

Instrumentation & Process Control

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Five Processes to Control

T_____

P_____

F_____

L_____

C_____

Five Processes to Control

Temperature

P_____

F_____

L_____

C_____

Five Processes to Control

Temperature

Pressure

F_____

L_____

C_____

Five Processes to Control

Temperature

Pressure

Flow

L_____

C_____

Five Processes to Control

Temperature

Pressure

Flow

Level

C_____

Five Processes to Control

Temperature

Pressure

Flow

Level

Composition

Composition (Analytical Transmitter - AT)

- pH
- DO
- Chlorine
- ORP
- Ammonia
- TOC
- COD
- BOD
- Phosphorus
- Carbon Monoxide
- Carbon Dioxide
- Conductivity
- Oxygen
- LEL
- Any other chemical or biological process measurements

Ron Janssen will discuss the analytical controls and how they relate to the waste water treatment process and some of the control schemes we use.

I will discuss general details of the remaining four processes, Temperature, Pressure, Flow, and Level

A classic example of these processes in every day life



Fuel
Level

Engine
Temperature

Flow
(Speed)

Oil Pressure

A typical example of a PID control loop that everyone can understand is cruise control.

- Gas pedal says where it needs to be on a flat surface.
- When you start to go up a hill the gas pedal goes down to maintain the speed set point.
- When you start to go down hill the gas pedal backs off to try and maintain the speed set point.

Temperature (TT)

- Sensors
 - RTD (resistance thermal detector)
 - Thermocouple (mVolt)

- Engineering Units
 - Celsius
 - Fahrenheit

Pressure (PT)

Three references for pressure

- Gauge Pressure or Atmospheric Pressure
0 psig
- Absolute Pressure or Perfect Vacuum
 $14.7 \text{ psia} = 0 \text{ psig}$
- Differential Pressure (Usually “H2O)

Pressure Engineering Units

- PSI or PSIG
- PSIA
- PSID
- “H₂O or IWC
- mm H₂O
- Feet Water Column
- “Hg (mercury)
- Kilo Pascal's (KPA)
- Meters Water Column (M)
- Many others

Flow (FT)

- Most flow (mag or turbine) transmitters measure velocity

Inch / second

- Multiply by pipe area (inch²)

$\text{Inch / Sec} * \text{inch}^2 = \text{inch}^3 / \text{sec}$

- Convert

$231 \text{ inch}^3 = 1 \text{ gallon}$

$60 \text{ sec} = 1 \text{ minute}$

**Transmitters are identified by
the Process they Measure,
NOT their Principle of
Operation.**

Flow (FT)

A Differential Pressure transmitter used to measure Flow is identified as a Flow Transmitter (FT).



Level (LT)

Pressure (weight) of liquid column.

- A pressure transmitter used to measure the process of level is identified as a Level Transmitter (LT)

Pressure Sensing Level (LT)



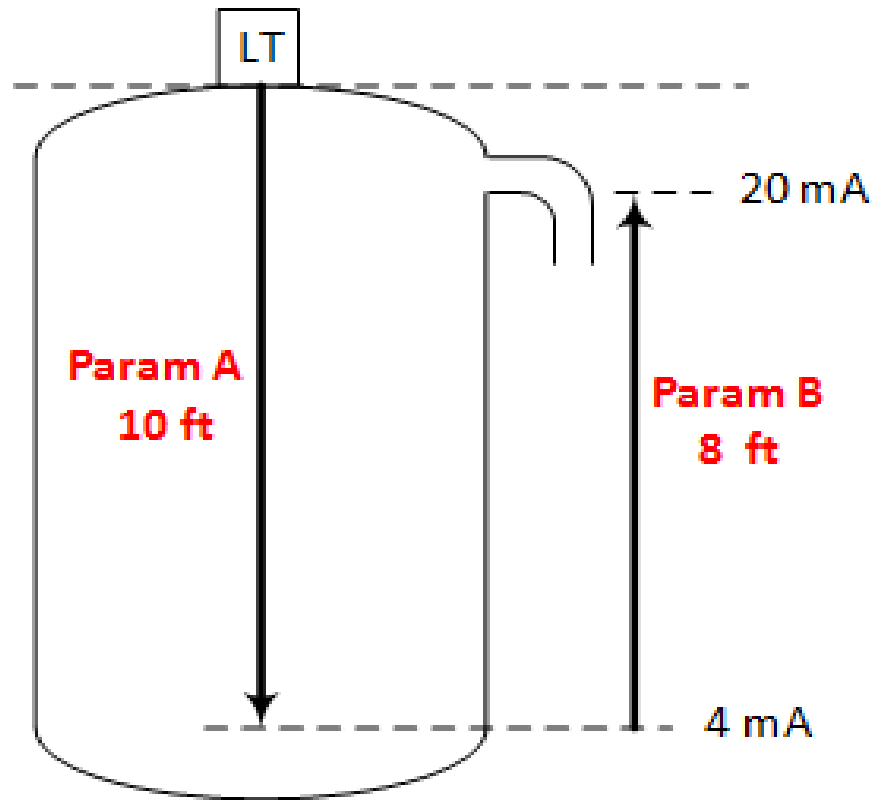
Level (LT)

