

Instrumentation Technology  
INST-1010

**Symbology**  
**Process and Instrumentation Diagrams - P&IP**

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Department of Engineering and Technology

B. Panoutsopoulos      Engineering Physics II      1

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**Today's meeting**

- Call Attendance
- Announcements
  
- Collect Homework
- Give examination
  - Display time clock
- Collect examinations
  
- Previous examination
  - Return
  - Discussion
  
- Introduce topic
  - Provide Handouts
  - Socratic discussion
  - Practice - Problems

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**Today's meeting**

- Call Attendance
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- Introduce topic
  - Provide Handouts
  - Socratic discussion
  - Practice - Problems
  
- Reminder: Obey the rules

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### Themes

- Define P&ID
- Identify various instruments by the shapes of balloons that represent them
- Identify and interpret functional identifiers in balloon symbols
- Describe how tag numbers pertain to an instrumentation loop
- Describe the function of line symbols

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4

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### Themes

- Identify the symbols for various actuators and valves
- Read a simple loop on a P&ID
- Describe the various types of information on a title block

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5

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### Themes

- Process Control
- Variables
- Automation
- Control Elements
- Control Loops
- Common Control Strategies
- Instrumentation
- Instrumentation and Industry
- Training
- Industry and Standards Organizations

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6

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**HISTORICAL INTRODUCTION**

Instrumentation: Process Control 7

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**SIGNALS**

Instrumentation: Process Control 8

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- Discuss Signals

Instrumentation: Process Control 9

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# GENERAL INSTRUMENT SYMBOLS

Instrumentation: Process Control 10

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## Symbols in Control Engineering Signal flow diagrams

- A signal flow diagram is the symbolic representation of the functional interactions in a system.
- The essential components of control systems are represented by means of block diagrams.
- If required, the task represented by a block symbol can be further described by adding a written text.
- However, block diagrams are not suitable for very detailed representations.
- The symbols described below are better suited to represent functional details clearly.

Instrumentation: Process Control 11

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## Symbols in Control Engineering Blocks and lines of action

- The functional relationship between an output signal and an input signal is symbolized by a rectangle (block).
- Input and output signals are represented by lines and their direction of action (input or output) is indicated by arrows.

```
graph LR; Input[General signal (input)] --> Block[ ]; Block --> Output[Temperature (output)];
```

Instrumentation: Process Control 12

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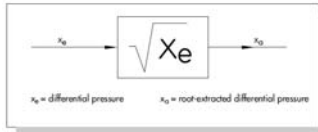
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### Example: Root-extracting a quantity

- Root-extracting a differential pressure signal
- (e.g. flow rate measurement via differential pressure sensors)



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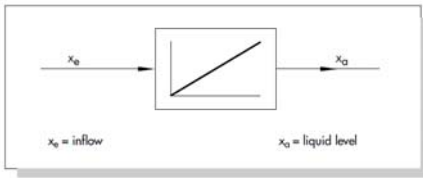
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### Development of a liquid level over time

- Example: Representing dynamic behavior (Fig. 4) (e.g. liquid level in a tank with constant supply)



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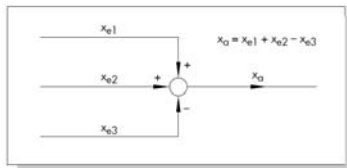
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### Example: Summing point

- The output signal is the algebraic sum of the input signals.
- This is symbolized by the summing point.
- Any number of inputs can be connected to one summing point which is represented by a circle.
- Depending on their sign, the inputs are added or subtracted.



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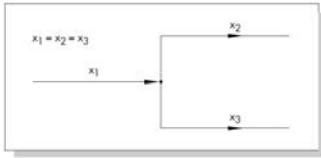
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### Example: Branch point

- A branch point is represented by a point.
- Here, a line of action splits up into two or more lines of action.
- The signal transmitted remains unchanged.



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16

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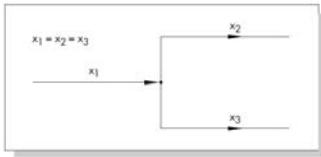
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### Example: Branch point

- The signal transmitted remains unchanged.
- Flow?
- Pressure?



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17

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### Block diagram of manual open loop control

- Example: Signal flow diagram of open loop and closed loop control systems
- The block diagram symbols described above help illustrate the difference between open loop and closed loop control processes clearly.

