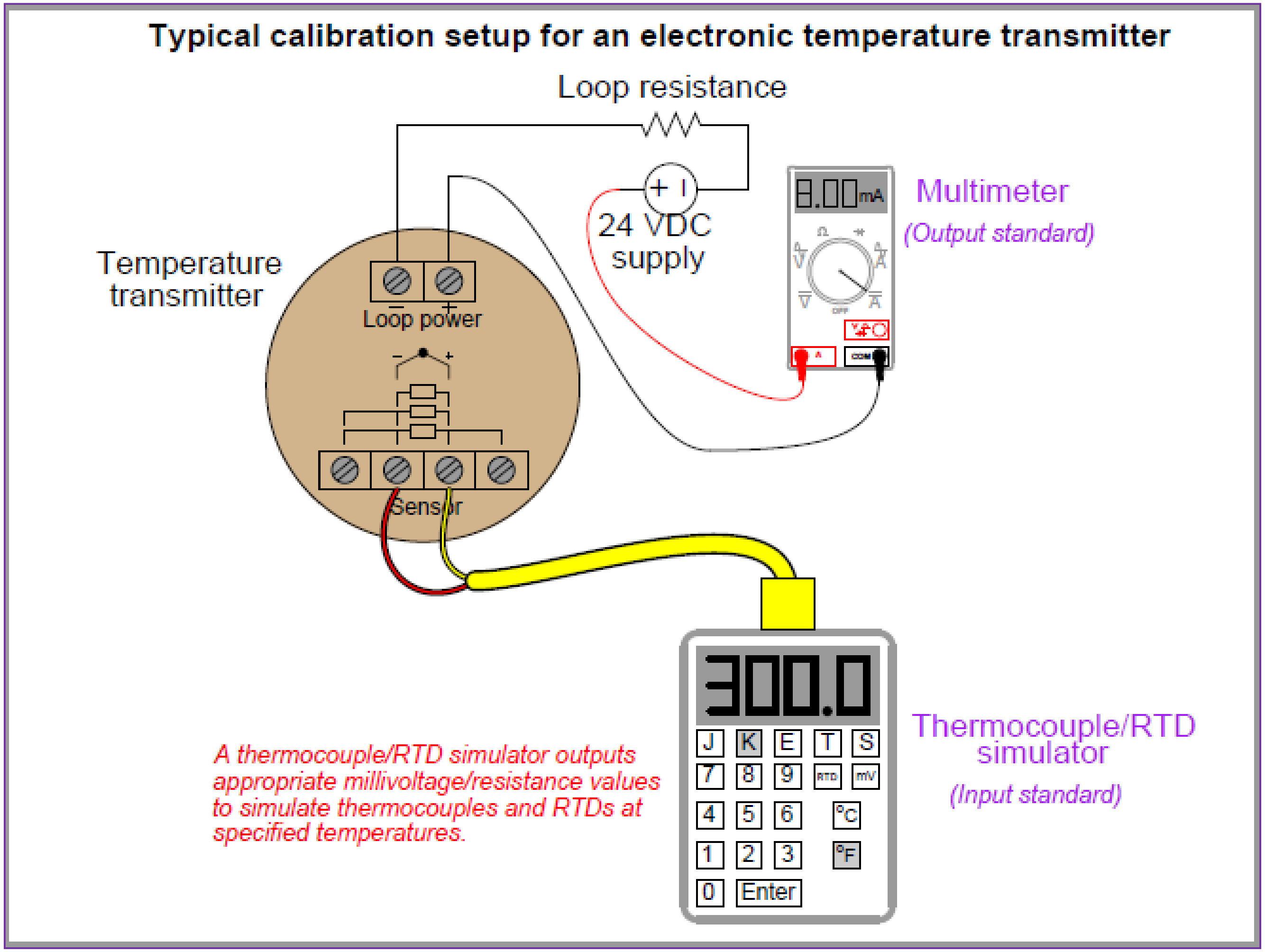
INSTRUMENT CALIBRATION

Example



INSTRUCTIONS CALIBRATION

Example



INSTRUMENT CALIBRATION

Discrete instruments

Examples of discrete instruments are process switches designed to turn on and off at certain values. A pressure switch, for example, used to turn an air compressor on if the air pressure ever falls below 85 PSI, is an example of a discrete instrument.

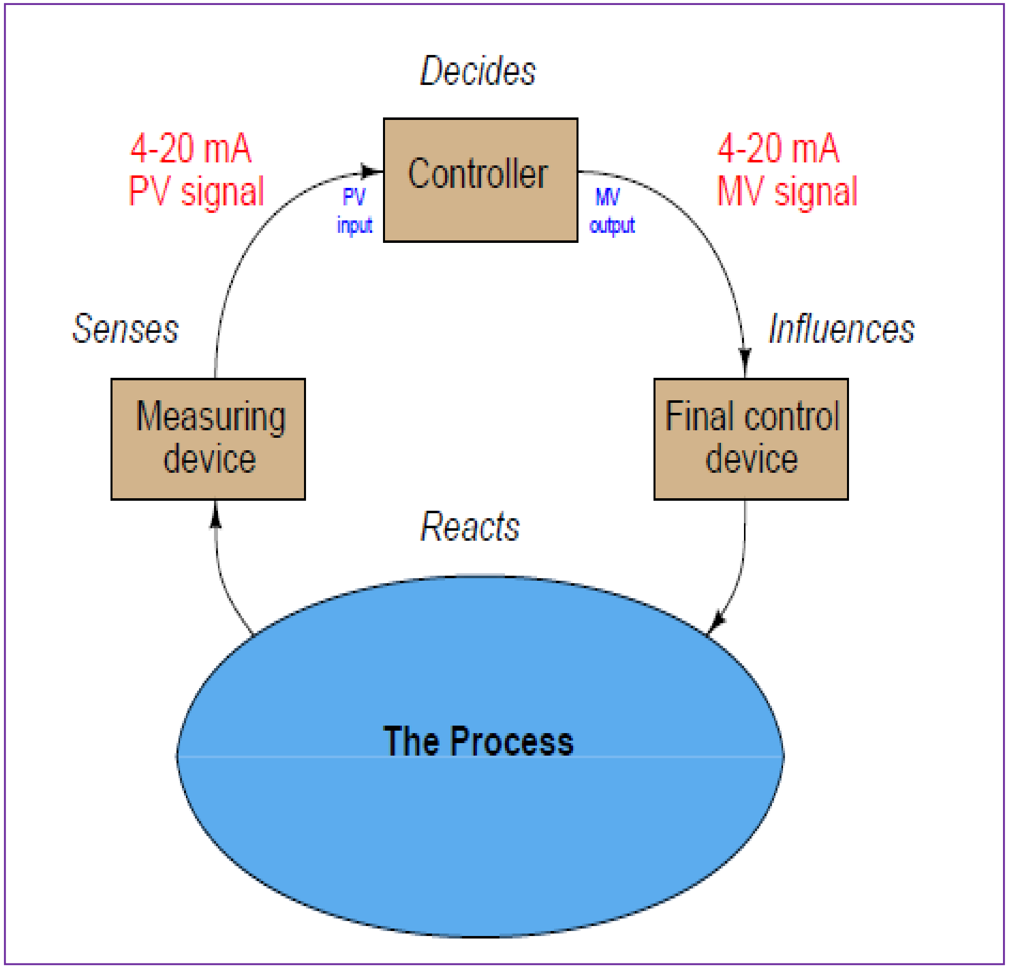
Two parameters need to be taken in consideration :