Ultrasonic / Radar Level Measurement

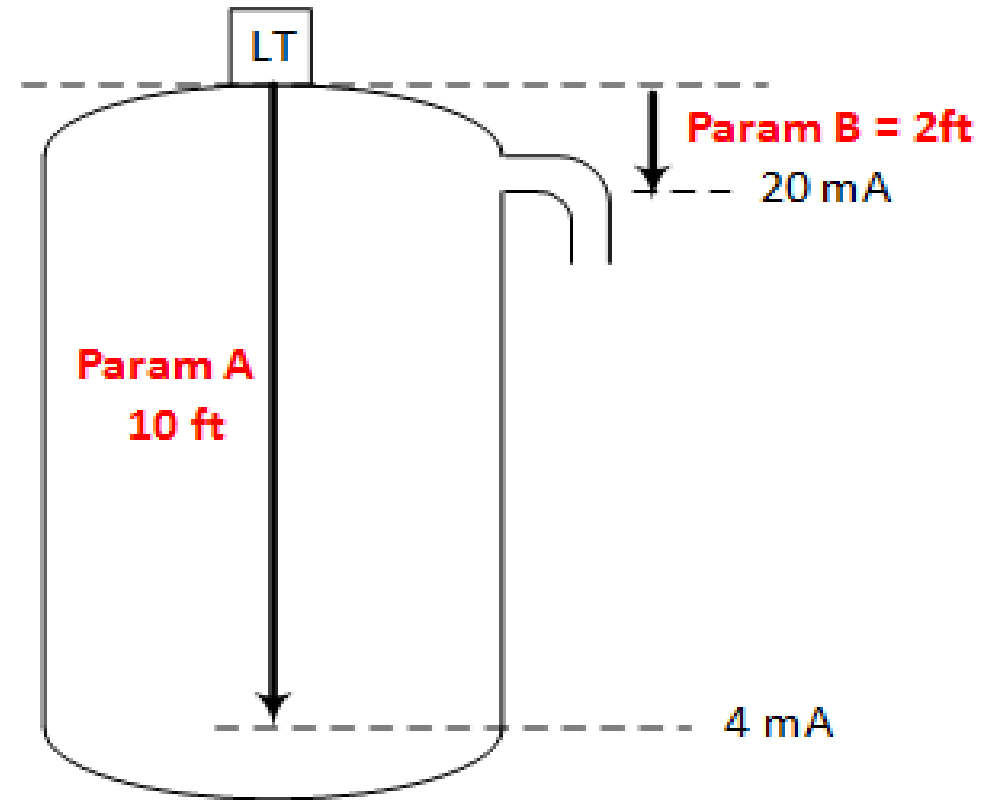
- Configurations depend on manufacturers specifications.

