

Values of Industrial Instrumentation

1.1 INTRODUCTION

As we come across through the application of applied science from our school level, we indulged ourselves to know the hidden curiosity behind the real-life engineering values.

The present technology is a reflex of what we learned in our primary standard and its proper application on other engineering streams.

For example, in earlier days people used to light up their home by wax candles, and the LED light used today is the proper application of what we say in one word is illumination technology.

Another good example is the use of electrically operated pumps, which can discharge huge tons of fluid in a single minute, whereas in earlier days operator used the manual rotating hand pump which was very slow and had lesser discharge.

The vogue for engineering was developed at mid-eighteenth century in American Society to fit the best engineers in the real life engineering systems. The American Society of Civil Engineering (ASCE), The American Institute of Mining Engineering (AIME), The American Society of Mechanical Engineering (ASME) and the American Institutes of Electrical Engineering (AIEE) are the four mothers' societies who developed their different code of ethics for the purpose of systematic, regular and disciplined work professions.

The engineering revolution brought by the scientists and the engineers has made the difficult task simple, as the entire

memory can be embedded in a single quarter-inch size silicon chip rather than older 1949 ENIAC (Electronic Numerical Integrator and Computer). The questions that always arose in the brain are that what are the defined norms that can depict the importance of instrumentation engineering concepts.

Industrial Instrumentation Society of Engineering (IISE) had the three main norms that partially define the values of its engineering concepts as follows:

- a. The analysis of real value signal always set a difference while comparing it with a predefined set value of the signal.
- b. The error optimization and navigation by monitoring and control will set some desired output, and
- c. The feedback system related to any LAN or compact mesh provides a faithful data to understand the quality of process signal.

1.2 INDUSTRIAL INSTRUMENTATION SYSTEM

An instrumentation system refers to the cascade of some sets of instruments, which helps to detect or measure process parameters and subsequently its control. It is developed to maintain certain sets of operation, which improves the product quality of the process industry as per the requirements. This system is designed as per the requirements of customer needs to meet specific process criteria irrespective of the initial costs.

The advanced instrumentation system is based on digital technology made off microelectronics components, which made the system rugged, flexible, and reliable with improved signal quality. The main function of this system is to measure, compare, record and control of the various process variables like temperature, pressure, flow, level, humidity and moisture, etc.

The industrial system consists of three parts—process instrumentation, telemetry, and automation, each part has its own importance and is interdependent. The process instrumentation parts gather the local information of the current running process and its critical behavior; the telemetry system improves the signal quality by minimizing the noise,

applying signal buffer and by providing discrete data transfer to the remote controller known as distributed control system, which further helps to monitor, record and control the behavior of process variables by supervisory control and data-acquisition system.

The key points of an instrumentation system are:

1. Designed as per the needs of the end user
2. For measurement, monitoring and control of process parameters.
3. For instrument intrinsic and human safety.
4. To adjust the process output by determining the set points of process variables.
5. The conditional interlocks can be built-up as per need.

The simple way to understand the instrumentation system is that the final signal output from the system should be much better than the raw input and strictly obey the process rules.

These measurand are generally known as process variables, which are either single identify or reference identifies. They are basically—flow, current, pressure, level, temperature, etc.

If the raw input into the system is any parameter, then the actuated output from the system can have any parametric form. The idea will be clear by referring Fig. 1.0.

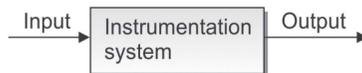


Fig. 1.0: Instrumentation system

The two main inherent characteristics of the instrumentation system are static and dynamic characteristics. Static variables are a time-varying process, whereas dynamic variables are non-time varying. The main static and dynamic aspects, which are the backbone of the instrumentation process system, are accuracy, precision, sensitivity, resolution, fidelity and lag, etc.

The vital role that instrumentation systems play is the measurement and the question is that what is the amount of accuracy is present in such a measurement system.

To understand the concept in more detail, let us consider a large process instrumentation system as shown in Fig. 1.1.

Let us take a simple example of an industrial temperature measurement by a calibrated thermocouple.

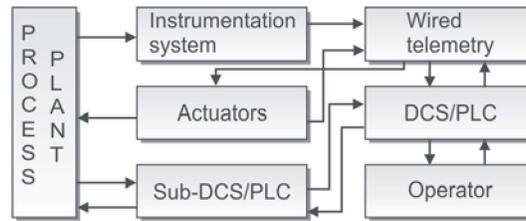


Fig. 1.1: Detailed instrumentation system

Example 1. A J-type thermocouple has a working range of -50°C to 750°C . When the temperature is 600°C on remote monitor, it shows 599.5°C on the local display. What is the percentage error on the full scale if the accuracy standard is taken as $\pm 1^{\circ}\text{C}$.