1. Set point
2. deadband

ELECTRICAL CONTROL LOOPS

ELECTRICAL CONTROL LOOPS

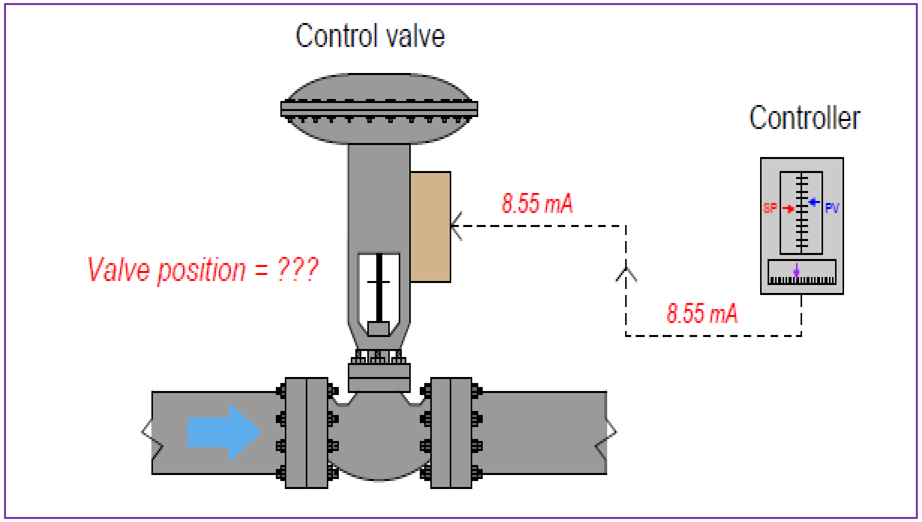
How information is sent in loop diagram



ELECTRICAL CONTROL LOOPS

Exercise

An electronic loop controller outputs a signal of 8.55 mA to a direct-responding control valve (where 4 mA is shut and 20 mA is wide open). How far open should the control valve be at this MV signal level?



$$y = \left(\frac{16}{100}\right)x + 4$$

$$8.55 = \left(\frac{16}{100}\right)x + 4$$

$$4.55 = \left(\frac{16}{100}\right)x$$

$$\left(\frac{100}{16}\right)4.55 = x$$

$$x = 28.4$$

ELECTRICAL CONTROL LOOPS

Exercise

Given a temperature transmitter with a measurement range of -88 degrees to +145 degrees and a signal range of 4 to 20 milliamps, calculate the proper signal output at an applied temperature of +41 degrees.

Solution: Take 41 degrees and subtract the LRV (-88 degrees) which is the same as adding 88 to 41, then divide by the span (145 degrees - -88 degrees, or 233 degrees) to arrive at 55.36% (0.5536).

Take this number and multiply by the span of the current signal range (16 milliamps) and lastly add the LRV of the current signal range (4 milliamps) to arrive at a final answer of 12.86 milliamps.

ELECTRICAL CONTROL LOOPS

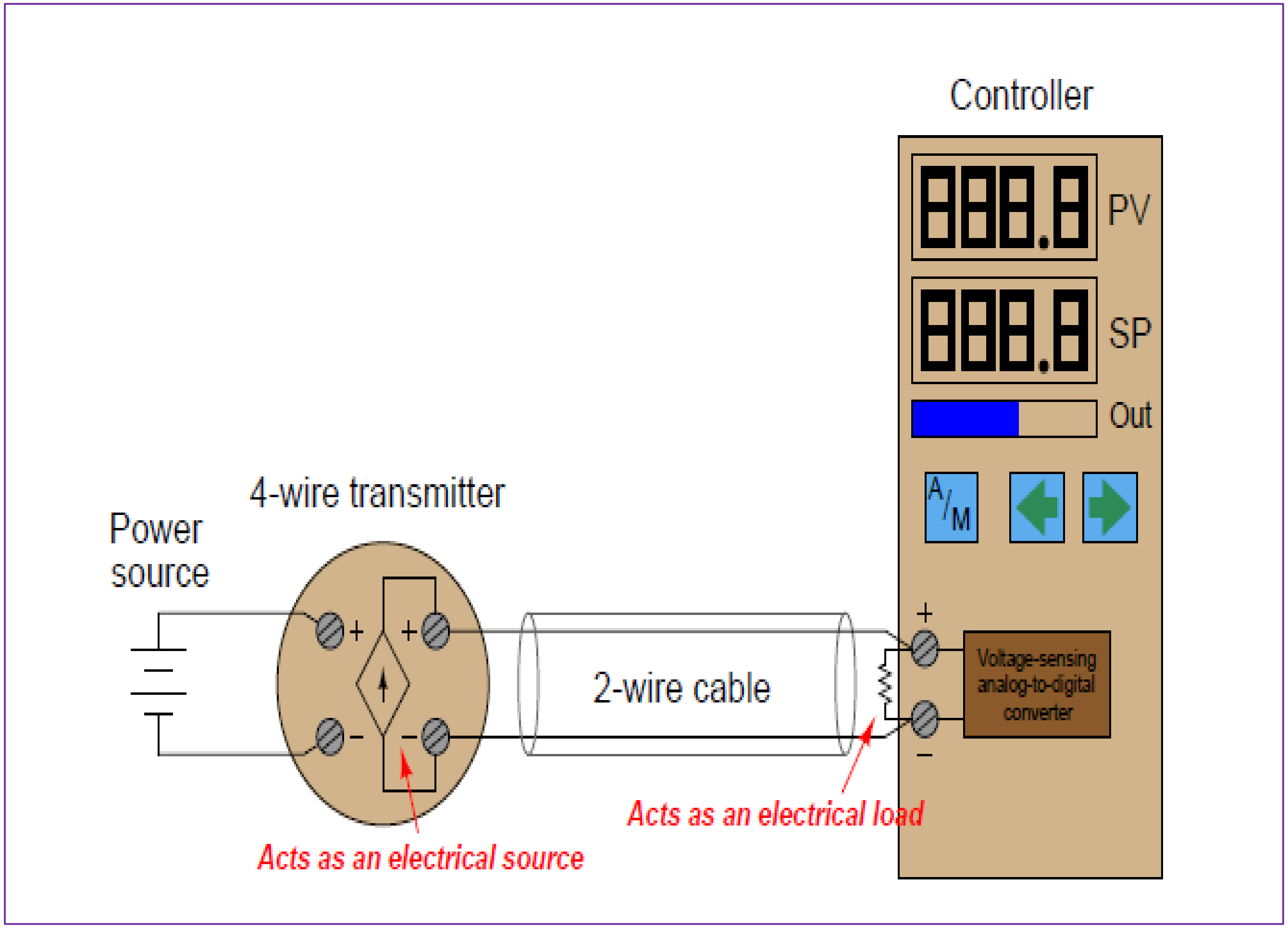
Exercise

Given a pressure transmitter with a measurement range of 150 to 400 PSI and a signal range of 4 to 20 milliamps, calculate the applied pressure corresponding to a signal of 10.6 milliamps.

