Setting the Standard for Automation™

Troubleshooting Instrumentation & Control Systems

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International Society of Automation

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Reasons for Troubleshooting

- Something not functioning properly
- You don't know what's wrong
- Equipment down or product out of specifications
- Isolate problems between the equipment and the process

Purpose of Troubleshooting

- Maintain Safety of Personnel and Plant Equipment
- Identify the problem
- Minimize down time
- Improve plant efficiency
- Improve product quality

Bottom Line Goals

- No unscheduled downtime
- Product running at specifications
- All instruments, controls, etc. are operating properly
- Reduce maintenance cost
- Minimize troubleshooting time
- Improve employee efficiency

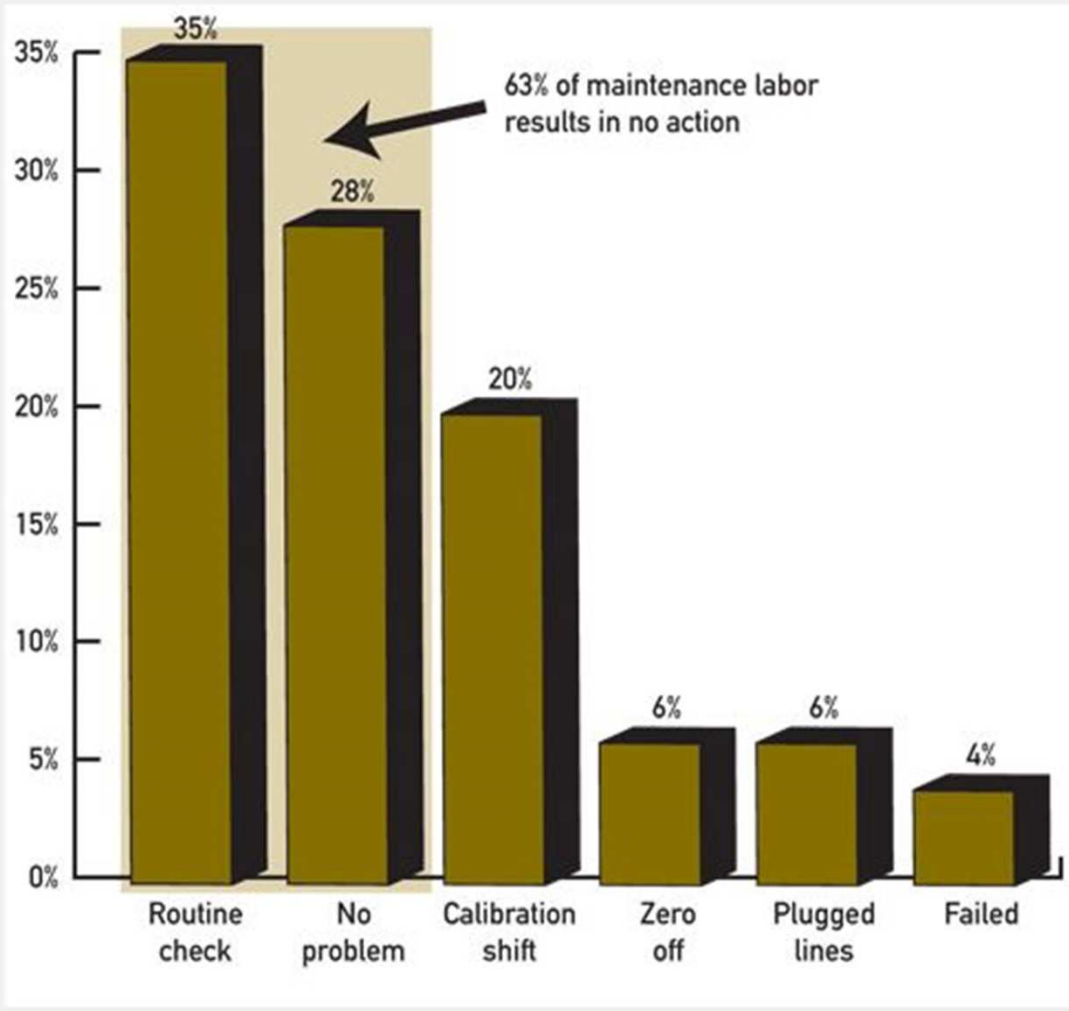
Bottom Line Goals - Impact Statement

- The global process industry loses $20 billion, or five percent of annual production, due to unscheduled downtime and poor quality.*
- ARC estimates that almost 80 percent of these losses are preventable and 40 percent are primarily the result of the operator or human in the loop. *
- ARC estimates unplanned downtime accounts for the equivalent of 20% of all production in the process industries. A single unplanned shutdown can wipe out your plant profit for the year. **

* 2009 Fieldbus Foundation - FFIEUC-Mumbai Conference

** NAMUR NE 107 recommendations come to the United States – Larry O'Brian

Wasted Effort



Wasted Effort

Figure 1. End users estimate that more than half of maintenance activities result in no action. Predictive diagnostics can help users develop a proactive maintenance strategy that avoids unnecessary trips to the field for routine scheduled maintenance.

What Are You Expected to Troubleshoot?

- Process
- Loop
- Device
- Discrete components
- Pneumatic equipment
- Electronic equipment
- Digital systems
- Networks
- Analytical systems
- Computers
- Board or module
- Process equipment
- Operation procedures

Skills Beneficial for Troubleshooting

- Certain skills can be helpful in troubleshooting
  - Logical or methodical approach
  - Ability to learn from past experiences
  - Curiosity
  - Patience
  - Self-motivated
  - Knowledge of information location
  - Use of computer based information
    - Drawings
    - Spare parts

Troubleshooting Skills Dependent On

- Your level of expertise
- Familiarity with your instrumentation or equipment
- What test equipment you have & familiarity with it
- Your company's philosophy
- Access to information resources
- What parts you have available (for repair)
- What time frame you have

Steps to Logical Analysis Troubleshooting

- Whatever troubleshooting method is used, a logical approach should be taken to identify and repair a problem
  - Verify that something is wrong
  - Identify and locate the problem
  - Fix the problem
  - Verify the problem is fixed
  - Follow-up to prevent future problems

Verify That Something is Wrong

- Ask the operator
- Observe for yourself
- Is the process being operated under normal conditions and productions rates
- Begin with and test with the assumption that the instrumentation and controls are not the problem
- Familiarize yourself with the loop
- Make sure you understand how the controls are supposed to function when operating properly
- Make sure you understand the associated equipment and how it can influence the operation of the suspect equipment