Solution. The accuracy standard of $\pm 1^{\circ}\text{C}$ on the full scale can accept an error over the range of 599°C to 601°C .

$$\begin{aligned} \text{Percentage error} &= \frac{\left(\text{Local value}\right) - \left(\text{Monitor value}\right)}{\text{Full scale}} \times 100 \quad \dots \text{Eqn (1)} \\ &= \frac{(599.5 - 600)}{750} \times 100 = -0.06\% \end{aligned}$$

The percentage error on the full scale is -0.06% and this is how the system percentage accuracy is determined.

1.3 INSTRUMENTS IDENTIFICATION

Instrument coding and identification setup was first developed by (Instrument Society of Automation) ISA, to maintain a uniform meaning for designating instruments by a defined prototype system.

A basic instrumentation standard was established as a reference purpose for symbolization and identification in processing system which covers the following.

1. FBD (functional block diagram).
2. P & ID (process and instrumentation diagram).
3. Hook-up diagram.
4. Logic and loop diagram.
5. Designed sketches as per data sheet.
6. Tag, specification and system design note.
7. Installation, operation and maintenance guidelines
8. Drawings (provision for future interlocks).
9. Technical paper and its detailed description.
10. PBOM (purchased bill of material), etc.
11. PFD (process flow diagram)

The identification of instruments or its associated controls in a closed loop is depicted by an alpha numeric code termed a TAG as per the rule of ISA vide the documents 14ANSI/ISA-S5.1-1984(R1992).

A typical identification tag is shown in Fig. 1.2, for your easy understanding as an example.

30-PAL-65A	Equipment tag number
30	Optional prefix
PAL	Functional identification
65	Loop number
A	Optional suffix
(-)	Optional separator

Fig. 1.2: Instrument identification plate prototype 1

The tag number on the instrument loop includes the plant area code information or any special function related to the man, machine and safety. The operational identification of the initial letter was selected as per measured variables, and the succeeding letters are either output or passive function. Another identification tag of field equipment is shown in Fig. 1.3 for your reference.

60-PIC-403	————	Equipment tag number
P-403	————	Loop identification
403	————	Loop number
PIC	————	Functional identification

Fig. 1.3: Instrument identification plate prototype 2

Loop numberings are of two types, parallel and serial. Parallel numbering starts with a numeric value for each series such as LIC-402, TIC-305, etc. The serial loop numbering starts with the single sequence of numeric value such as 10, 101, 1012, etc., and if a loop has more instruments with alike functional identification, then the loop numbering will be written as PIC-403C, TIC-403C (examples only), where “C” is the added suffix to the given loop.

In process industries where a large number of loops are active all the time, so it is not easier for an operator to remember all the loops, so in graphics screen, numerous numbers of face plates with different tag and service detail are built for easier of operation. Figure 1.4 shows the detail face plate of the various instruments.

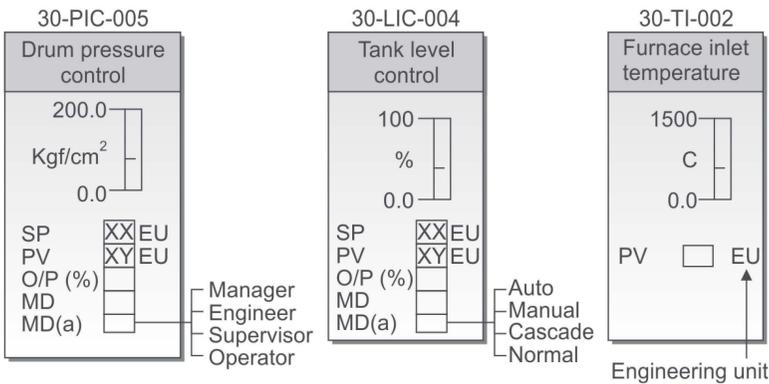


Fig. 1.4: Front view of face plate 2

SP: Set point; PV: Process value; O/P: Output; MD: Mode

Symbols are the diagrammatic representation within the instrumentation system on drawings. It gives the complete

information regarding the location and the purpose of the instrument being used on the drawing sheet.

There are a few guidelines for representing symbols on a data sheet; some of them are as follows:

1. The sequential order of instrument arranged in a loop diagram shall clearly give the full information about its functional logic.
2. Symbols can be drawn in 360° orientation on drawing except the tag number and functional blocks (horizontal orientation only).
3. The special symbol (control valve, motorized actuator, etc.) should be tagged by the bubbles and brief description shall be added in closer to the symbol.
4. The special symbols individually not to be tagged on the main diagram irrespective of its interconnecting interlocks in loops.
5. Single-line representation between two symbols is enough to describe the meaning of a loop flow diagram.
6. Pneumatic, electrical, hydraulic, etc. symbols can be shown in a flow diagram to resemble the meaning of the process loop.

Table 1.0 represents the description of a few selected symbols with its figure.