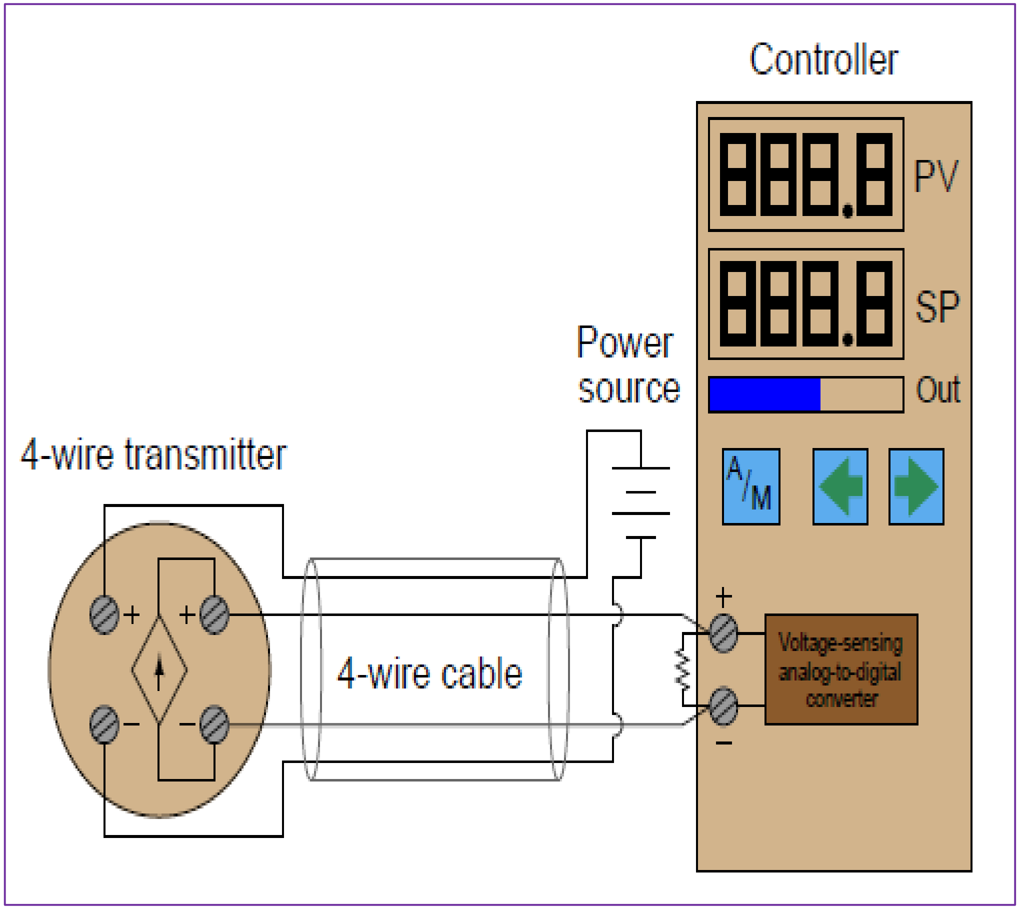
Solution: Take 10.6 milliamps and subtract the LRV (4 milliamps), then divide by the span (16 milliamps) to arrive at 41.25% (0.4125). Take this number and multiply by the span of the pressure range (400 PSI - 150 PSI, or 250 PSI) and lastly add the LRV of the pressure range (150 PSI) to arrive at a final answer of 253.125 PSI.

