HIPPS Pressure Sensors / Transmitters

Andy Crosland

BDM – Safety Instrumented Systems

18 February 2016

EMERSON.
Process Management

Agenda

- Emerson Pressure Measurement
- Diagnostics in Safety Instrumented Systems
- Diagnosing typical failures in HIPPS Sensors
- HIPPS Sensor Architecture
  - Why do we need 2oo3 voting
- Process Connection and Isolation
- Proof Testing

EMERSON
Process Management

Rosemount Pressure Has Demonstrated Technology Leadership for 40+ Years

1151

- Rugged capacitance sensors & transmitter packaging
- Modular construction
- Dual compartment housing
- > 5 million units sold

3051C/T

- Coplanar™ Design Platform
- "Free-floating" Sensor
- ASIC-Surface Mount Technology
- Integral Manifolds, Flow Elements
- > 3 million units sold

3095

- MultiVariable™ DP, P, & T
- Dynamically Compensated Mass Flow
- Full AGA & ISO Flow Calcs
- > 100,000 units sold

3051S Series

- Scalable Platform
- Best Performance
- Wireless
- MultiVariable
- Adv. Diagnostics
- > 400,000 units sold

1969 **1980** **1990** **2000**

Industry Firsts

Capacitance Sensors

Coplanar

DP MassFlow

MultiVariable

Control In The Field

Truly Scalable Architecture

Dual Compartment Housing

Smart Low Power

DP Flowmeters

Advanced Diagnostics

Modular Construction

Integral Manifolds

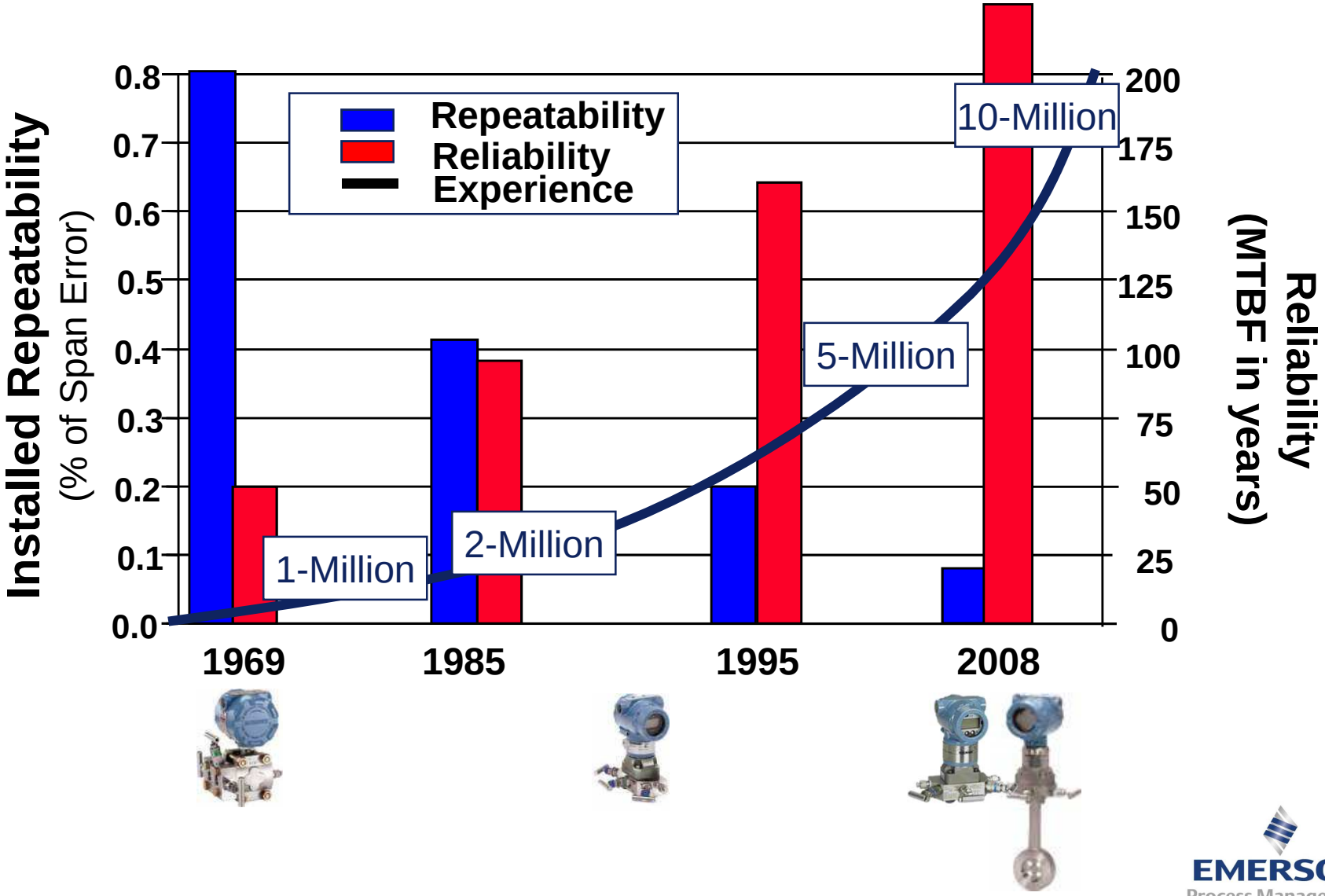
Total Performance

5 & 10 Year Stability

12 Year Warranty

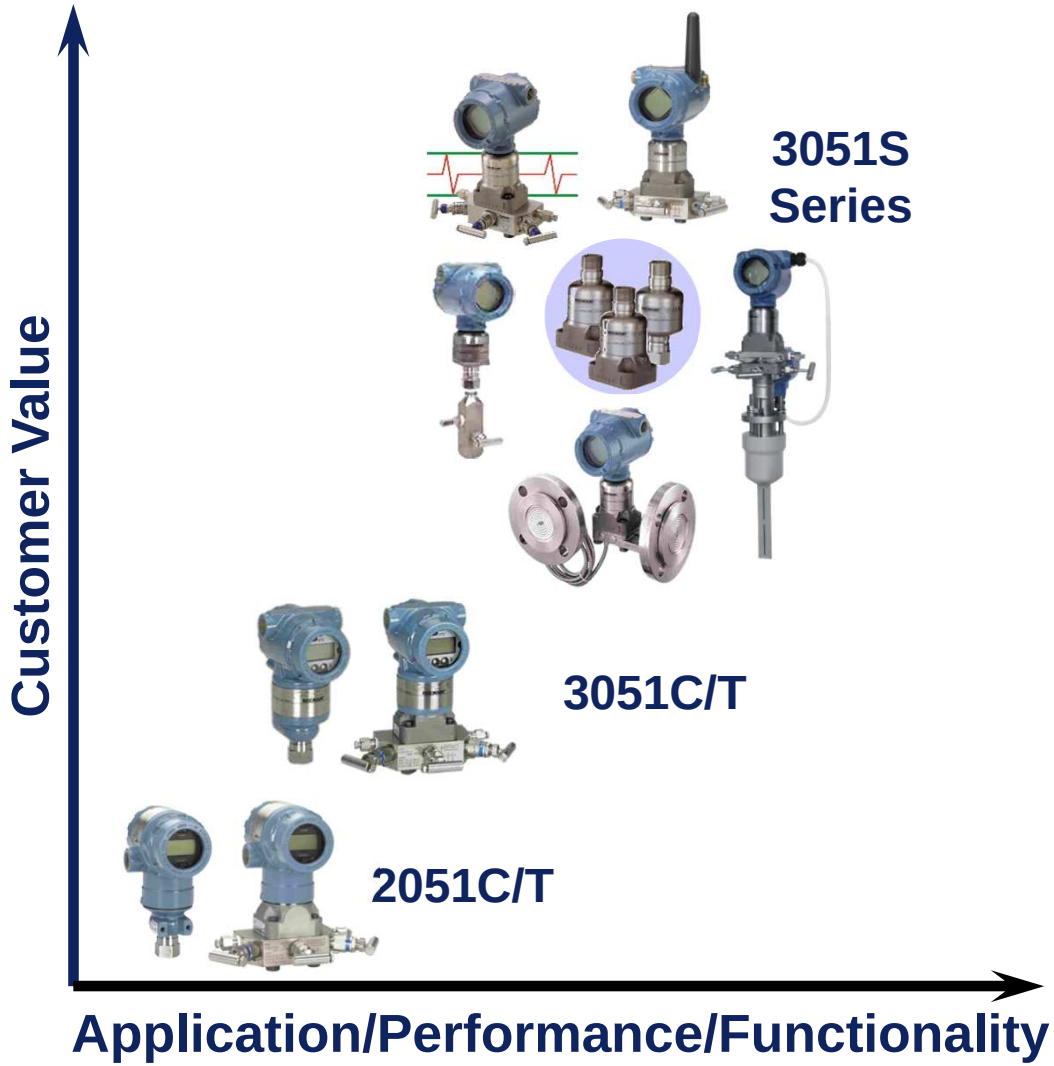
Remote Display

Pressure Design Innovations Achieve Best Performance and Reliability



EMERSON
Process Management

Rosemount's Pressure Portfolio is Versatile Enough to Meet All Your Needs!



Application Solutions

DP Flow

DP Level