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18

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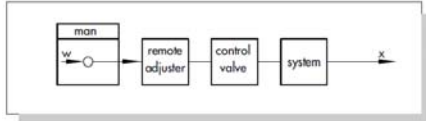
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### Block diagram of manual open loop control

- The operator positions the remote adjuster only with regard to the reference variable  $w$ .
- Adjustment is carried out according to an assignment specification (e.g. a table: set point  $w_1$  = remote adjuster position  $v_1$ ;  $w_2 = v_2$ ; etc.) determined earlier.



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19

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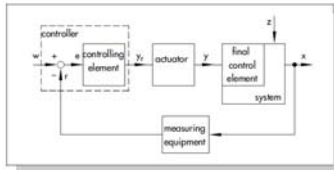
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### Block diagram of manual closed loop control

- In the closed action flow of closed loop control (Fig.), the controlled variable  $x$  is measured and fed back to the controller, in this case man.
- The controller determines whether this variable assumes the desired value of the reference variable  $w$ .



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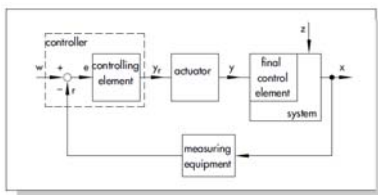
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### Block diagram of manual closed loop control

- When  $x$  and  $w$  differ from each other, the remote adjuster is being adjusted until both variables are equal.



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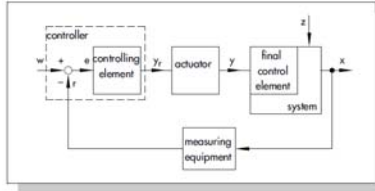
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### Block diagram of a control loop Device-related representation

- Using the symbols and terminology defined above, Fig. shows the typical action diagram of a closed loop control system (abbreviations see page 10)



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### graphical symbols for detailed, solution related representations

- Whenever the technical solution of a process control system shall be pointed out, it is recommended to use graphical symbols in the signal flow diagram (Fig. 10).
- As this representation method concentrates on the devices used to perform certain tasks in a process control system, it is referred to as solution-related representation.
- Such graphical representations make up an essential part of the documentation when it comes to planning, assembling, testing, start-up and maintenance.

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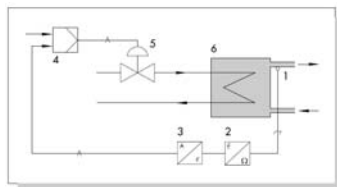
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### Graphical symbols for describing temperature control

- Temperature control of a heat exchanger system*
  - 1 Sensor (temperature)      2 Transmitter
  - 3 Signal converter          4 Controller
  - 5 Pneumatic linear valve    6 Heat exchanger



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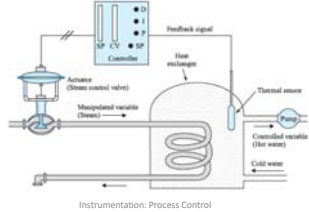
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### Graphical symbols for describing temperature control

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### symbols

- Each unit has its own graphical symbol that is usually standardized.
- Equipment consisting of various units is often represented by several lined-up symbols.

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26

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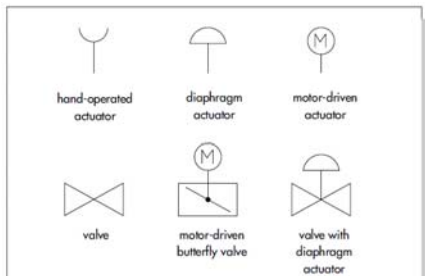
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### symbols



Instrumentation: Process Control

27

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### symbols



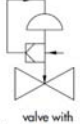
controller  
(former symbol)



controller



PI controller



valve with  
diaphragm actuator  
and attached  
positioner

Instrumentation: Process Control 28

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### Graphical symbols for controllers, control valves and software-based functions

- According to DIN 19227 Part 2
  - functions performed by
  - software are marked
  - with a flag
    - Deutsches Institut für Normung e.V. (DIN;
    - in English, the German Institute for Standardization)



roof-extracting  
element,  
software-based



software counter  
with limit switch

Instrumentation: Process Control 29

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### graphical symbols for process control

- Graphical symbols used for process control are specified in DIN 19227, including symbols for sensors, adapters, controllers, control valves, operating equipment, generators, conduits and accessories (Figs. 11 and 12).
- However, there are a number of other DIN standards covering graphical symbols, such as DIN 1946, DIN 2429, DIN2481, DIN 19239 and DIN 30600 (main standard containing approximately 3500 graphical symbols).
- It is recommended to always use standardized graphical symbols.
- In case a standardized symbol does not exist, you may use your own.