ELECTRICAL CONTROL LOOPS

4-wire ("self-powered") transmitter current loops

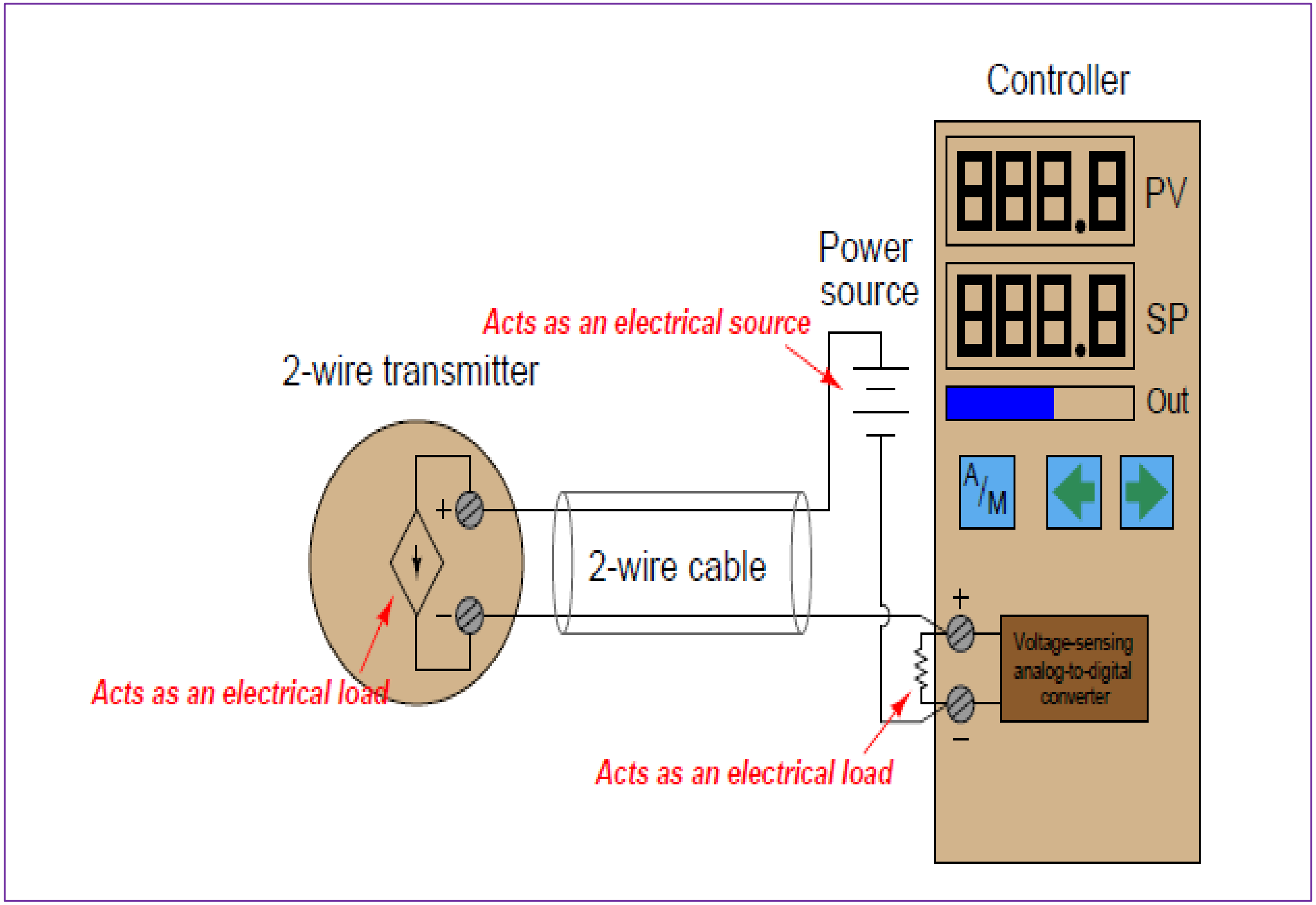


Extended 4 wire cable



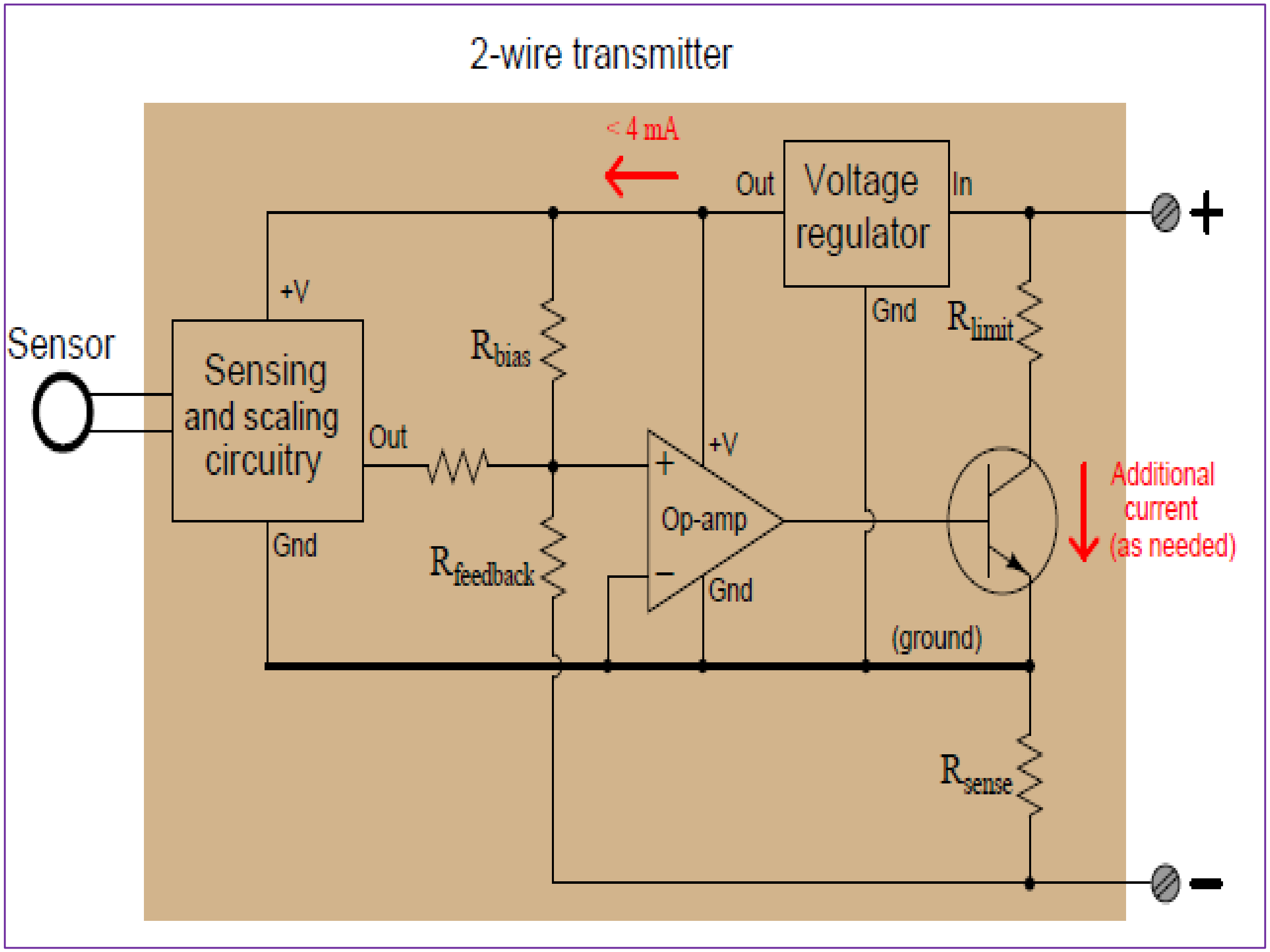
ELECTRICAL CONTROL LOOPS

2-wire (“loop-powered”) transmitter current loops



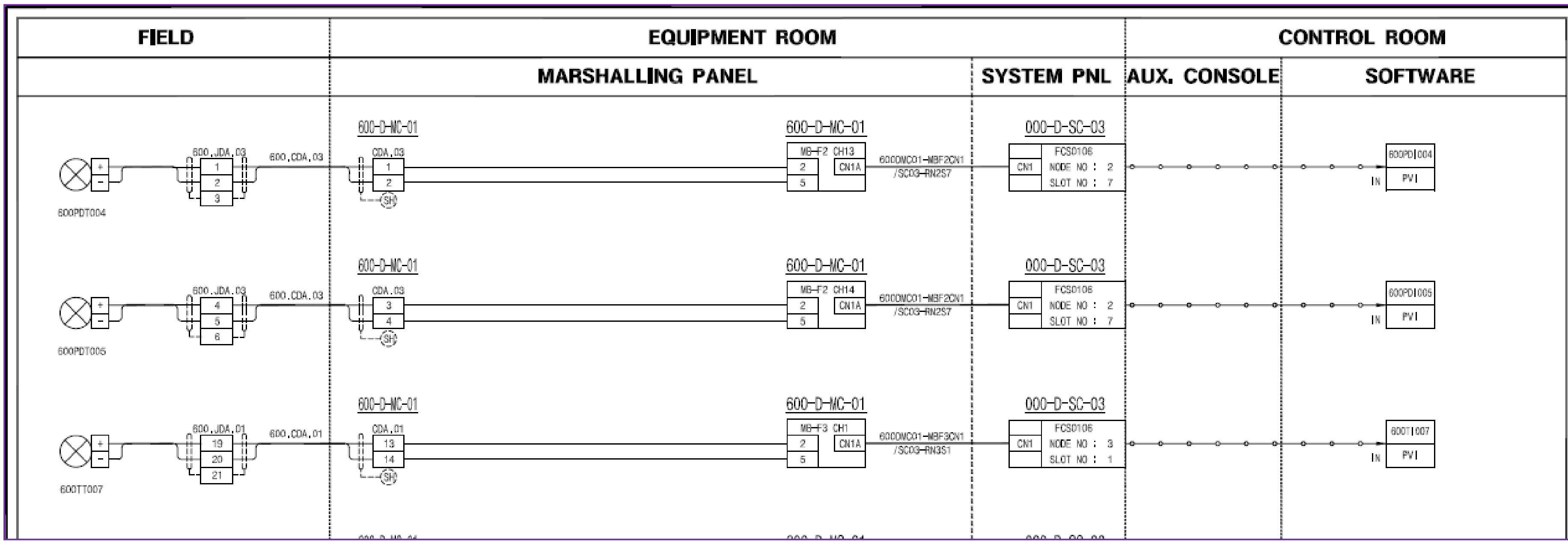
ELECTRICAL CONTROL LOOPS

How to 2 wire loops work ?!