Manifolds

Target Market Solutions

Sanitary – 1199, 2090F

Pulp & Paper – 2090P

Oil & Gas – 4600, 3095F MODBUS

All Industry – 3095M, 1151, 2088

Certified Pressure Transmitters (QT / QS) Options

Pressure | Temperature | Flow | Level | Tank Gauging | Accessories | Discontinued Products

Certified to IEC 61508 (Quality Certification option QT)

Select A Product Below

3051S with DA2 Option	3051S	3051	2051
			

3051S ERS™ System


User Justification Required per IEC 61511 (Quality Certification option QS)

Select A Product Below

3051S	3051	3051SMV
		

2051	2088	3051S ERS™ System
		

4600


All Pressure Transmitters are Certified SIL3 Systematic Capability Random Integrity SIL2 with HFT=0; SIL3 with HFT=1

Systematic Capability: SC 3 (SIL 3 Capable)

Random Capability: Type B Element

SIL 2@HFT=0 SIL 3@HFT=1, Route 1_H

For models where SFF ≥ 90%

SIL 2@HFT=0 SIL 3@HFT=1, Route 2_H

PFD_{AVG} and Architecture Constraints must be verified for each application

EMERSON
Process Management

Many Options!

Rosemount 3051S Series selection guide

Rosemount 3051S Coplanar™ differential, gage, or absolute transmitter

See ordering information on page 5.

- Coplanar platform enables integrated manifold, primary element, and seal system solutions
- Dual-capacitance Saturn™ sensor technology corrects for overpressure and line pressure effects
- Calibrated spans from 0.1 inH_2O to 4000 psi (0.25 mbar to 276 bar)
- Available with 316L SST, Alloy C-276, Alloy 400, Tantalum, gold-plated Alloy 400, or gold-plated 316L SST process isolators

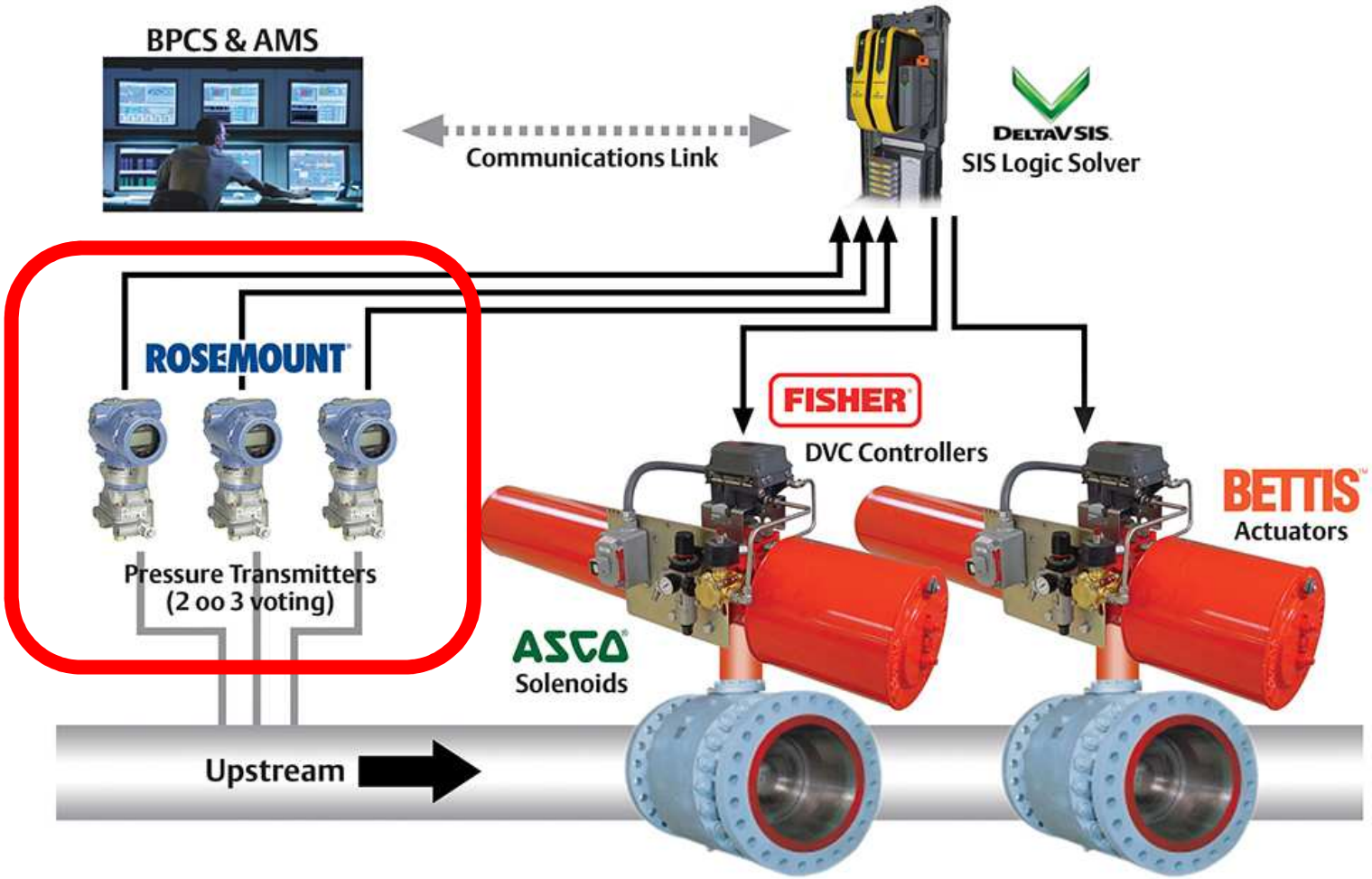
Rosemount 3051S In-line gage or absolute transmitter

See ordering information on page 14.