Identify and Locate the Problem

- Confirm whether the instrumentation and control or something else is causing the problem
  - Make the easiest checks first
  - Can the desired control be achieved with the control loop in manual?
  - Could the measuring instrument be correct and actually showing that something has changed in the process?
  - Isolate the problem to the instrumentation and controls or to something else (process, equipment, etc.)
  - Inform Production of the steps that you are taking that could cause an upset, alarm, etc.
  - Work to isolate the source of the problem using one of 3 methods
    - History
    - Input/Output
      - Series
      - Divide and Conquer
- Develop a plan for how to proceed to locate and confirm cause

Fix the Problem

- Once you feel the problem has been isolated, develop a plan to repair the problem
- Inform Production of your repair plan
- Repair or recommend the repair of the problem
- Follow production area safety procedures and manufacturer specifications and procedures during repair
- Communicate closely with Production

Verify that the Problem Is Fixed

- Confirm that all repaired and associated parts of the system operate correctly, including
  - Measurements
  - Control
  - Alarms
  - Interlocks

- Confirm that the Operator is satisfied with the performance of the repaired system and understands how it is to operate under all conditions

Follow Up to Minimize Future Problems

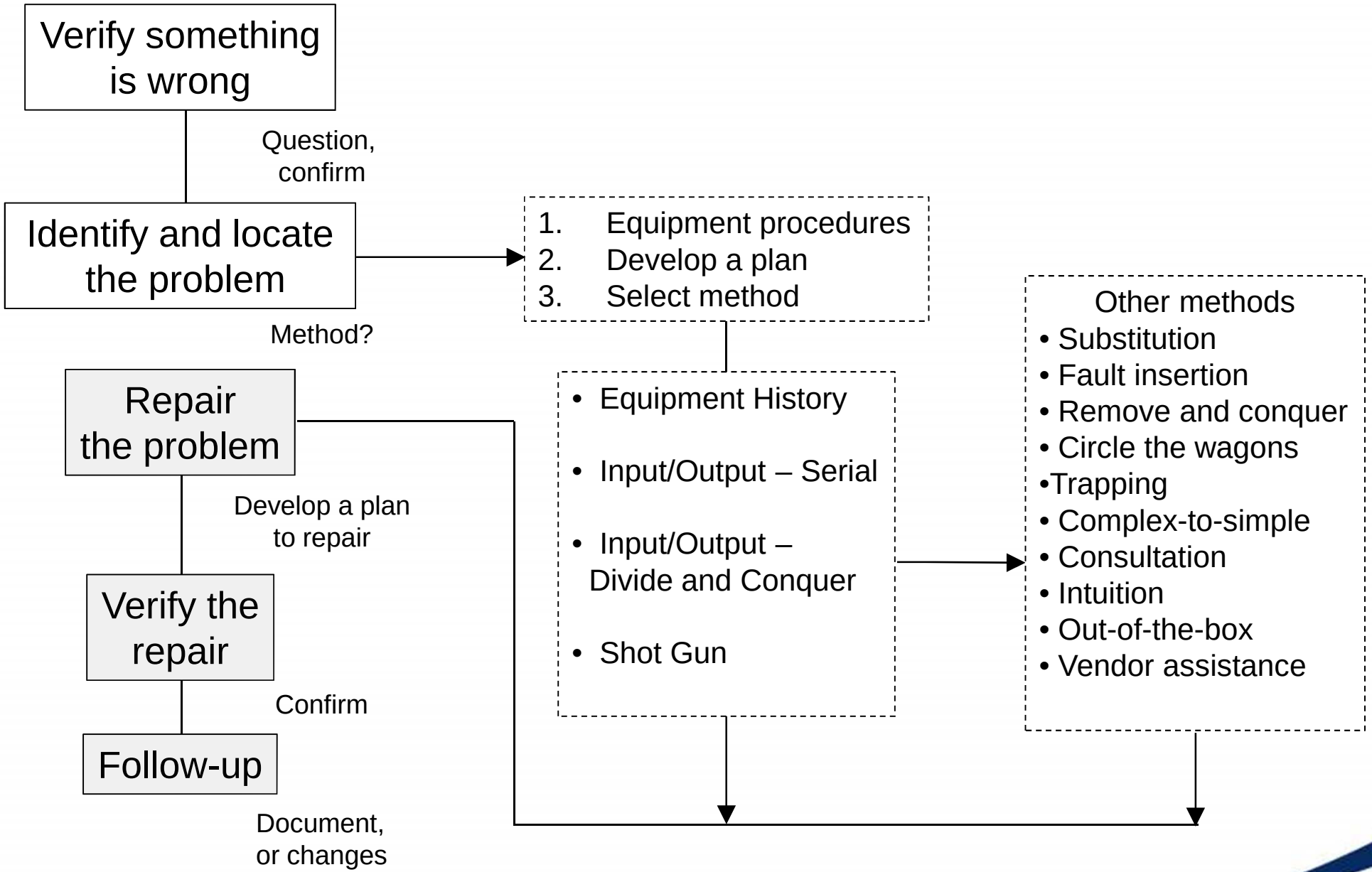
- Document in history file
- Suggest changes, if needed
- Upgrade PM program
- Submit changes to update all documentation (As built)

Documentation for Troubleshooting

- Current documentation is as important a troubleshooting tool as any test equipment or other tools

  - Process & Instrument Diagrams – P&ID
  - Instrument loop diagram
  - Instrument maintenance records
  - Instrument specifications and manuals
  - Electrical – motor control schematics
  - Interlock and alarm information
  - System drawing
  - Operational logs/procedures and data

Troubleshooting Framework Review



Pneumatic Test Equipment

Dead Weight Tester

Calibration Gauge

Pressure Gauge

Dead Weight Tester
Electronic

Calibration Pump

Calibration Kit

Pressure Module

Pressure
Calibrator/Recorder

Electronic Test Equipment

DVM
(True RMS)