Table 1.0 Symbolic representation of instruments	
Sl.no. Description	Symbols
1. Process instrumentation connection	
2. Pneumatic signal	
3. Electrical signal	
4. Hydraulic signal	
5. Diaphragm valve	
6. Solenoid valve	
7. Pneumatic two-way diaphragm valve	

Alike symbols, tables are used in process data sheet to represent the system in a textual format for easy understanding of the desired drawings. Tables mainly consist of three vital parameters: Identification letters, varied letter combination and functioning diagrams (as per SAMA—scientific apparatus manufacturer association).

For example, to understand the meaning of “L” and “P” in terms of industrial instrumentation, let us refer Table 1.1.

<i>Initial letter</i>	<i>Measured variable</i>	<i>Controller readout</i>			<i>Switch</i>	<i>Transmitter</i>	<i>Primary and final element</i>	
L	Level	LRC	LIC	LCV	LSH	LT	LE	LV
P	Pressure	PRC	PIC	PCV	PSH	PT	PE	PV

Abbreviations: LRC: Level regulating controller; PRC: Pressure regulating controller; LIC: Level indicator controller; PIC: Pressure indicator controller; LCV: Level control valve; PCV: Pressure control valve; LT: Level transmitter; LE: Level element; LSH: Level switch high; PSH: Pressure switch high; LV: Level value; PV: Pressure value; PE: Pressure element.

1.4 BEHAVIOR OF INSTRUMENTS

The wide varieties of instrument used to run a process plant are selected according to the process application. These instruments are well calibrated and shall have a due calibration period to maintain its output consistently.

An instrument shall perform well in all respect initially for 2 to 3 years approximately and gradually its performance starts decreasing.

It is very important to carry on a schedule for instrument calibration and maintenance; this will somehow increase the performance of equipment under defined physical and environmental conditions.

The malfunctioning in instruments is mainly due to the aging and improper CLIT (cleanliness, lubrication, inspection and tightness). The behavior of an instrument can be easily understood by its present trends while monitoring on a graphics display.

The following parameters are responsible for an instrument malfunction or uncertain behaviors and should be always taken care.

1. Surrounding temperature
2. Surrounding humidity and moisture
3. Suspended dust of surroundings
4. Design range
5. Designed pressure
6. Stress-strain factor
7. Plasticity of equipment
8. Point defects
9. Vibration
10. Photons effect
11. Static and dynamic errors, etc.

While selecting and seizing any instrument for a designed process system, an engineer shall have sufficient knowledge about that process conditions. Deficiencies in knowledge and skill may harm man-machine and production within the system.

Let us see the following case study to understand the involved problem within the infrared moisture measurement sensor.

Case Study

- **Instrument used:** Infrared moisture measurement sensor
- **Application:** Food conveyor
- **Parameter to measure:** Moisture
- **Type of malfunction:** Defined time-varying output
- **Operational principle of instrument:** Water from the body absorbed by the infrared light (same wavelength) measures the moisture present within the body.
- **Malfunctions detail:** Every day at a fixed time, the output of the infrared moisture sensor is erratic and affects the other interlocks of the processing system.
- **RCA (root cause analysis):** After detail fish bone analysis, it was found that the installed position of the sensor comes

indirect contact with the sunlight at a particular period every day. The rays impinge on the sensor face by the small hole from the roof top ventilator.

- The wavelength radiated by the sensor cannot be able to absorb the same wavelength reflected by the body during this defined time-varying period and start malfunction.
- **Corrective steps:** It was noticed that this phenomenon is time varying and automatically got rectified as the sunrays shifted and again on the next day at the same time, it starts to malfunction.
- The position of the infrared moisture sensor shifted to a newly defined position so that there will be no direct hit of sun-rays on the sensor's face.

Moisture calculation formula for foods is shown by Eqn (2):

$$\% \text{ Moisture} = \frac{M_w}{M_s} \times 100 \quad \dots \text{Eqn (2)}$$

M_w = Mass of water (18.0 gm/mole); M_s = Mass of sample

EXERCISES

Short Answer Questions

1. What are the basic requirements for instrumentation system?
2. Explain parallel loops. Is it possible to have both the loops in a single nameplate for instrument identification?
3. How symbols and tables are considered on designed data sheet?
4. What do you understand by point defects on instruments?
5. Explain the system of fishbone analysis.
6. Name the chemical reaction method by which the moisture of low water content food are determined.

Multiple Choice Questions

1. **First engineering code of ethics was developed by:**
 - a. ASCE
 - b. AIME
 - c. AIEE
 - d. All of them

2. **Loop number is done:**
 - a. Parallel
 - b. Serial
 - c. Both
 - d. None
3. **The Tag Number 50-PIC-12Y, here PIC represents:**
 - a. Functional description
 - b. Equipment description
 - c. Process detail
 - d. Optional prefix
4. **360° symbol orientation on drawing are possible, *except*:**
 - a. Loop number
 - b. Tag number
 - c. Both a and d
 - d. Faceplate
5. **Infrared moisture sensor work on:**
 - a. Lambert's law
 - b. Stefan-Boltzmann
 - c. Same wavelength absorptivity
 - d. Karl Fisher's law