ELECTRICAL CONTROL LOOPS

Total loop drawing



ELECTRICAL CONTROL LOOPS

Instrumentation Signal Standards

Two main signal transmission media;

✓Air (pneumatic systems)

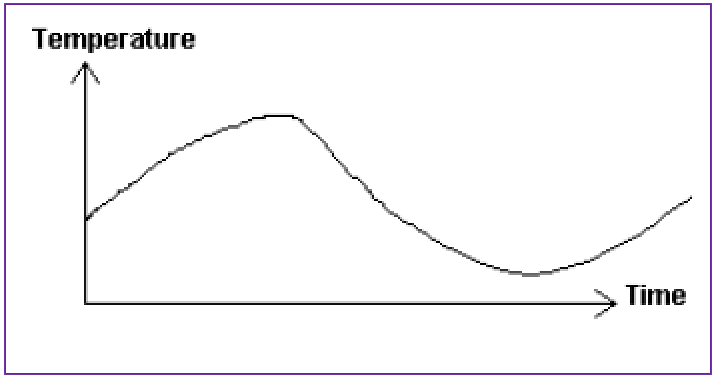
✓Electricity (current and voltage systems)

✓New :optical systems

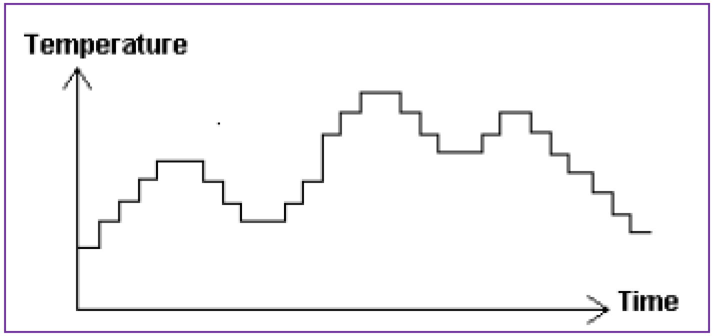
ELECTRICAL CONTROL LOOPS

How is a Signal Represented?

• Analog
Varies smoothly,
continuous
Example: glass thermometer



• Digital
Varies in a step-wise manner
Example: thermometer
with digital display



ELECTRICAL CONTROL LOOPS

Pneumatic Signal Transmission Systems

Process variable changes are mapped into corresponding changes in air pressure level in a dosed air system.

Measurement Units

✓English units - pound per sq. inch (psi)
✓Metric: 1psi=68.95 mbar or 1 bar = 14.5psi
✓1 psig = 1 psi gauge i.e. pressure above atmospheric (15 psi).
✓Absolute pressure (psia) = psig + psi (atmospheric).

A 'live' �zero at 3 psig. This allows elements in the system to differ between a low signal and a system failure (0 psi)

✓3 psi to represent sent 0%: � �
✓15 psi to represent 100%

ELECTRICAL CONTROL LOOPS

Live Zero

Both 3-15 PSI and 4-20 mA signal standards are referred to as live zero because their ranges begin with a non-zero value. This **"live" zero** provides a simple means of discriminating between a legitimate 0% signal value and a failed signal (e.g. leaking tube or severed cable)

ELECTRICAL CONTROL LOOPS

Pneumatic System

AIR	
Advantages	Disadvantage
•Cheap • Plentiful supply • Non-corrosive • Easier trouble shooting • No fire risk	• Requires compression plant, filtration • Must be clean, oil free. Moisture free • Fairly slow response to pressure changes • Frequent maintenance • Dependent on power supply to compression plant

ELECTRICAL CONTROL LOOPS

Electrical System

Electrical	
Advantages	Disadvantage
• Much faster response to change of voltage level or current • easily interfaced with control computers and logic systems • Less moving parts • Greater reliability • Less maintenance • May have battery back-up against power interruption	• Expansive generating equipment • Requires stabilization of supplies for control accuracy • May constitute a fire hazard • Requires intrinsically safe circuitry for hazardous areas • Skilled trouble shooting at component level • Dependent on power supply

ELECTRICAL CONTROL LOOPS

Electrical Industrial Signal Transmission Systems

1. Electrical transmission may utilize voltage as well as current as signaling media. The use of wireless systems is on the Increase

2. Standards exist for analog and digital communication

 1. Standard electrical voltage ranges include: -10V to +10V, OV to +5V, +1 to +5V This is for both analog and digital communication

 2. Post industrial instrumentation communication uses current as the signal medium.

3. The standard range for current analog signal transmission Is 4mA - 20mA

3. 0-20mA standards exist for digital signaling.

ELECTRICAL CONTROL LOOPS

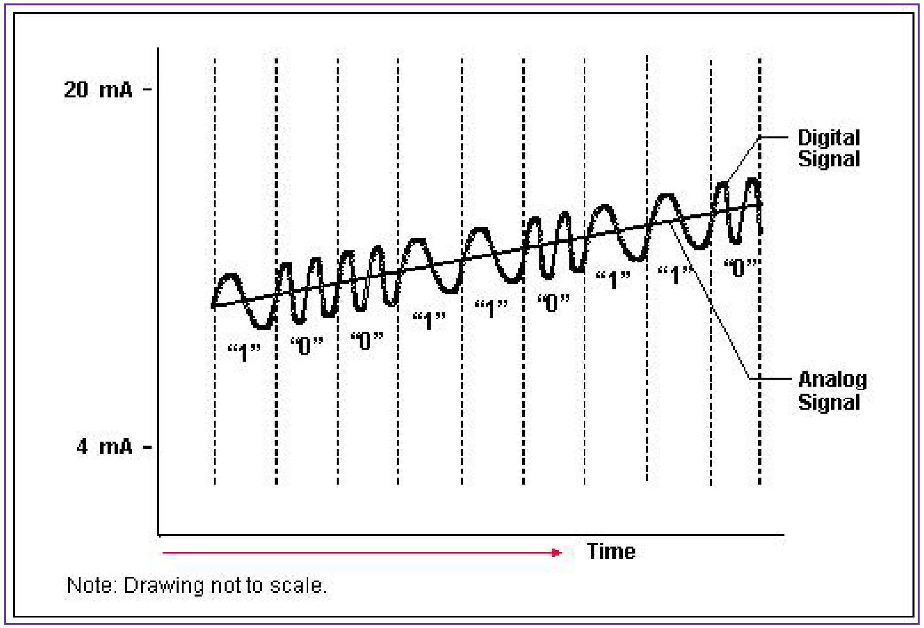
Current Vs Voltage

The key advantages of the current loop are that the accuracy of the signal is not affected by voltage drop in the interconnecting wiring, and that the loop can supply operating power to the device. Even if there is significant electrical resistance in the line, the current loop transmitter will maintain the proper current, up to its maximum voltage capability allows transmitter devices to be powered by the same current loop (called ***two-wire transmitters). Such instruments are used to measure pressure, temperature, flow, pH or other process variables. A current loop can also be used to control a valve positioner or other output actuator.***

HART Protocol

HART communication uses the conventional 4 to 20 mA current loop for data transmission. The communication systems requires (almost) no additional wiring. The HART protocol is therefore also a good solution when smart field devices are to be integrated in an already existing plant.