Process Calibrator

mA Clamp Meter

HART Hand Held

Process Calibrator
Low Cost

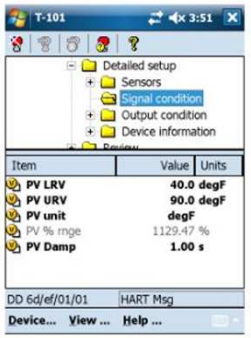
Pressure
Calibrator

IR Temp

Torque Screwdriver

Dry Blocks

HART USB Modem



HART – Smartphone
+ blue tooth

Digital Test Equipment

RJ-45 Tester/Wire Mapper

Fieldbus Monitor

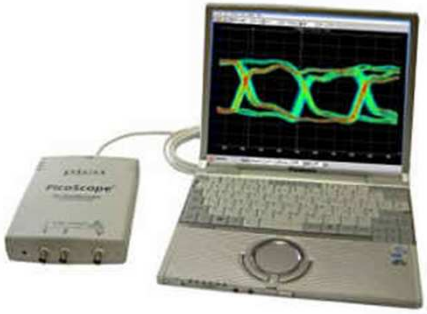
Profibus PA Monitor

Wiring Validator

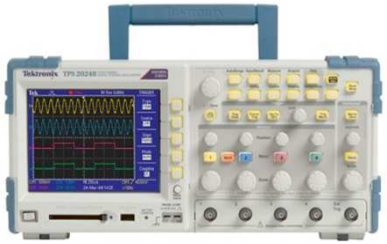
LAN Trouble Shooter

Wireless Kit

ProfiTrace Analyzer



Wire Mapper – Cable Tester



Digital/Storage Scopes

Old Smart Phones

WhatsApp
Skype
You Tube

Bar Code Scanner
Bubble Level
Strobe Light
Sound Meter
Red Laser
Camera
Flash Light

Quick Office
EsFile Explorer
Wifi File Explorer
Notes
Cam-Scanner
Convert Pad
Math Calculators
Ohms Law Calculator
Instrument Range Calculator
RTD/TC Calculators