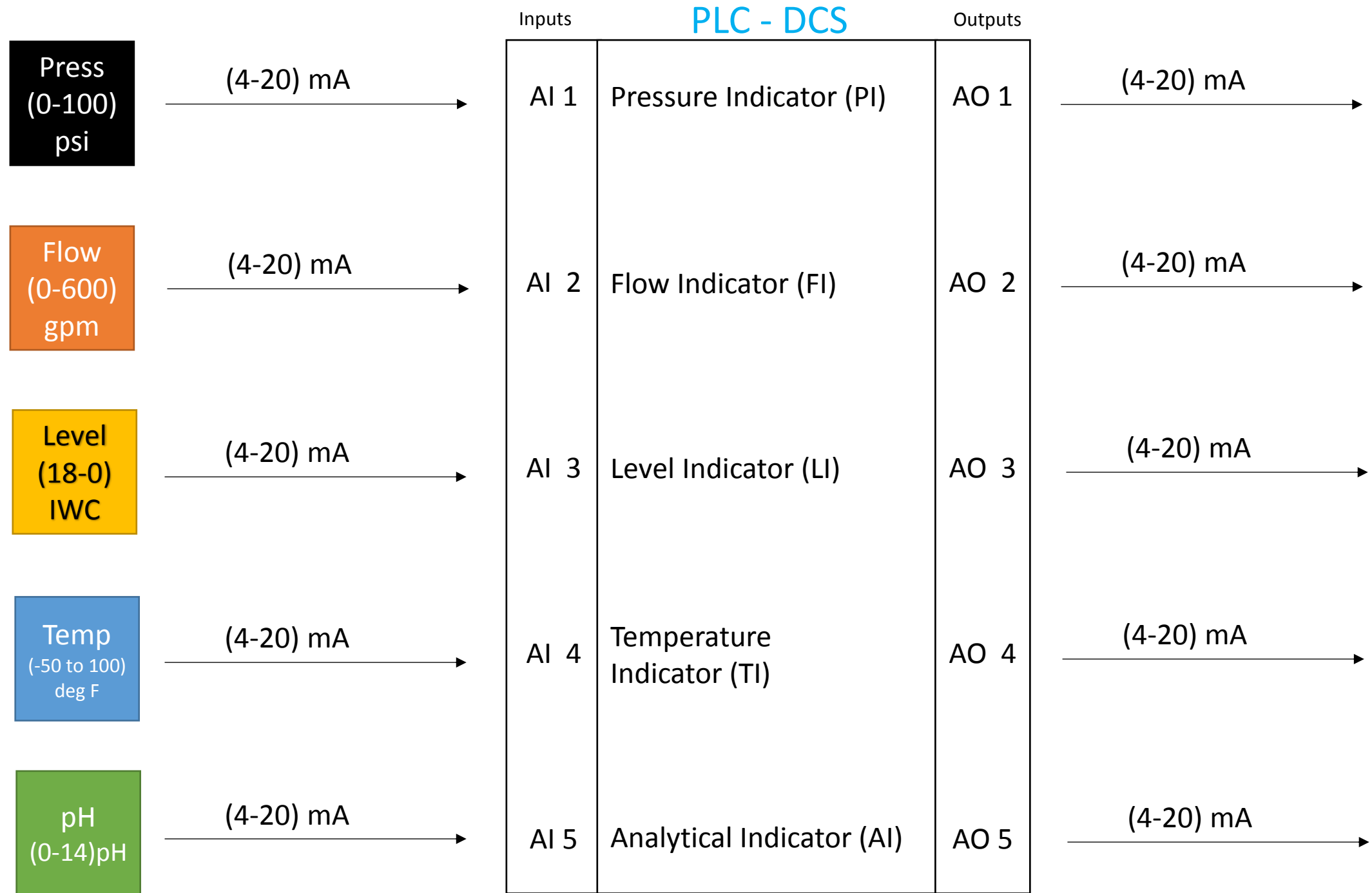
Level Transmitter Configuration

Manufacturer #1



Manufacturer #2





Standard Signals

(4-20)mA (also called 20% offset)

(0-20)mA

(1-5) Volts DC

(0-5) Volts DC

(0-10) Volts DC

(-10 to 10) Volts DC

(3-15) psi

My first lesson in my first
computer class in 1974

*Garbage In
Garbage Out*

You can't make
good decisions
with bad
information!

Instrumentation Misconceptions

They are not like a toaster.

You can't just pull them out of the box, plug them in and they'll work.



Instrumentation Reality

- Smart Pressure Transmitter – 50 parameters to utilize
 - Smart Flow Transmitters – 75 parameters to utilize
 - Frequency Drive – 300 parameters to utilize
 - Ultrasonic Level Transmitter – 100 parameters to utilize
-
- You can get the configuration 98% right and it will function 100% wrong.

Problems That Have Been Identified Transmitter Mounting

Water condenses in air
flow measurements
building condensate in
sample lines.



Problems That Have Been Corrected Transmitter Mounting

Air rises to the
highest point
causing errors in
liquid sample
lines



Problems That Have Been Corrected

- Transmitters wired incorrectly
 - pH and Temperature signal wires swapped

PLC - DCS

Inputs

Outputs

Press
(0-100)
psi

(4-20) mA

AI 1

Pressure Indicator (PI)

AO 1

(4-20) mA

Flow
(0-600)
gpm

(4-20) mA

AI 2

Flow Indicator (FI)

AO 2

(4-20) mA

Level
(18-0)
IWC

(4-20) mA

AI 3

Level Indicator (LI)

AO 3

(4-20) mA

Temp
(-50 to 100)
deg F

(4-20) mA

AI 4

Temperature
Indicator (TI)