- Direct threaded connection, manifold or seal system solutions
- Piezoresistive sensor technology allows calibrated spans from 0.3 to 10000 psi (20.7 mbar to 689 bar)
- Available with 316L SST or Alloy C-276 process isolators

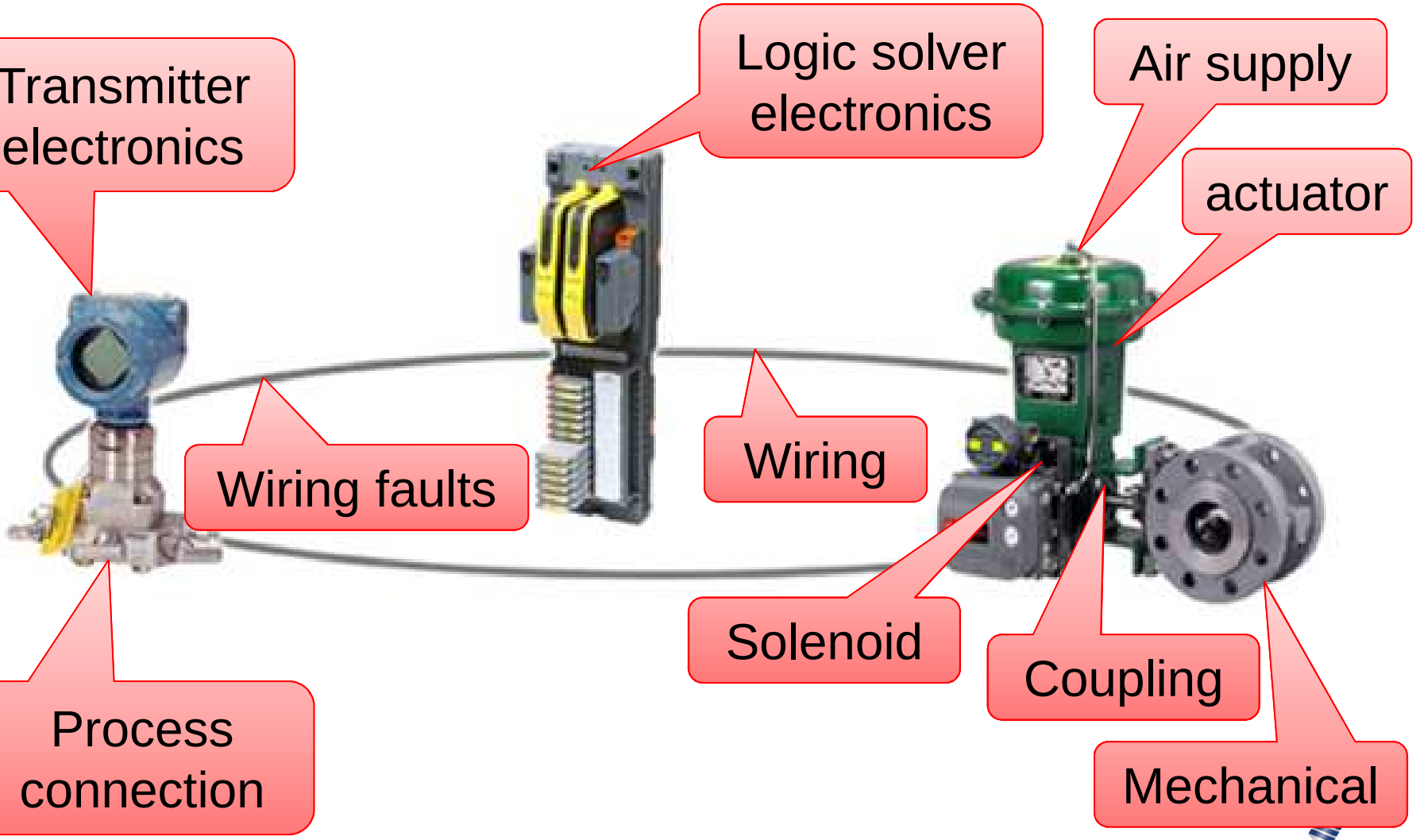
Sensor (Initiator) is part of the overall HIPPS safety function

A ”Generic” image of a HIPPS system



EMERSON
Process Management

Consider the total loop of the SIF: Where could failures occur?



EMERSON
Process Management

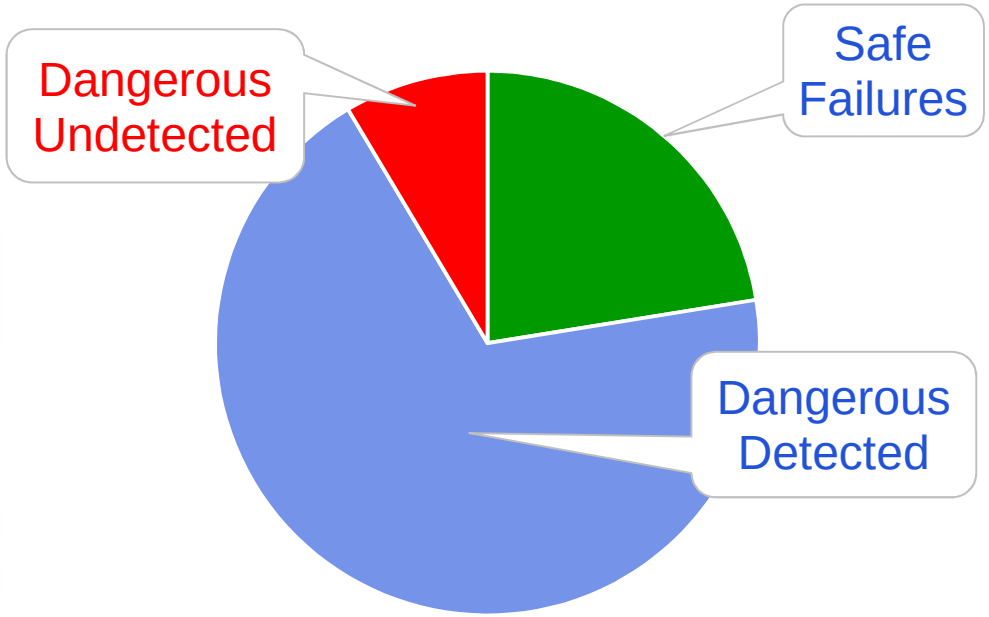
Safety System element failures

DANGEROUS

Detected

Undetected

SAFE



Why do we need diagnostics in Safety Instrumented Systems?

Type of Failure	Consequences for the Plant
SAFE	Process shuts down safely • Loss of production • Hazards when re-starting
Dangerous Undetected	Process continues to operate • Important protection layer missing • We do not know there's a problem

EMERSON
Process Management

Product Certificates provide failure rate Data

exida CERTIFICATION

Certificate / Certificat

Zertifikat / 合格証

ROS 1107062 C001

exida hereby confirms that the:

Rosemount 3051 4-20mA HART Pressure Transmitter

The manufacturer may use the mark:

CERTIFIED exida IEC 61508 SIL 3 CAPABLE

Valid until April 1, 2015.