E&H Instrument Lookup
HART Calibrators
Loop Tuners

Google Drive

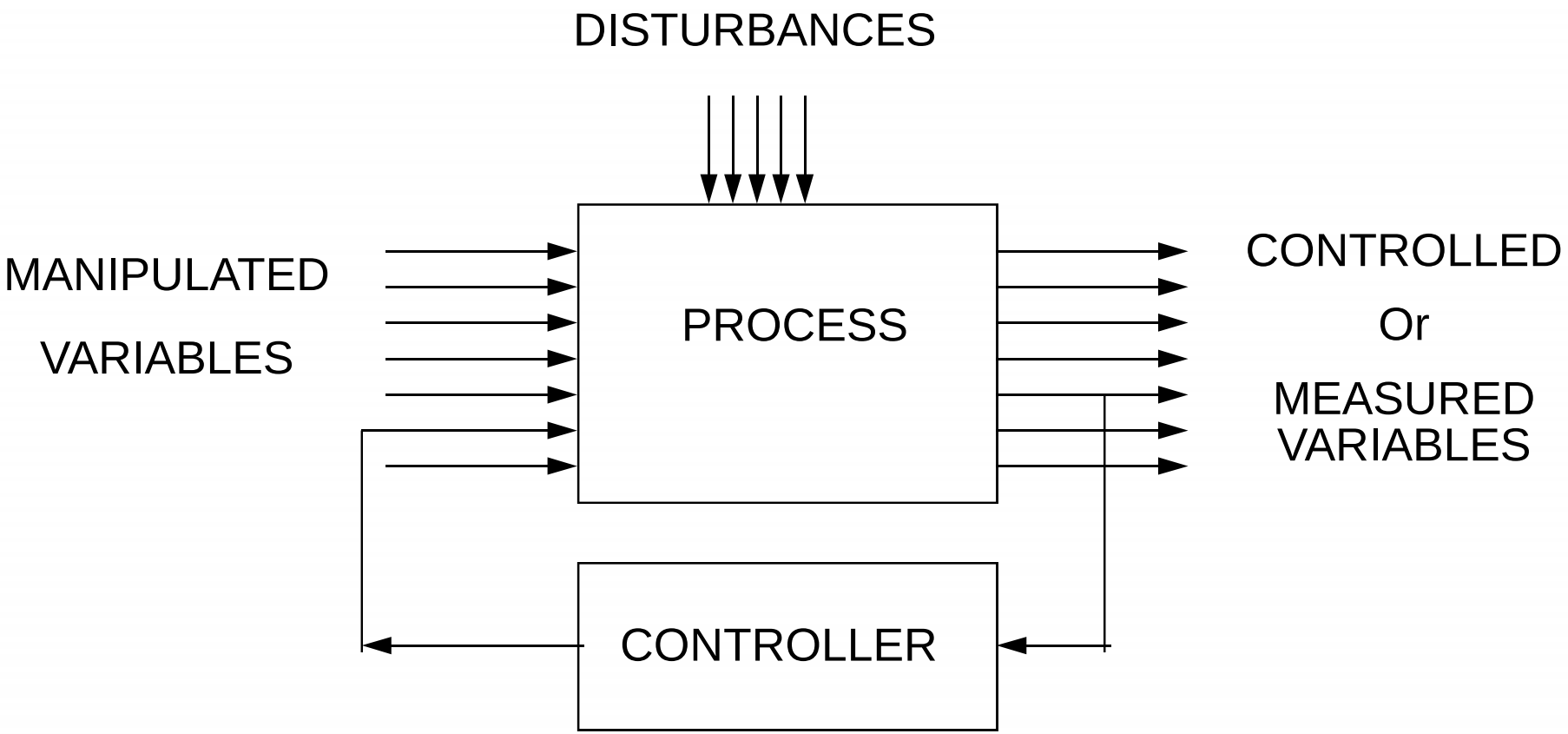
Box.com

PdaNet

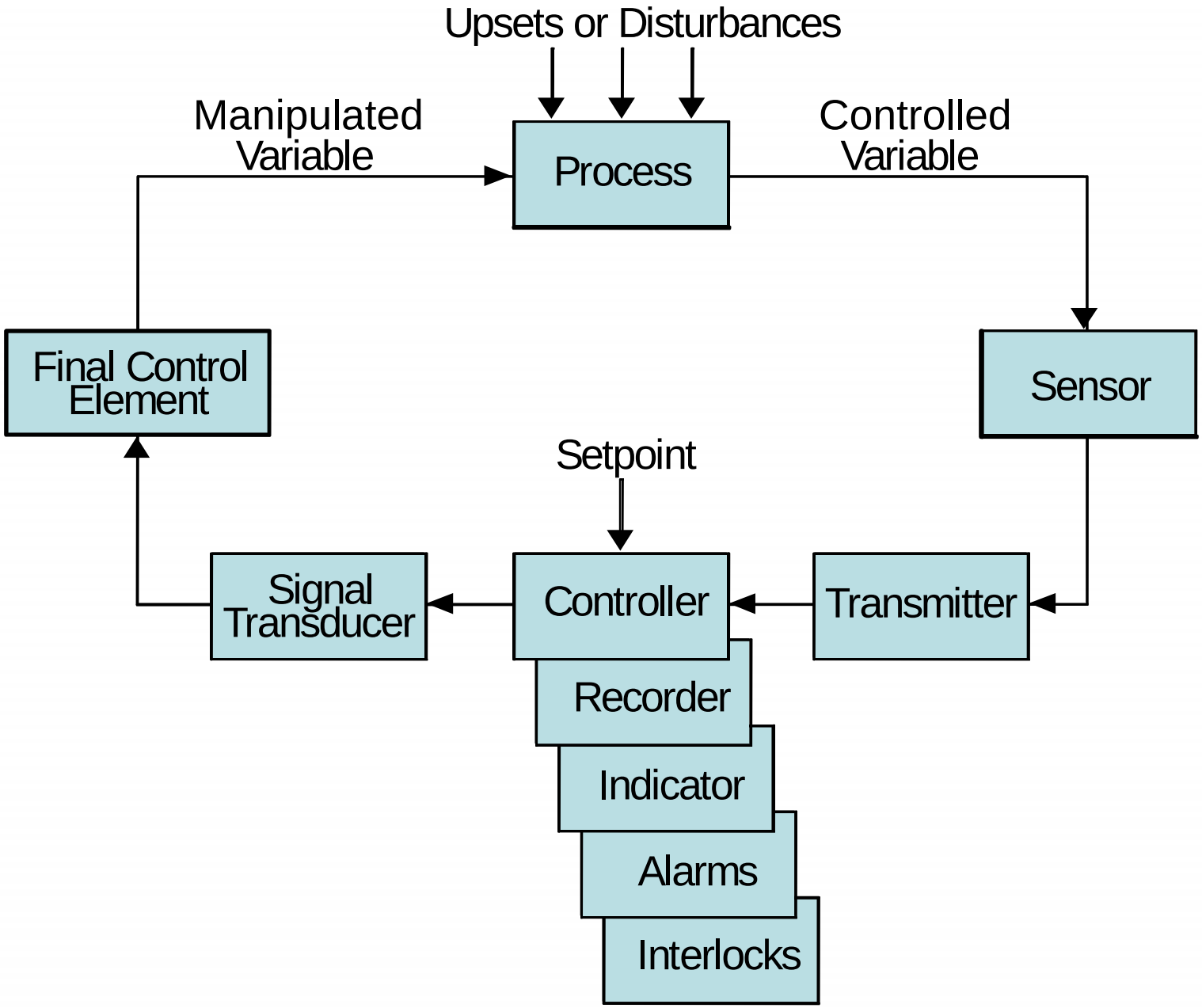
Pictures
Instruction Books
Notes
Books

Process Control

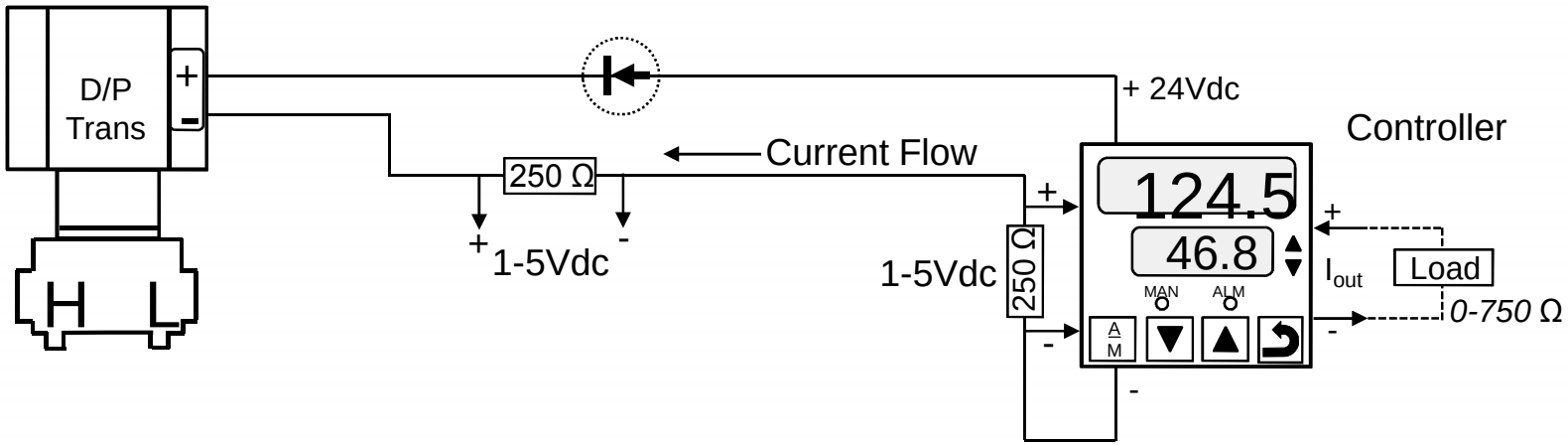
- The ***regulation or manipulation of variables*** influencing the conduct of a process in such a way as to obtain a product of desired quality and quantity in an efficient manner

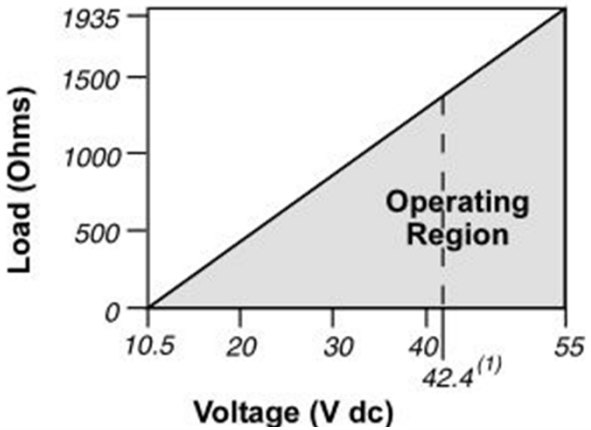


Instruments in a Feedback Control Loop



Current Loop Characteristics





Standard Signal Values (250 ohm)

4mA = 1 vDC = 0%
8mA = 2 vDC = 25%
12mA = 3 vDC = 50%
16mA = 4 vDC = 75%
20 mA= 5 vDC = 100%