Instrumentation: Process Control 30

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### Graphical symbols used for process control

The diagram illustrates six graphical symbols used in process control:

- Pressure sensor:** A rectangle with 'P' inside, and a circle with 'P' below it.
- Temperature sensor:** A rectangle with 'Pt 100 DIN' and 'T' inside, and a circle with 'T' below it.
- Level sensor:** A rectangle with a horizontal line and 'L' inside, and a circle with 'L' below it.
- Flow sensor:** A rectangle with a vertical line and 'F' inside, and a circle with 'F' below it.
- Analog indicator:** A rectangle with a diagonal line and an arrow pointing to the right.
- Adjuster:** A square with a diagonal line and an arrow pointing to the top-right corner.

Instrumentation: Process Control 31

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### Graphical symbols for sensors, transmitters, adjusters and indicators according to DIN 19227 Part 2

The diagram illustrates three graphical symbols according to DIN 19227 Part 2:

- i/p converter, elect. into pneum. standardized signal:** A square with a diagonal line, 'E' in the top-left triangle, and 'A' in the bottom-right triangle.
- current transmitter with pneumatic standardized output signal:** A square with a diagonal line, 'I' in the top-left triangle, and 'A' in the bottom-right triangle.
- pressure transmitter with electric standardized output signal:** A square with a diagonal line, 'P' in the top-left triangle, and 'E' in the bottom-right triangle.

Instrumentation: Process Control 32

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### Instrumentation and control tags

- According to DIN 19227 Part 1

The diagram illustrates instrumentation and control tags according to DIN 19227 Part 1:

- TI 106:** A circle with 'TI' above and '106' below, connected to a vertical line representing a process stream.
- FRCA 302:** A circle with 'FRCA' above and '302' below, connected to a vertical line representing a process stream.

Instrumentation: Process Control 33

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### instrumentation and control tags

- Instrumentation and control tags
- Apart from the solution-related representation, process control systems can also be represented by means of instrumentation and control tags (DIN 19227 Part 1) which describe the task to be done.
- An instrumentation and control tag is represented by a circle.
- When the circle is divided by an additional line, editing and operating procedures are not carried out on site, but in a centralized control station.
- In the bottom half of the circle, you will find the instrumentation and control tag number.
- The identifying letters in the top half specify the measuring or input variable as well as the type of signal processing, organizational information and the signal flow path.
- If additional space is needed, the circle is elongated to form an oval (Fig. 13).

Instrumentation: Process Control 34

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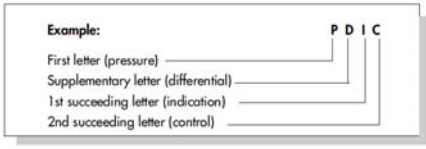
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### identifying letters in an instrumentation

- The typical use of identifying letters in an instrumentation and control tag is shown below:

**Example:**



P D I C  
 First letter (pressure) \_\_\_\_\_  
 Supplementary letter (differential) \_\_\_\_\_  
 1st succeeding letter (indication) \_\_\_\_\_  
 2nd succeeding letter (control) \_\_\_\_\_

Instrumentation: Process Control 35

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### The meaning and the order of the identifying letters are listed in the following

Group 1: Measuring or input variable		Group 2: Processing
First letter	Supplementary letter	Succeeding letter (order: I, R, C, ...any)
A		Fault message, alarm
C		Automatic control
D	Density	
E	Electric quantities	Sensing function
F	Flow rate, throughput	
G	Distance, length, position	
H	Hand (manually initiated)	High limit
I		Indication
K	Time	

Instrumentation: Process Control 36

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The meaning and the order of the identifying letters are listed in the following

<b>K</b>	Time	
<b>L</b>	Level	Low limit
<b>O</b>		Visual signal, yes/no indication
<b>P</b>	Pressure	
<b>Q</b>	Material properties	Integral, sum
<b>R</b>	Radiation	Record or print
<b>S</b>	Speed, rotational speed, frequency	Circuit arrangement, sequence control
<b>T</b>	Temperature	Transmitter function

Instrumentation: Process Control

37

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The meaning and the order of the identifying letters are listed in the following table.

<b>U</b>	Multivariable	
<b>V</b>	Viscosity	Control valve function
<b>W</b>	Velocity, mass	
<b>Y</b>		Calculating function
<b>Z</b>		Emergency interruption, safety device

Instrumentation: Process Control

38

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### instrumentation and control tags

- The two possible methods of graphical representation are compared with each other in the Figs. 14 and 15.
- The device-related representation according to DIN19227 Part 2 (Fig. 15) is in general easily understood.
- Whereas instrumentation and control tags according to DIN19227 Part 1 (Fig. 14) are more suitable for plotting complex systems.