Revision 1.4 December 13, 2013

ANSI Accredited Program PRODUCT CERTIFICATION #1004

Rosemount 3051 4-20mA HART Pressure Transmitter

Certificate / Certificat / Zertifikat / 合格証

ROS 1107062 C001

Systematic Capability: SC 3 (SIL 3 Capable)

Random Capability: Type B Element
SIL 2@HFT=0 SIL 3@HFT=1, Route 1_H
For models where SFF ≥ 90%

exida CERTIFICATION
64 N Main St
Sellersville, PA 18960

T-002, V3.0-3

Systematic Capability

The product has met manufacturer design process requirements of Safety Integrity Level (SIL) 3. These are intended to achieve sufficient integrity against systematic errors of design by the manufacturer.

A Safety Instrumented Function (SIF) designed with this product must not be used at a SIL level higher than stated.

Random Capability

The SIL limit imposed by the Architectural Constraints for each element.

IEC 61508 Failure Rates in FIT[1]

Route 1_H Table

Device	λ_{SD}	λ_{SU}	λ_{DD}	λ_{DU}	SFF
3051 4-20mA HART Pressure Transmitter: Coplanar Differential & Coplanar Gage	0	84	258	32	91%
3051 4-20mA HART Pressure Transmitter: Coplanar Absolute, Inline Gage & Absolute	0	94	279	41	90%

[1]FIT = 1 failure /

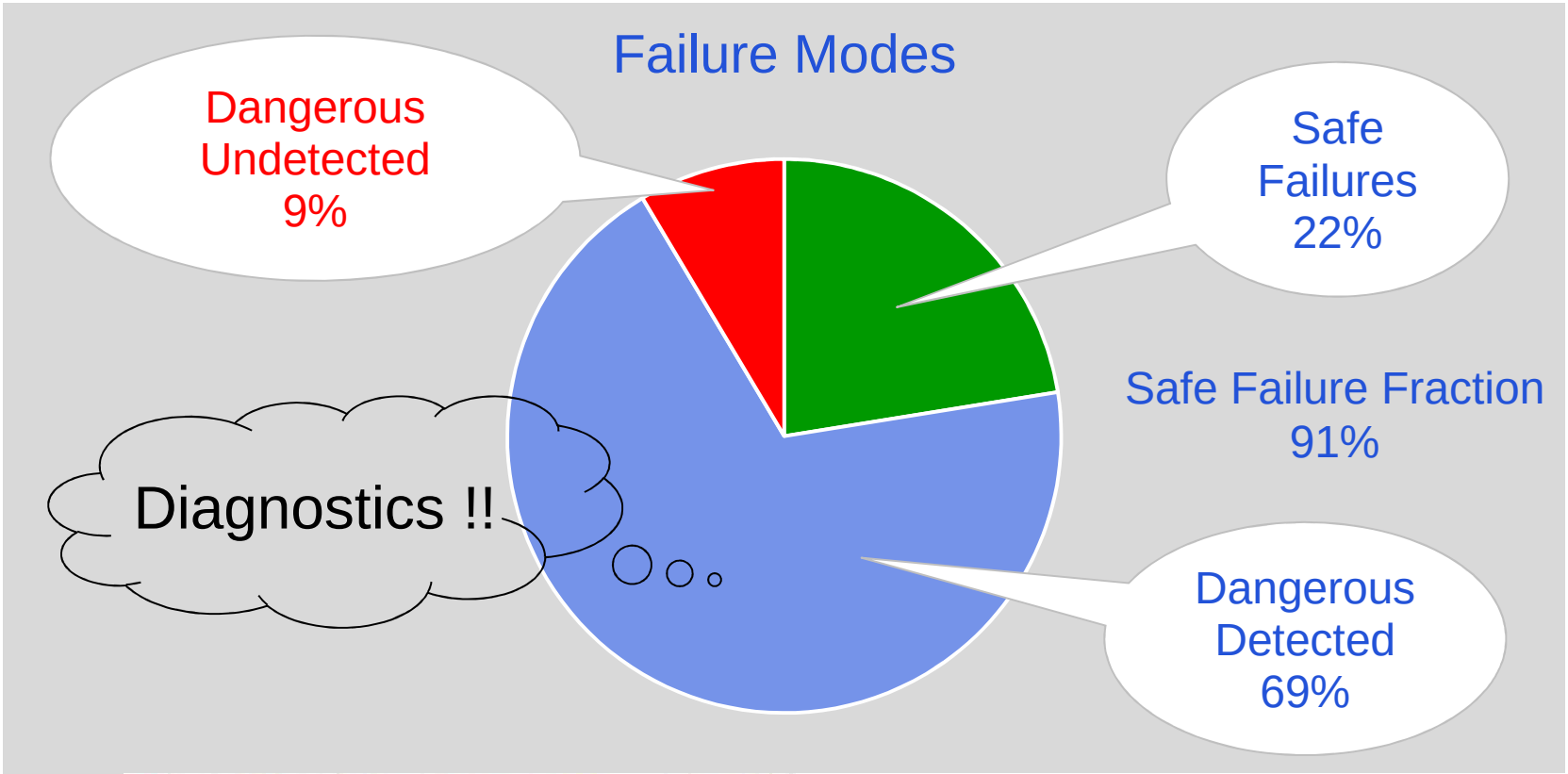
[2]SFF not require
Route 2_H approa
SIL Verification

[3]Refer to ROS 13/04-008 R001 V1R0 for the Flowmeter FMEDA report for models that are excluded.

[4]Refer to the Remote Seal (ROS 1105075 R001 V1R3) FMEDA report for the additional failure rates to use when using with attached Remote Seals, or use exSILentia.