Other Current Loop Characteristics

Comparison of Voltages at Load and Transmitter (PS = 24vDC)									
%	mA	R_{load} = 250 Ω	Tx V	R_{load} = 100 Ω	Tx V	R_{load} = 62 Ω	Tx V	R_{load} = 5 Ω	Tx V
100	20.0	5v	19v	2v	22v	1.24v	22.76v	0.1v	23.9v
75	16.0	4v	20v	1.6v	22.4v	0.992v	23.00v	0.08v	23.92v
50	12.0	3v	21v	1.2v	22.8v	0.744v	23.26v	0.06v	23.94v
25	8.0	2v	22v	0.8v	23.2v	0.496v	23.5v	0.04v	23.96v
0	4.0	1v	23v	0.4v	23.6v	0.248v	23.75v	0.02v	23.98v

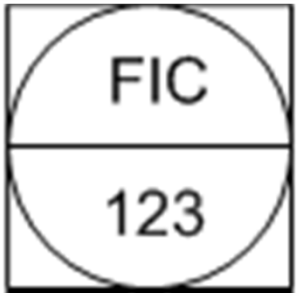
NAMUR Standard NE-43		
>22.0 mA	Wiring Problem (short)	
20.5 – 22.0 mA	Transmitter Failure	
20.0 – 20.5 mA	Normal Over Range	
4.0 – 20.0 mA	Normal Operation	
3.8 – 4.0 mA	Normal Under Range	
3.6 – 3.8 mA	Transmitter Failure	
0 – 3.6 mA	Wiring Problem (open)	

Instrument Symbols & Identification

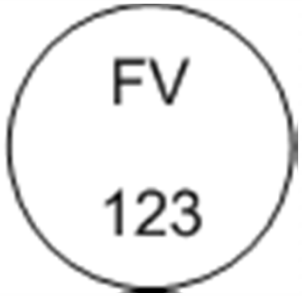
- Functional identification
- Instrument numbering
- Functional locations
- Signal transmission
- Measuring element symbols
- Final control element symbols
- Example P&ID

Example – Balloons and Tags

Flow
Transmitter
In Field



Flow
Controller
In BPCS



Flow
Valve
In Field

Instrument to Instrument Connection Symbols

INSTRUMENT SUPPLY OR CONNECTION TO PROCESS

UNDEFINED SIGNAL

PNEUMATIC SIGNAL

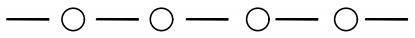
ELECTRONIC SIGNAL

HYDRAULIC SIGNAL

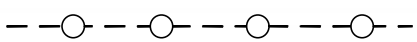
CAPILLARY TUBE

ELECTROMAGNETIC SIGNAL (GUIDED)

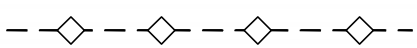
ELECTROMAGNETIC (WIRELESS) SIGNAL (UNGUIDED)



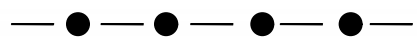
COMMUNICATIONS LINK – BETWEEN SYSTEM DEVICES



COMMUNICATIONS LINK – TO/FROM SMART (HART) DEVICE



COMMUNICATIONS LINK – TO/FROM INTELLIGENT (FIELDBUS) DEVICE



COMMUNICATIONS LINK – BETWEEN TWO SYSTEMS (e.g. DCS and SIS)