The acronym .***HART. . Highway Addressable Remote Transducer .*** shows that the protocol originally was defined for measuring transducers. The protocol specification available today, however, supports data exchange with sensors as well as with actuators.



ELECTRICAL CONTROL LOOPS

HART Features

There are several reasons to have a host communicate with a field instrument. These include:

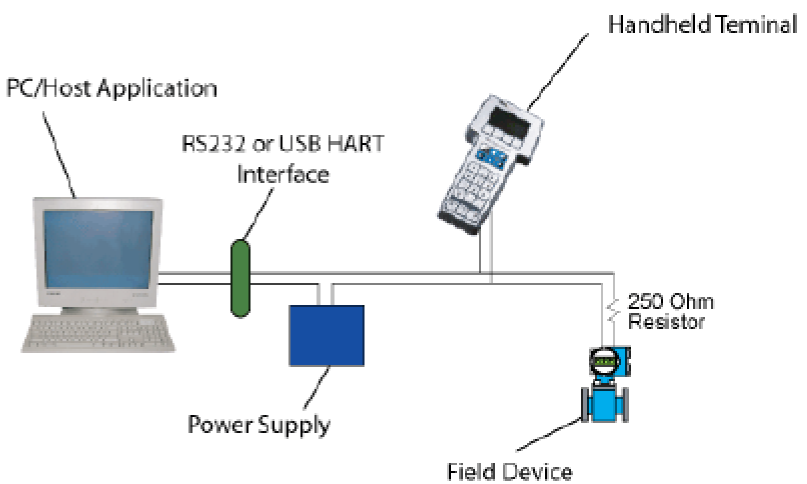
- Device Configuration or re-configuration
- Device Diagnostics
- Device Troubleshooting
- Reading the values of additional measurements provided by the device
- Device Health and Status

ELECTRICAL CONTROL LOOPS

HART

The most important performance features of the HART protocol include:

- proven in practice, simple design, easy to maintain and operate
- compatible with conventional analog instrumentation
- simultaneous analog and digital communication
- flexible data access via up to two master devices
- supports multivariable field devices
- sufficient response time of approx. 500 ms
- freely available to any manufacturer or user



PIPING AND INSTRUMENT DRAWING

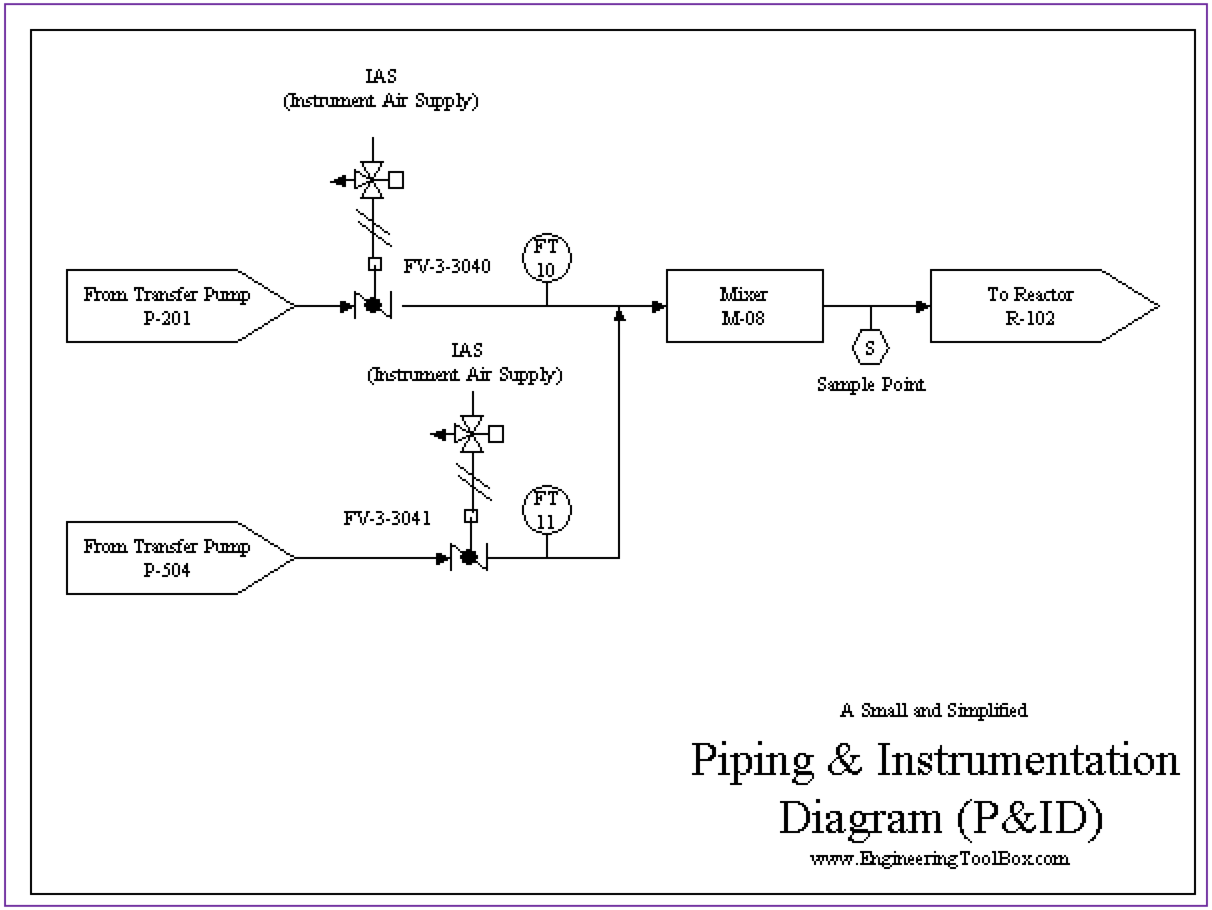
PIPING AND INSTRUMENT DRAWING

Definition

DEFINITION A piping and instrumentation diagram/drawing (P&ID) is defined by the Institute of Instrumentation and Control as follows:
A diagram which shows the interconnection of process equipment and the instrumentation used to control the process. In the process industry, a standard set of symbols is used to prepare drawings of processes. Also P & I D shows all of piping including the physical sequence of branches, reducers, valves, equipment, instrumentation and control interlocks P & I Ds are used to operate the process system