Instrumentation: Process Control

39

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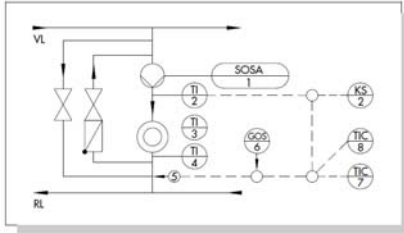
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### Instrumentation and control tags

- Fig. 14: Representation of a control loop according to DIN 19227 Part 1



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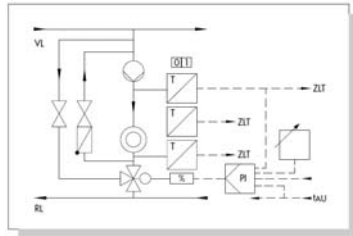
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### Representation of a control loop

- According to DIN 19227 Part 2 device-related symbols



Instrumentation: Process Control 41

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### General instrument or functional symbols

General instruments	Primary location normally accessible to operator	Field-mounted	Auxiliary location normally accessible to operator
Discrete instrument	○	○	○
(a) Shared display, shared control	◻	◻	◻
Computer function	◻	◻	◻
Programmable logic controller	◻	◻	◻
(b) Normally inaccessible or behind-the-panel devices or functions may be depicted by using a dashed horizontal line.	○	◻	◻

Instrumentation: Process Control 42

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**General instrument or functional symbols**

- Individual instruments
- Represented with a balloon
- Circle by itself
- Stand-alone instrument
- Circle in a square
- Shared device

Instrumentation: Process Control 43

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**Tag Numbers**

- Alphanumeric code
- Placed inside each symbol to identify it
- Functional identifiers
- First letter:
  - P, T, F, and L
- Second letter:
  - R, C, and T
- Third and fourth letters
- Example: PDAH

Instrumentation: Process Control 44

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**Tag Numbers**

- List of standard identifiers
- See Table 16-1 in the text
- Loop identifiers
- Located in bottom portion of the symbol
- Loop
- One or more instruments arranged to measure and control a process variable

Instrumentation: Process Control 45

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### Line symbols

-  Instrument Supply
-  Connection to Process
-  Pneumatic Signal
-  Electrical Signal
-  Hydraulic Signal
-  Capillary Tube
-  Electromagnetic or Sonic Signal (Guided)
-  Software Link
-  Mechanical Connection

Instrumentation: Process Control 46

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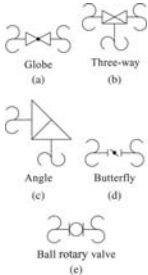
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### Valve and Actuator Symbols

- Control valves
- Linear-motion valves
- Globe
- Three-way
- Angle
- Rotary-motion valves
- Butterfly
- Ball
- Dampers



Instrumentation: Process Control 47

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### Valve and Actuator Symbols

- Flow actuator



Instrumentation: Process Control 48

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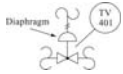
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### Valve and Actuator Symbols

- Pneumatically activated diaphragm symbol



The diagram shows a valve symbol with a diaphragm actuator. The diaphragm is represented by a circle with a vertical line through its center. The valve symbol is a diamond shape with a horizontal line through its center. The diaphragm is connected to the top of the valve. The text "Diaphragm" is written to the left of the diaphragm symbol, and "TV 401" is written inside a circle to the right of the valve symbol.

Instrumentation: Process Control 49

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### Valve and Actuator Symbols

- Identifiers for various actuators



The diagram shows three symbols for actuators: (a) a square with the letter 'S' inside, (b) a circle with the letter 'M' inside, and (c) a diamond shape with a horizontal line through its center.

Instrumentation: Process Control 50

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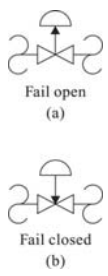
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### Valve and Actuator Symbols

- Symbols that show the failure mode of a valve



The diagram shows two symbols for valve failure modes: (a) "Fail open" and (b) "Fail closed". Both symbols are diamond shapes with a horizontal line through their centers. In (a), the diaphragm is above the valve and has an upward-pointing arrow. In (b), the diaphragm is above the valve and has a downward-pointing arrow.