Refer to ISA5.1 Table 5.3.2 for additional symbols

Flow Measuring Element Symbols

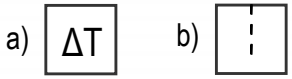

Orifice plate or restriction orifice


Pitot tube


Turbine flowmeter


Vortex shedding flowmeter

Magnetic flowmeter



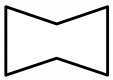
Thermal mass flowmeter


Positive displacement flowmeter


Cone flowmeter

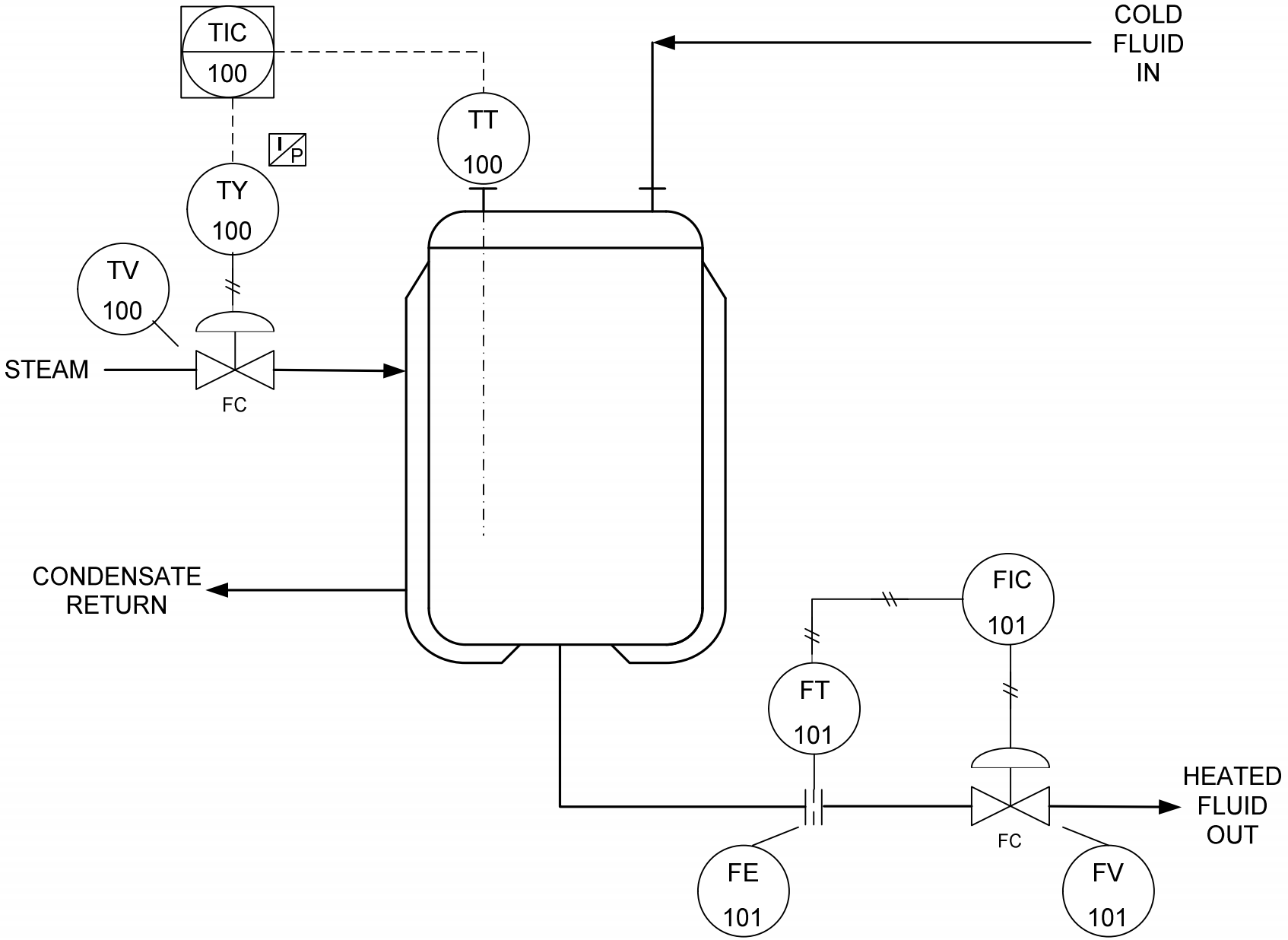

Coriolis mass flowmeter


Sonic flowmeter