PIPING AND INSTRUMENT DRAWING

Example



PIPING AND INSTRUMENT DRAWING

P & I D should include:

☐ Instrumentation and designations
☐ Mechanical equipment with names and numbers
☐ All valves and their identifications
☐ Process piping, sizes and identification
☐ Miscellaneous - vents, drains, special fittings, sampling lines, reducers and increasers
☐ Permanent start-up and flush lines
☐ Flow directions
☐ Interconnections references
☐ Control inputs and outputs, interlocks
☐ Interfaces for class changes
☐ Computer control system input
☐ Vendor and contractor interfaces
☐ Identification of components and subsystems delivered by others
☐ Intended physical sequence of the equipment

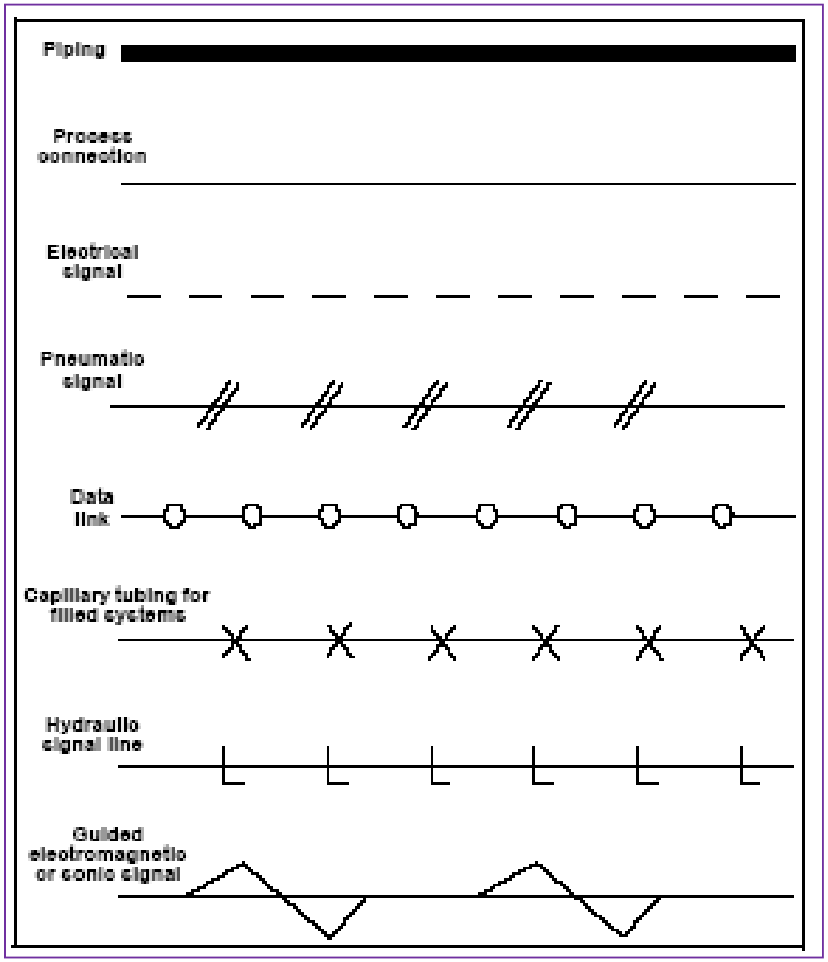
PIPING AND INSTRUMENT DRAWING

A P&ID should not include:

- ☐ Instrument root valves
- ☐ control relays
- ☐ manual switches
- ☐ equipment rating or capacity
- ☐ primary instrument tubing and valves
- ☐ pressure temperature and flow data
- ☐ elbow, tees and similar standard fittings
- ☐ extensive explanatory notes