Page 2 of 2

EMERSON Process Management

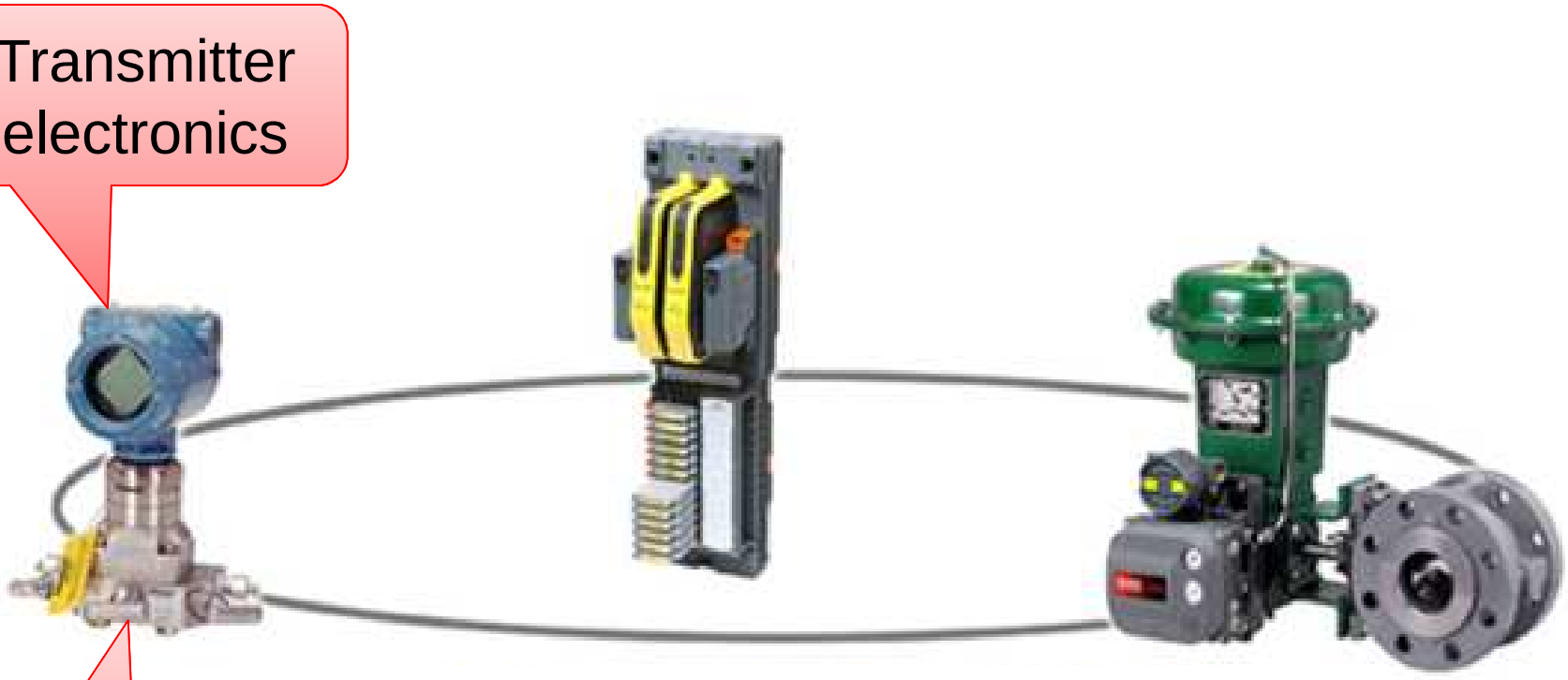


IEC 61508 Failure Rates in FIT[1]

Route 1_H Table

Device	λ_{SD}	λ_{SU}	λ_{DD}	λ_{DU}	SFF
3051 4-20mA HART Pressure Transmitter: Coplanar Differential & Coplanar Gage	0	84	258	32	91%
3051 4-20mA HART Pressure Transmitter: Coplanar Absolute, Inline Gage & Absolute	0	94	279	41	90%

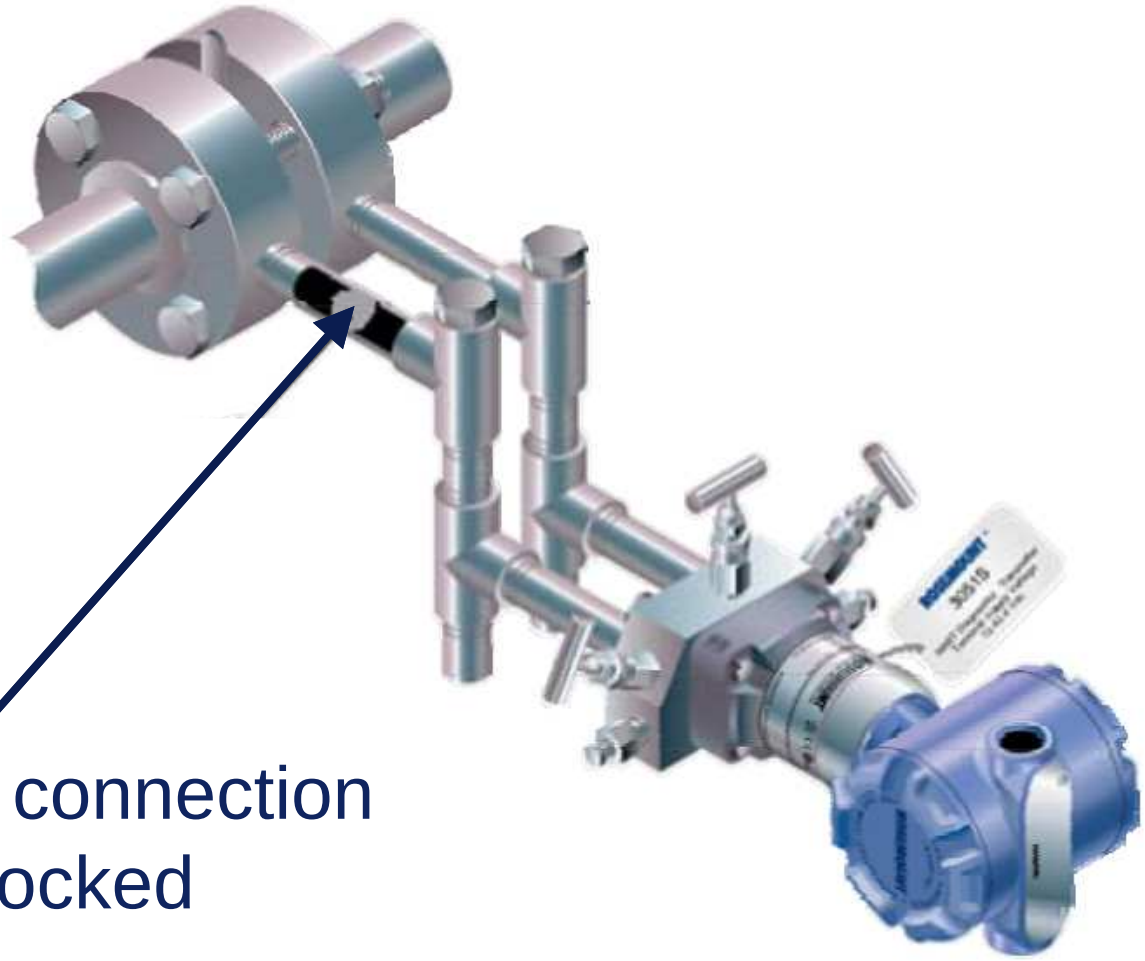
Where could failures occur?



EMERSON
Process Management

Pressure Transmitters

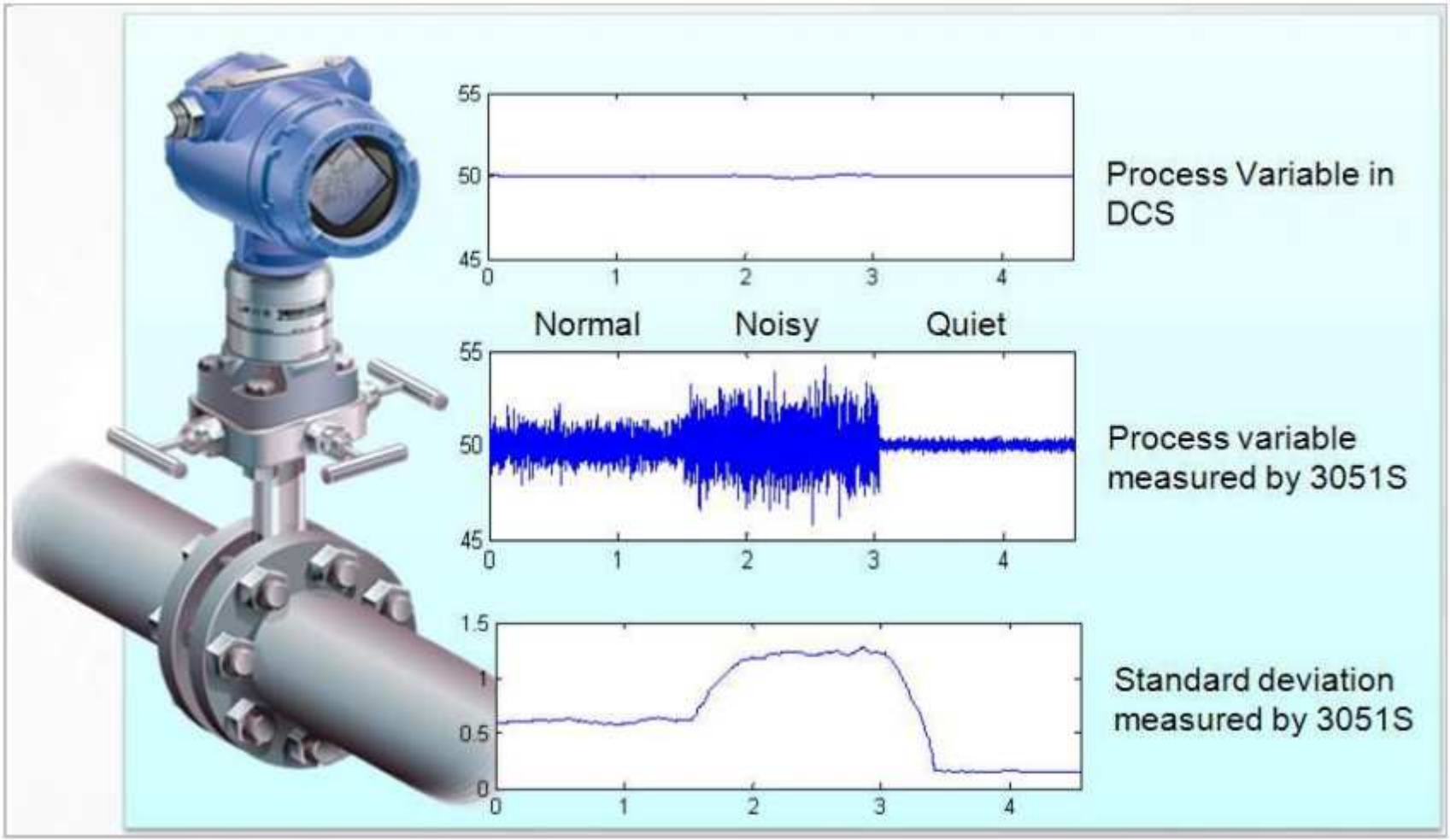
- Applications
  - Pressure
  - Level
  - Flow (DP)