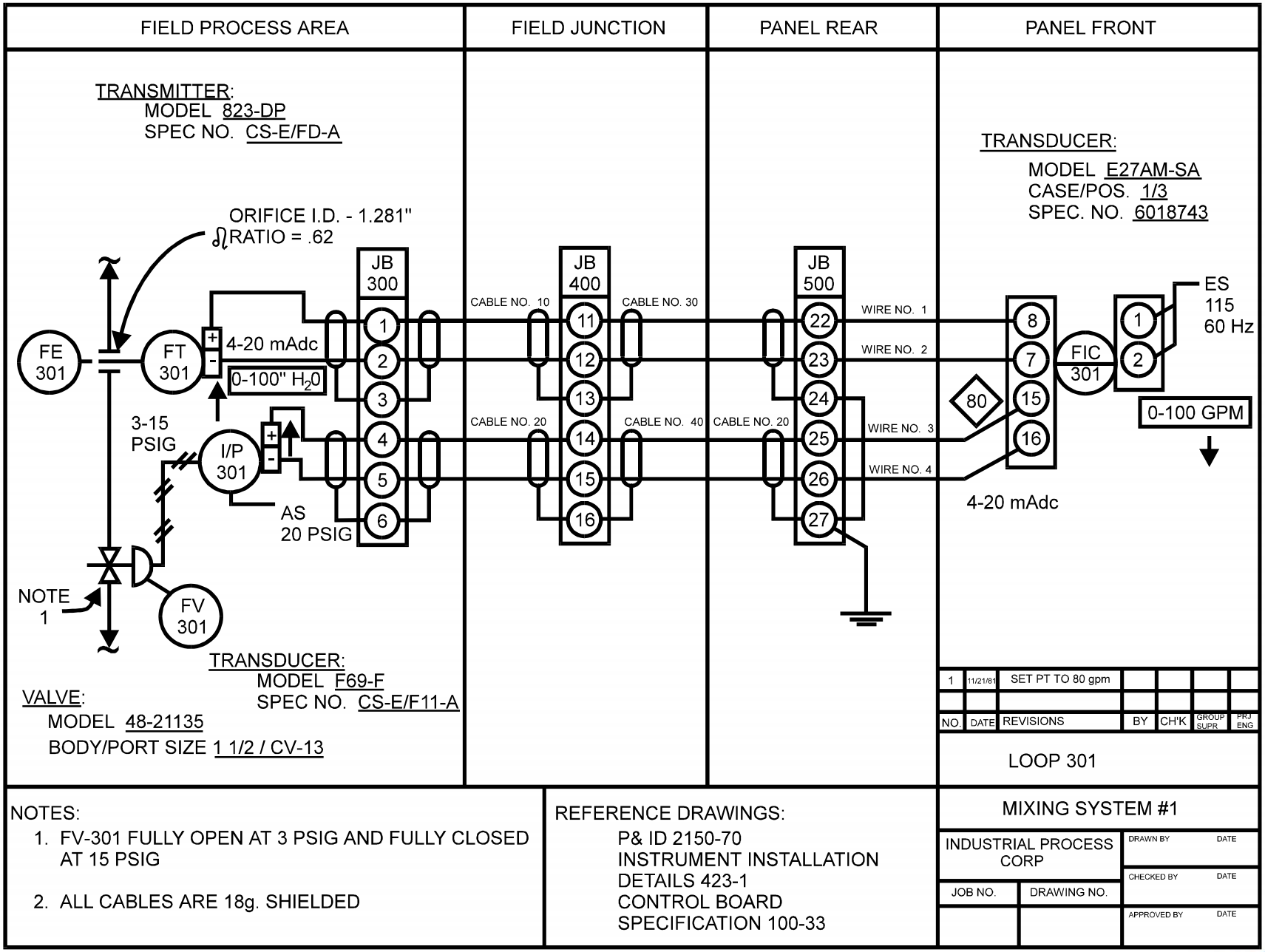

Open channel flume

Refer to ISA5.1 Table 5.2.3 for additional symbols

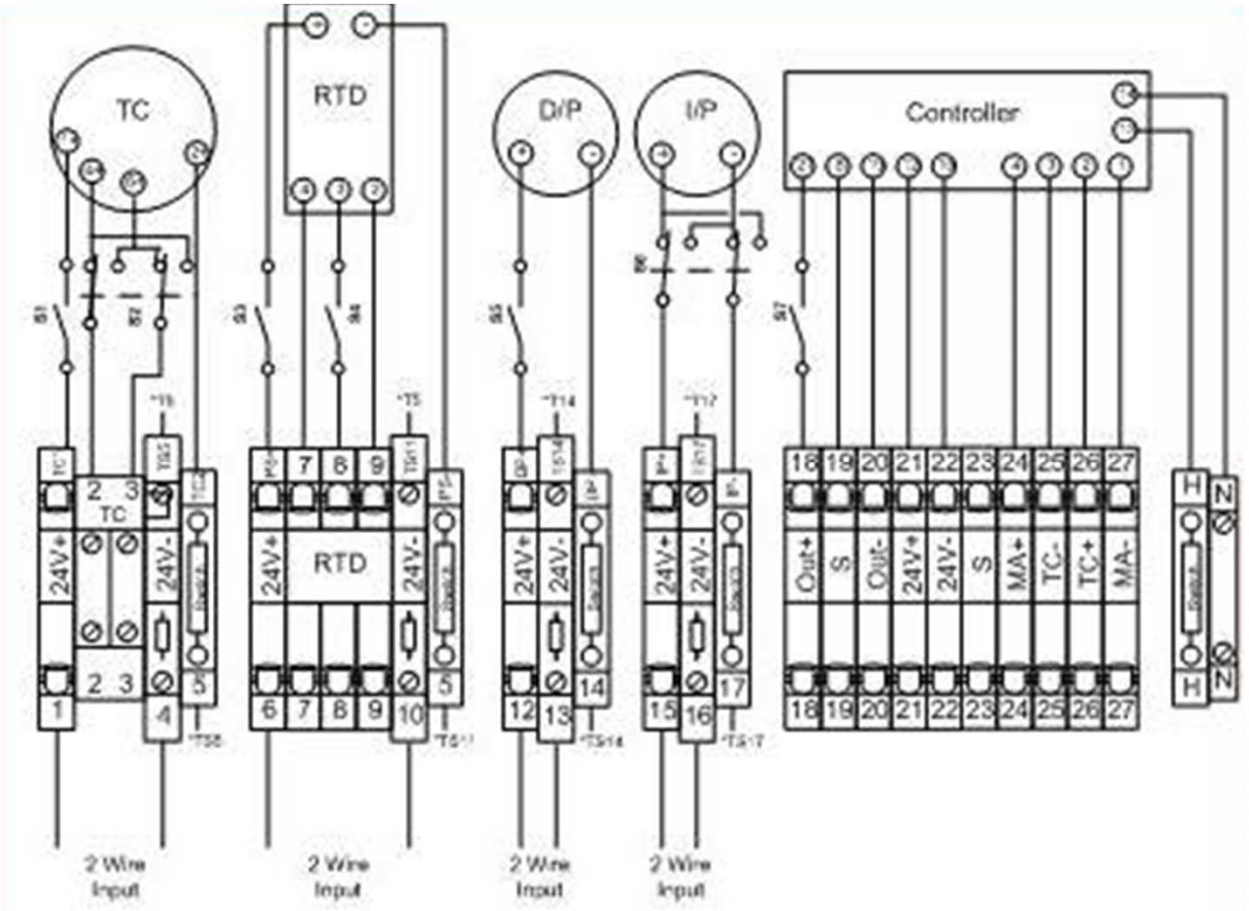
Piping & Instrumentation Drawing (P&ID)



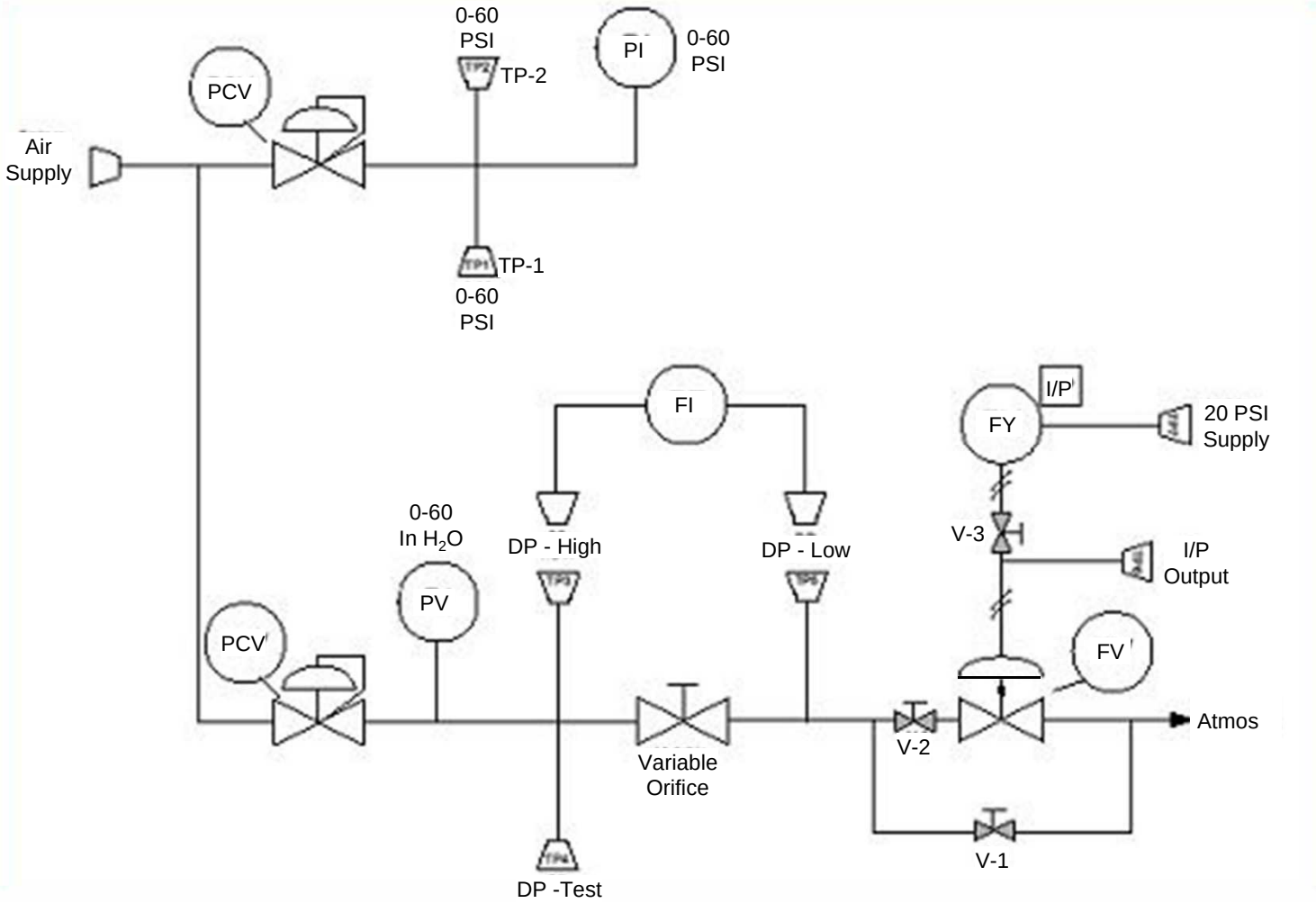
Example Loop Diagram



Portable Training Lab



Portable Training Lab – Instrument Air Diagram



Troubleshooting Safety

- Electrical hazards
- Compressed air hazards
- Test equipment
- Working with energized (“live”) equipment