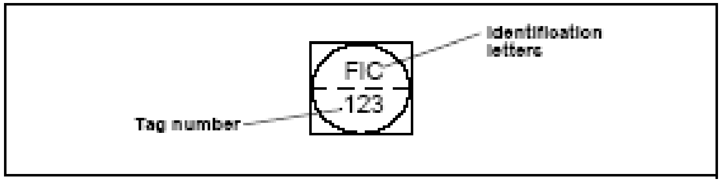
PIPING AND INSTRUMENT DRAWING

Line Symbols



PIPING AND INSTRUMENT DRAWING

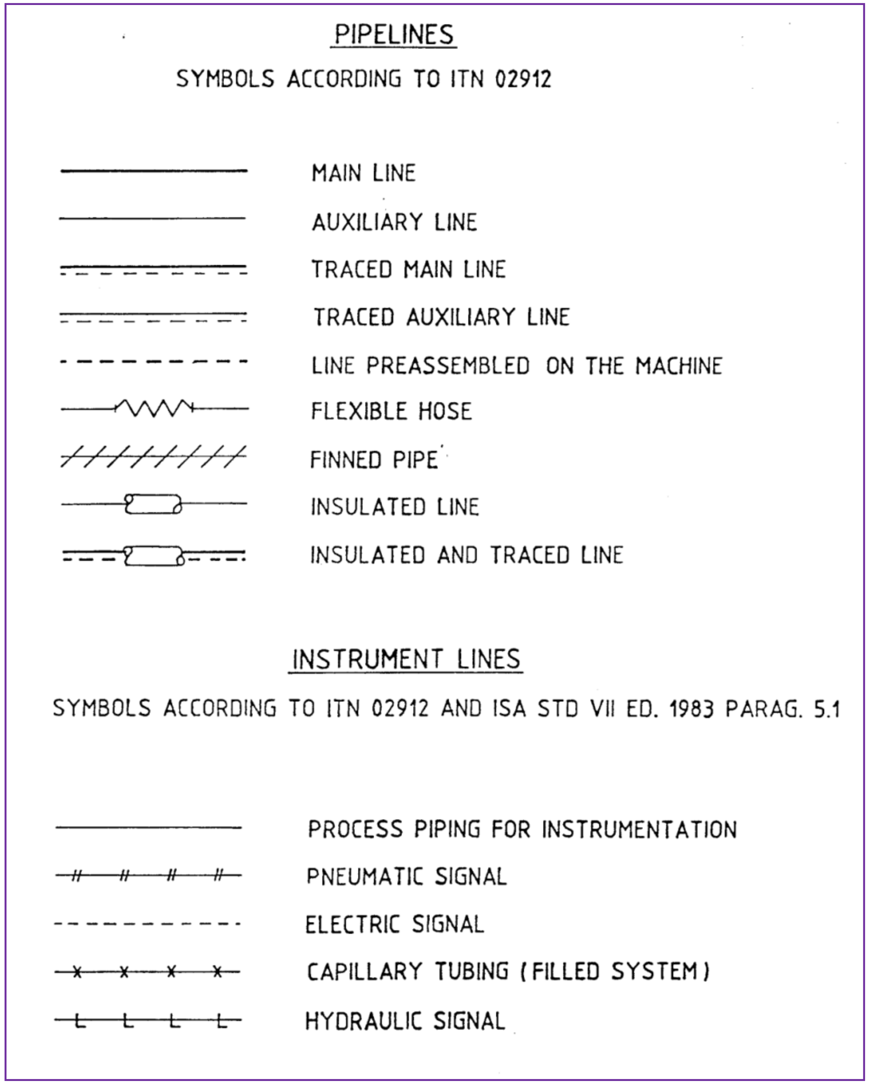
Instrument Symbols



Identification Letters and Tag Number

	FIRST LETTER	SUCCEEDING LETTERS		
	Measured Variable	Read-out or Passive Function	Output Function	Modifier
A	CURRENT	ALARM		AVERAGE
C			CONTROL	CONTACT
E		ELEMENT		
F	FLOW RATE			
G		GLASS		
H	HAND (MANUAL)			HIGH
I		INDICATE		
L	LEVEL			
M		MOTORIZED		MEDIAN
P	PRESSURE			
R	NEUTRON FLUX	RECORD	RELAY	
S		SOLENOID	SWITCH	
T	TEMPERATURE		TRANSMIT	
V				VALVE
W		WELL		
X			TRANSDUCER	
Y			COMPUTE	
Z	POSITION			

PIPING AND INSTRUMENT DRAWING



PIPELINES

SYMBOLS ACCORDING TO ITN 02912

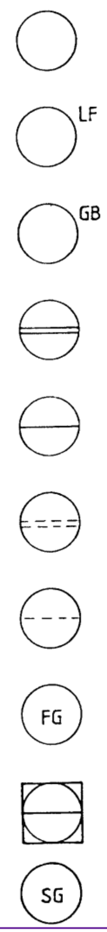
MAIN LINE
AUXILIARY LINE
TRACED MAIN LINE
TRACED AUXILIARY LINE
LINE PREASSEMBLED ON THE MACHINE
FLEXIBLE HOSE
FINNED PIPE
INSULATED LINE
INSULATED AND TRACED LINE

INSTRUMENT LINES

SYMBOLS ACCORDING TO ITN 02912 AND ISA STD VII ED. 1983 PARAG. 5.1

PROCESS PIPING FOR INSTRUMENTATION
PNEUMATIC SIGNAL
ELECTRIC SIGNAL
CAPILLARY TUBING (FILLED SYSTEM)
HYDRAULIC SIGNAL

PIPING AND INSTRUMENT DRAWING

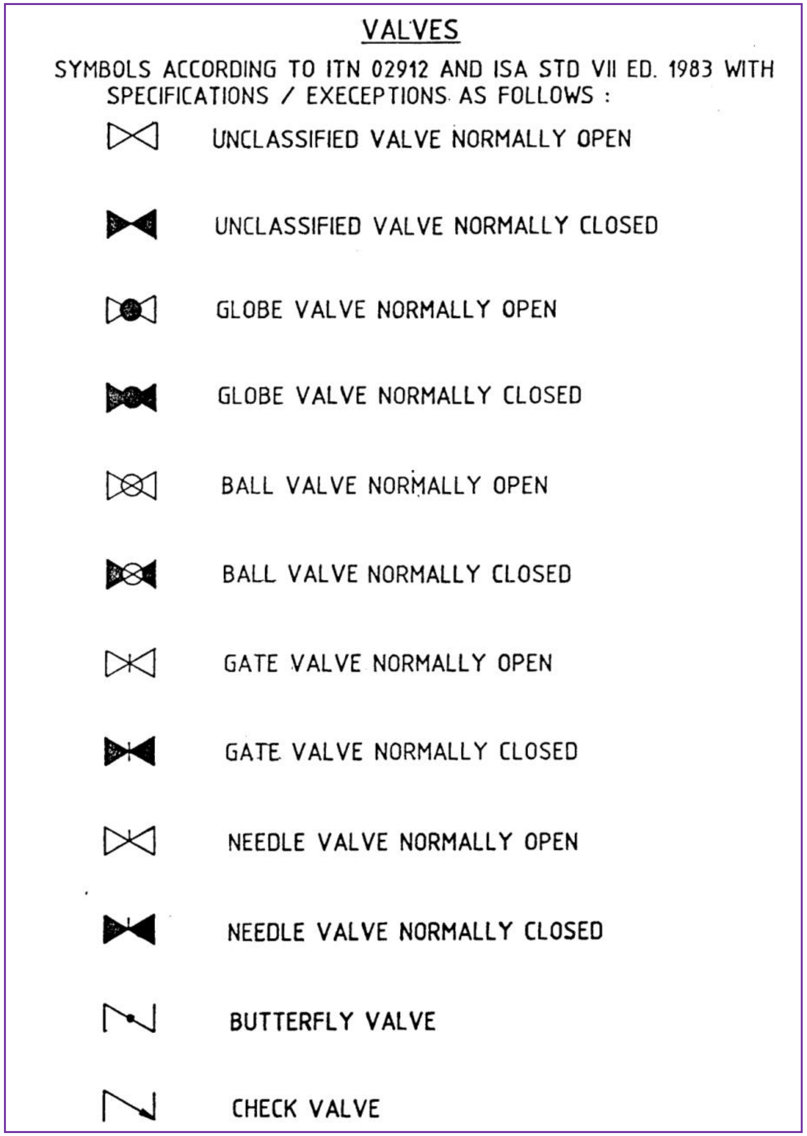


INSTRUMENTS

SYMBOLS ACCORDING TO ITN 02912 AND ISA STD VII ED. 1983 WITH SPECIFICATIONS / EXEPTIONS AS FOLLOWS :

	LOCALLY MOUNTED INSTRUMENT
LF	LOCAL FIELD MOUNTED INSTRUMENT
GB	INSTRUMENT MOUNTED ON LOCAL GAUGE BOARD
	INSTRUMENT FRONT MOUNTED ON LOCAL PANEL
	INSTRUMENT FRONT MOUNTED ON MAIN PANEL (CONTROL ROOM)
	INSTRUMENT REAR MOUNTED ON LOCAL PANEL
	INSTRUMENT REAR MOUNTED ON MAIN PANEL (CONTROL ROOM)
FG	FLOW SIGHT GLASS
	SHARED DISPLAY IN CONTROL ROOM
SG	SIGHT GLASS (MANUFACTURER'S STD)

PIPING AND INSTRUMENT DRAWING



VALVES

SYMBOLS ACCORDING TO ITN 02912 AND ISA STD VII ED. 1983 WITH SPECIFICATIONS / EXECEPTIONS AS FOLLOWS :

UNCLASSIFIED VALVE NORMALLY OPEN

UNCLASSIFIED VALVE NORMALLY CLOSED

GLOBE VALVE NORMALLY OPEN

GLOBE VALVE NORMALLY CLOSED

BALL VALVE NORMALLY OPEN

BALL VALVE NORMALLY CLOSED

GATE VALVE NORMALLY OPEN

GATE VALVE NORMALLY CLOSED

NEEDLE VALVE NORMALLY OPEN

NEEDLE VALVE NORMALLY CLOSED

BUTTERFLY VALVE

CHECK VALVE