AO 4

(4-20) mA

pH
(0-14)pH

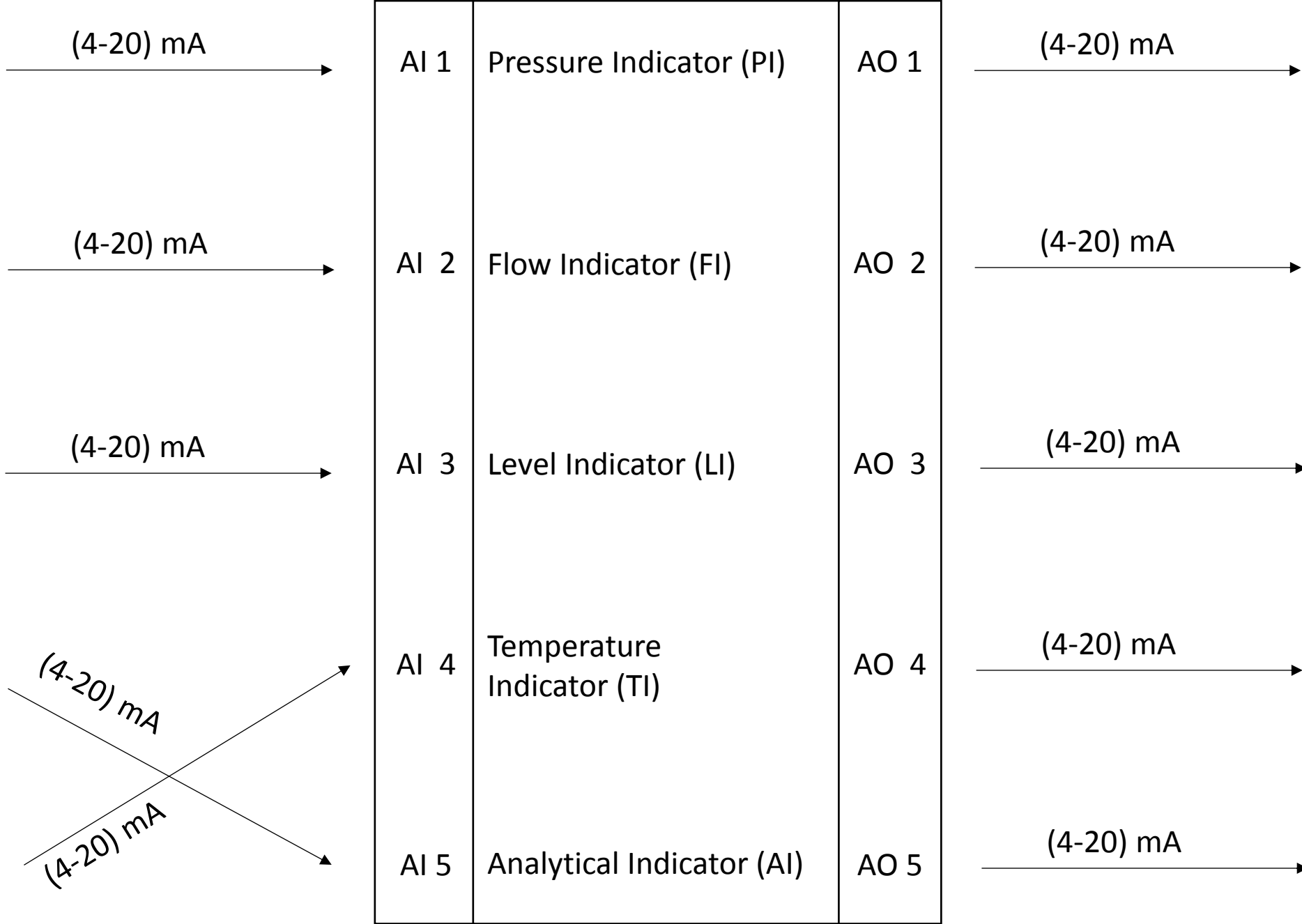
(4-20) mA

AI 5

Analytical Indicator (AI)

AO 5

(4-20) mA



Problems That Have Been Corrected

- Misconfiguration of frequency drives.
 - Too long to discuss
- Bad mapping of data to and from SCADA, PLC, or DCS
 - A Flow Transmitter wired to first PLC, mapped on to second PLC then mapped to DCS. 600 gpm simulation indicated as 540 gpm. 10% error since initial installation.
 - Three freq drives and set points mapped wrong.
 - 50% signal divided by 10 and ran at 5%