HART Systems Review

- Highway addressable remote transducer
- A “hybrid” analog/digital technology
- An instrument’s primary variable is transmitted via 4-20ma
- A de facto standard for field communication
- Communication is modulated as an AC signal superimposed onto the 4-20mA signal
- Uses frequency shift keying (FSK)
- Utilizes a device description (DD) language
- Enables asset management

HART COMMANDS : OVERVIEW

Universal	Common Practice	Device Specific
Read device type	Read dynamic variables	Read /write low-flow cut-off
Read PV and units	Write damping time constant	Start, stop or clear totalizer
Read current output and percent of range	Write device range value	R/W density calibration factor
Read predefined dynamic variables	Calibrate (set zero, set span)	Choose PV (mass, flow, or density)
R/W tag, descriptor, date	Set fixed output current	R/W materials or construction information
R/W 32 character message	Perform self-test	Trim sensor calibration
Read range values, units, and damping time constant	Perform master reset	PID enable
R/W final assembly number	Trim PV, zero	Write PID set point
Write polling address	Write PV unit	Valve characterization
	Trim DAC zero and gain	Valve set point
	Write transfer function (square root/linear)	Travel limits
	Write sensor serial number	User units
	R/W dynamic variable assignments	Local display information

(Note: this is a partial list of HART commands)

DCS – Troubleshooting Features

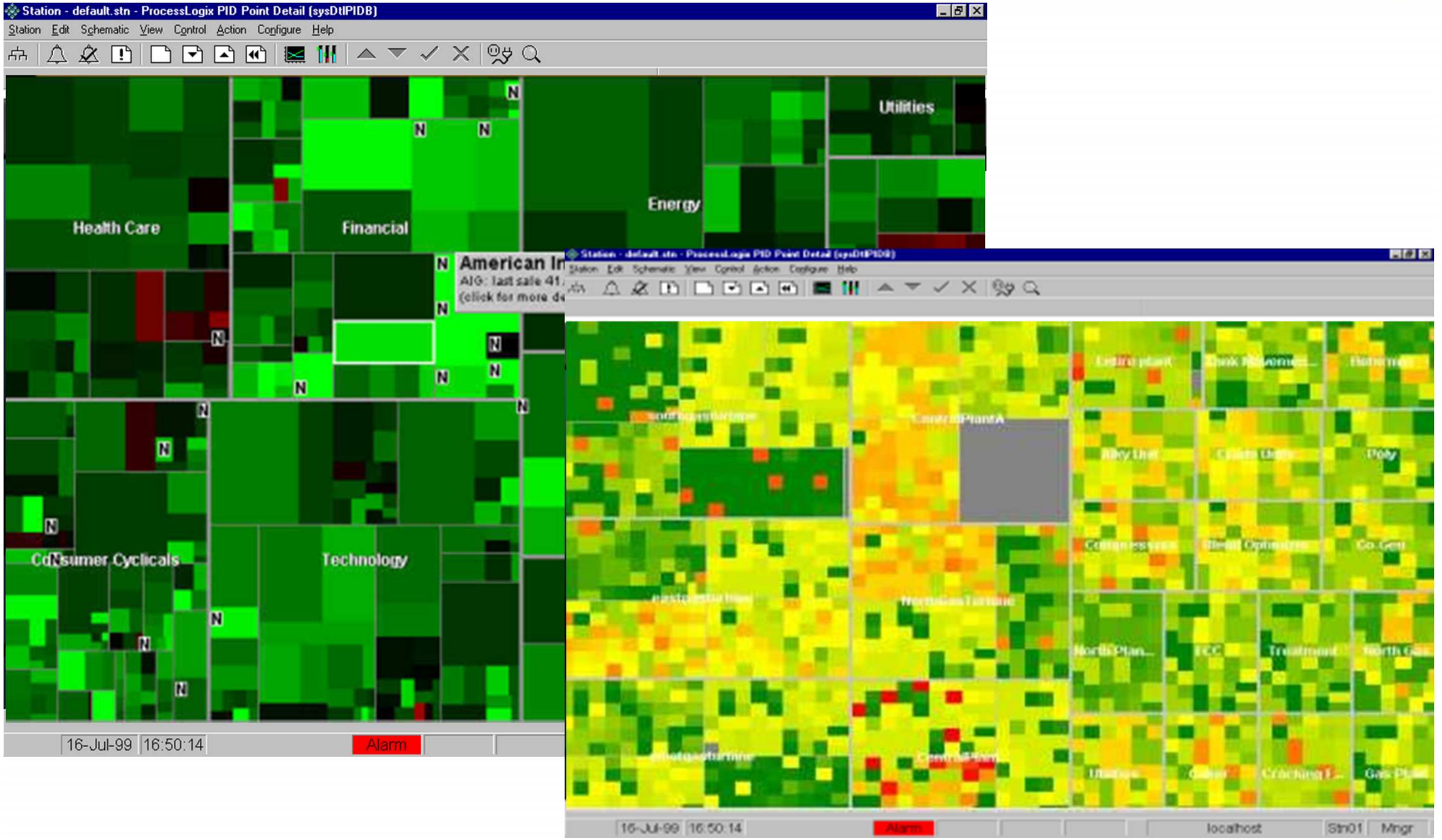
- Process graphic display
- Loop display and Detailed Loop Displays
- Real time trends and Historical Data Collection
- Alarms and alarm summary
- Event logger
- Operator action journal
- Sequence of events
- System management
- Sequence Of Events
- Function block details
- Control strategy configuration
- Intelligent field device configuration
- Change management

NAMUR – NE 107

- Requirements regarding self-monitoring and diagnosis in field instrumentation and classification of diagnostic events
- Provides improved operator, engineering and asset management

Device Status	Condition	Output Status	HMI Color Status
Device OK	Normal	Valid output signal	Green
Comm OK	Normal	Valid output signal	Green
Maintenance Required	Maintenance Required	Output signal is still valid	Blue
Warning Maint Required	Maintenance Required	Output signal is still valid	Blue
Maintenance Mode	Out of Specification	Output signal out of the specified range	Yellow
Simulation Mode	Function Check	Temporary non-valid output signal	Orange
Error	Failure	Non-valid output signal	Red
Config Error	Failure	Non-valid output signal	Red
Comm Error	Failure	Non-valid output signal	Red
Process Error	Failure	Non-valid output signal	Red

Tree Maps



Alarms & TreeMapping