Impulse line connection
Plugged / Blocked

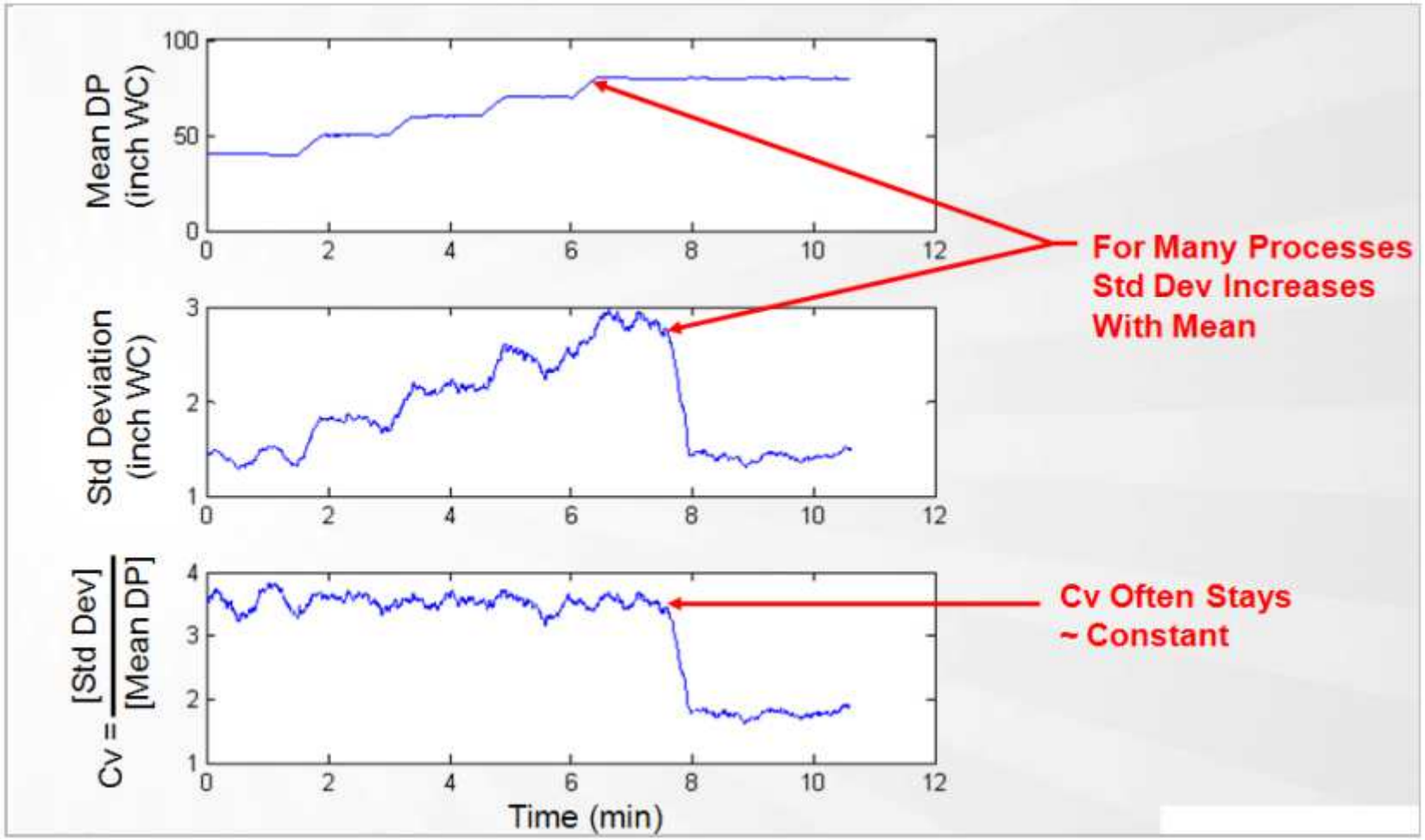
EMERSON
Process Management

Using Statistical Process Monitoring to detect impulse line plugging



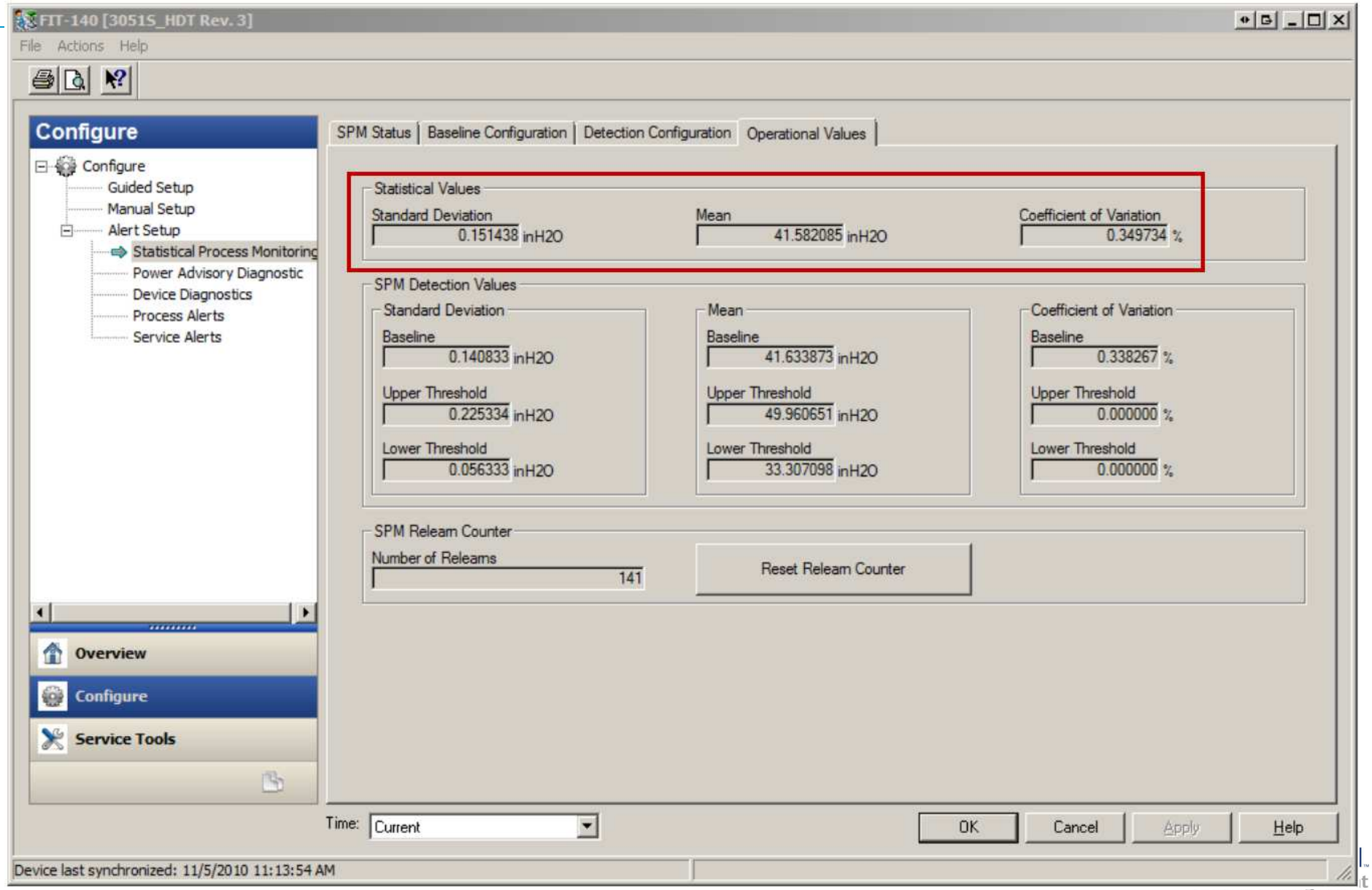
EMERSON
Process Management

Coefficient of Variation (Cv)