Instrumentation: Process Control 51

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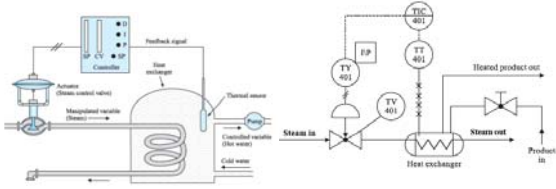
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## Reading a Single Loop

- Six steps
- Control loop (401) for a heat exchanger application



Instrumentation: Process Control

52

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## Information Block

- Includes:
  - Title block
  - Revisions
  - Materials list
  - Notes

Instrumentation: Process Control

53

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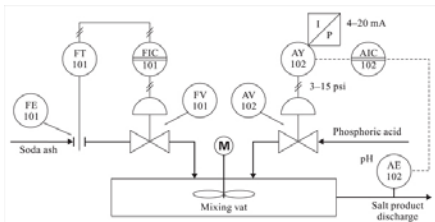
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## Information Block



In loop 101, soda ash flows into the mixing vat. The flow is detected by an orifice flow sensor, which is shown connected directly to the process. It sends a pneumatic feedback signal to a flow/indicator/controller mounted behind the panel. FIC 101 sends a pneumatic signal to a diaphragm that controls the valve that regulates flow.

In loop 102, an analyzer sensor that monitors pH sends an electrical signal to an indicator/controller. An analyzer transducer converts the electrical signal from the controller to pressure, which causes a diaphragm to change the valve that controls the flow of phosphoric acid.

Instrumentation: Process Control

54

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### The title block

ACME PROCESS CORP.	
MIXING SYSTEM #1	
DRAWN BY:	DATE
CHECKED BY:	DATE
APPROVED BY:	DATE
SHEET NO.	DRAWING NO.
1 of 1	3250-7A

Instrumentation: Process Control

55

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### Revisions

REVISIONS					
REV #	DATE	DESCRIPTION	BY	CH'K	APRV

(a)

Instrumentation: Process Control

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### Material list

MATERIAL LIST			
TAG #	MANUFACTURER	MODEL	PART #
TV-302	FISHER	513RP	61121-41
PV-309	MASONEILAN	47-21134	54378-39
FIC-301	FOXBORO	130M	22447-12
PT-309	FISHER	4157	61247-33
TT-302	FOXBORO	45P-F2	22336-19
LV-305	FISHER	667F7	62458-20
PIC-308	MOORE	528M	14436-38
TIC-302	MOORE	528M	14436-38
LIC-305	FOXBORO	130M	22447-12
LT-305	TAYLOR	4807A	43741-80
LT-307	TAYLOR	4807A	43741-80
FV-308	MASONEILAN	48211-35	54267-37

(b)

Instrumentation: Process Control

57

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**SYNOPSIS**

Instrumentation: Process Control 58

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•The ISA has developed standard symbols and nomenclature used in instrumentation diagrams.

**Instrument Symbols and Numbers**

**Tags**

L	Measured Variable (Level)
LT	Functional Identification (Level Transmitter)
08	Loop Number
LT 08	Complete Instrument Tag

Note: Hyphens may be used as separators

**Typical Combinations**

LC	Level Controller (Blind)
LIC	Level Indicating Controller
LRC	Level Recording Controller
LI	Level Indicator
LT	Level Transmitter
LV	Level Valve

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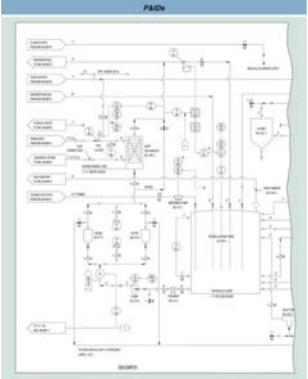
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•Piping and instrumentation diagrams contain information about the instruments being used as well as the equipment employed.



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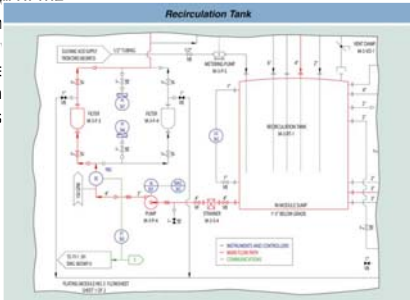
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•A detail view of the recirculation drawing showing the instruments related to the pumping system




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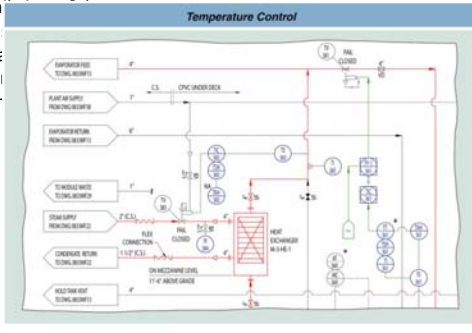
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•A detail view of the temperature control drawing showing the instruments related to the transfer control




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**APPENDIX:**

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Instrumentation: Process Control

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