Problems That Have Been Corrected

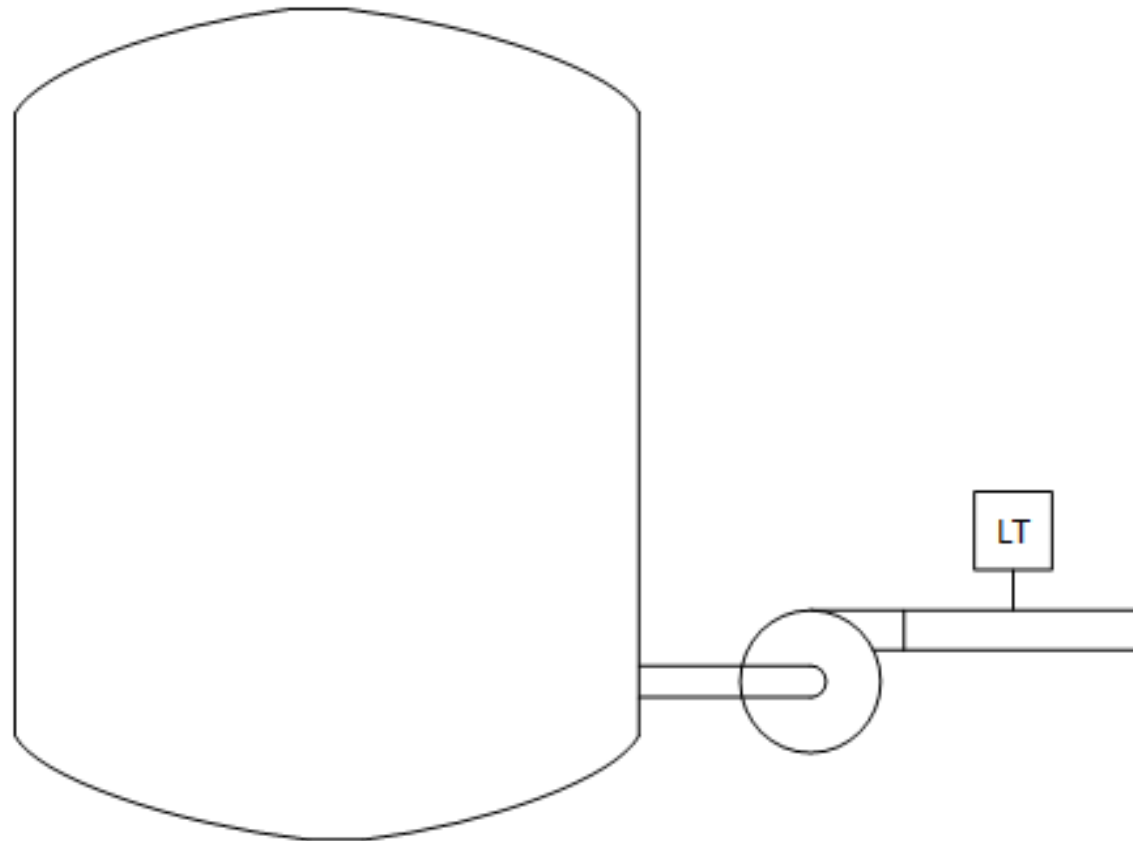
- Square root extraction incorrectly used for flow measurement with DP sensing.
- Thermocouples
 - Red wire is negative.
 - Extension wire must be thermocouple wire. Can NOT use regular wire.
- Fail safe strategies not considered.
 - If you unplug a signal and don't get an alarm it's not designed fail safe.

Problems That Have Been Corrected

- Damaged, wrong, inaccurately marked equipment shipped from factory.
 - Marked from the manufacturer as (0-100)deg C but was actually (0-100) deg F
 - PSIA transmitters purchased when they needed PSIG.
- Flow Elements mounted horizontal at the high point of the piping.

Incorrect instrument location.

Pressure sensing LT mounted at outlet of pump.



Commissioning or Validation

Most of the above issues would have been avoided with proper Commissioning or Validation.

This process confirms the accuracy of data from instruments to the SCADA screens and from the SCADA screens to the instruments.

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**This is what confirms you don't have
*“Garbage In”***

Commissioning or Validation

Once you have confirmed there is no “*Garbage In*” then control schemes (programming) can be implemented and tested.

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Everything!**

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- If it's a simple process keep it simple.
- You don't need cruise control for a horse!
- You don't use cruise control in a blizzard. You need to keep your hands on the wheel, feet on the pedals and drive the car.

Ron Janssen will be next discussing
some of our control strategies.