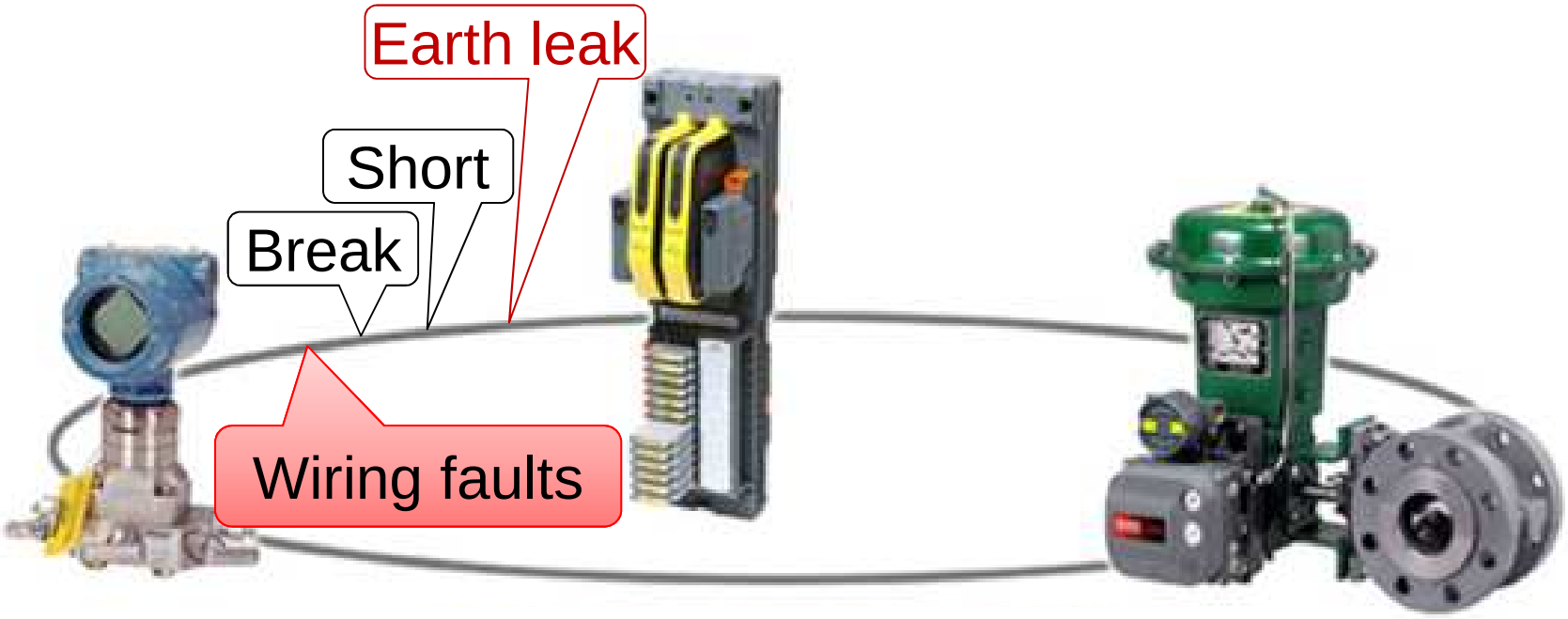


EMERSON
Process Management

Diagnostics available via HART

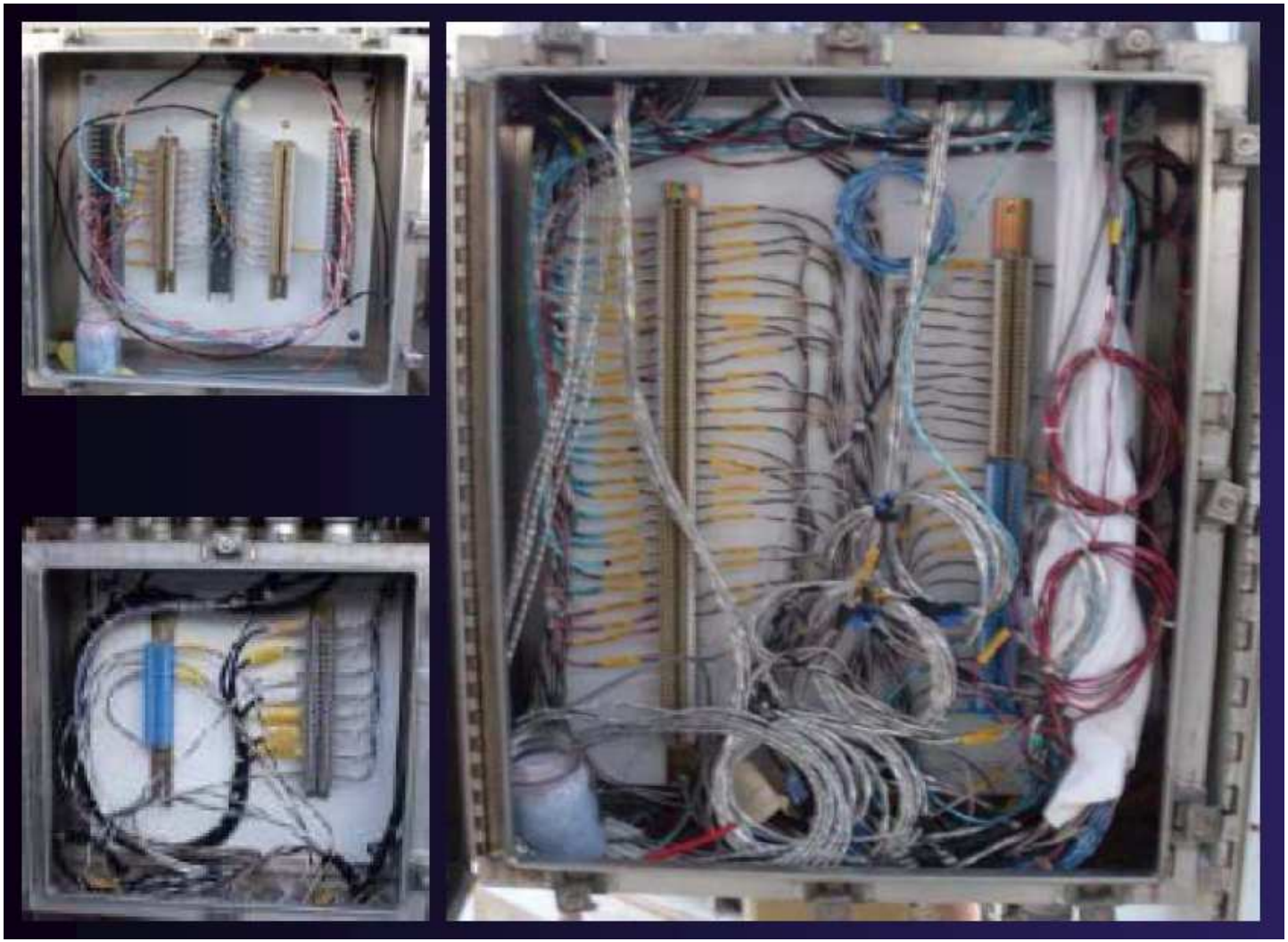


Where else could failures occur?



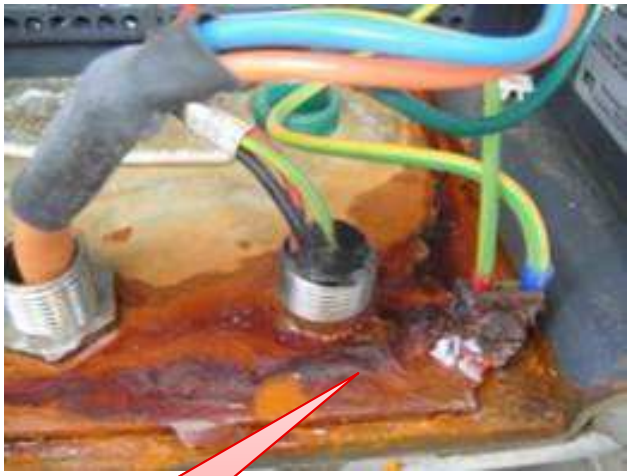
EMERSON.
Process Management

Wiring faults can occur in Junction Boxes

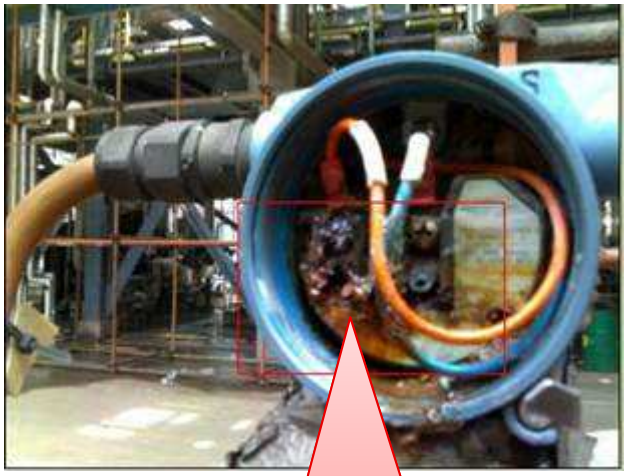


EMERSON
Process Management

Wiring faults can occur in the field devices themselves



Earth?

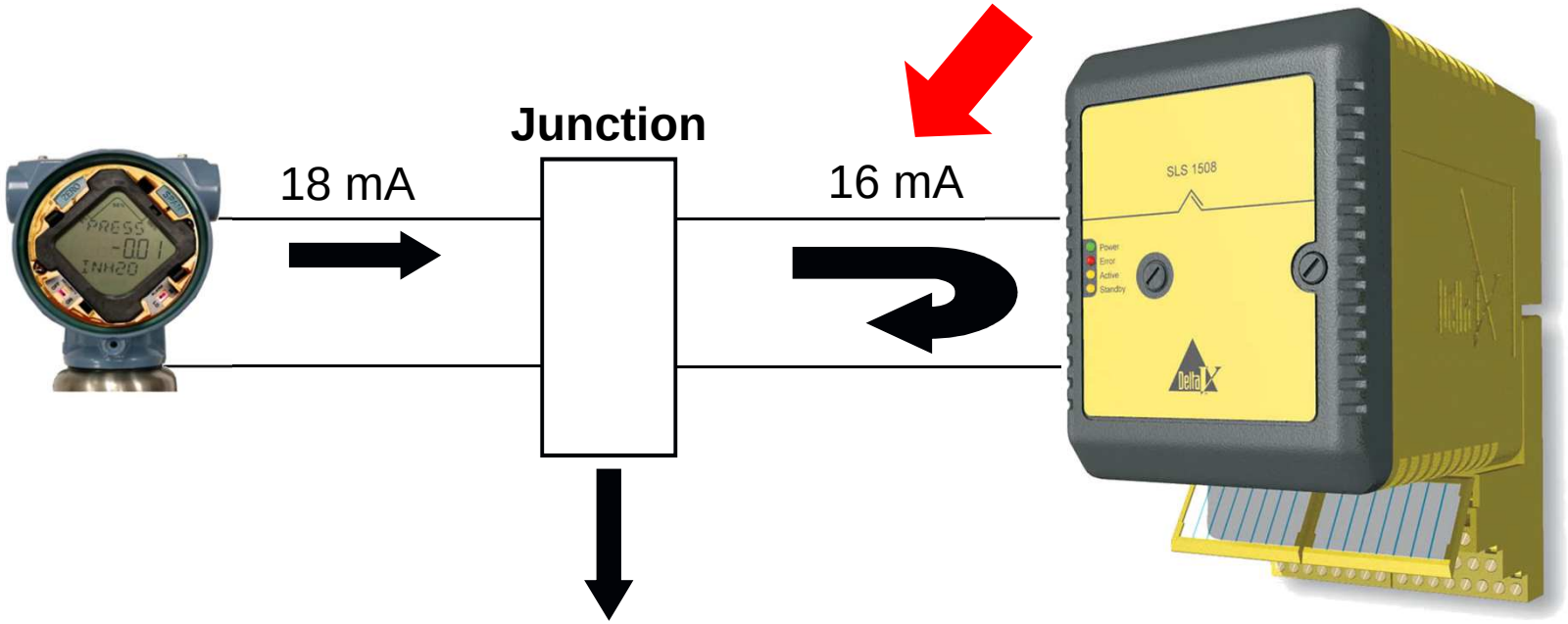


Corrosion!

Water!

EMERSON
Process Management

Effects of an earth leak fault



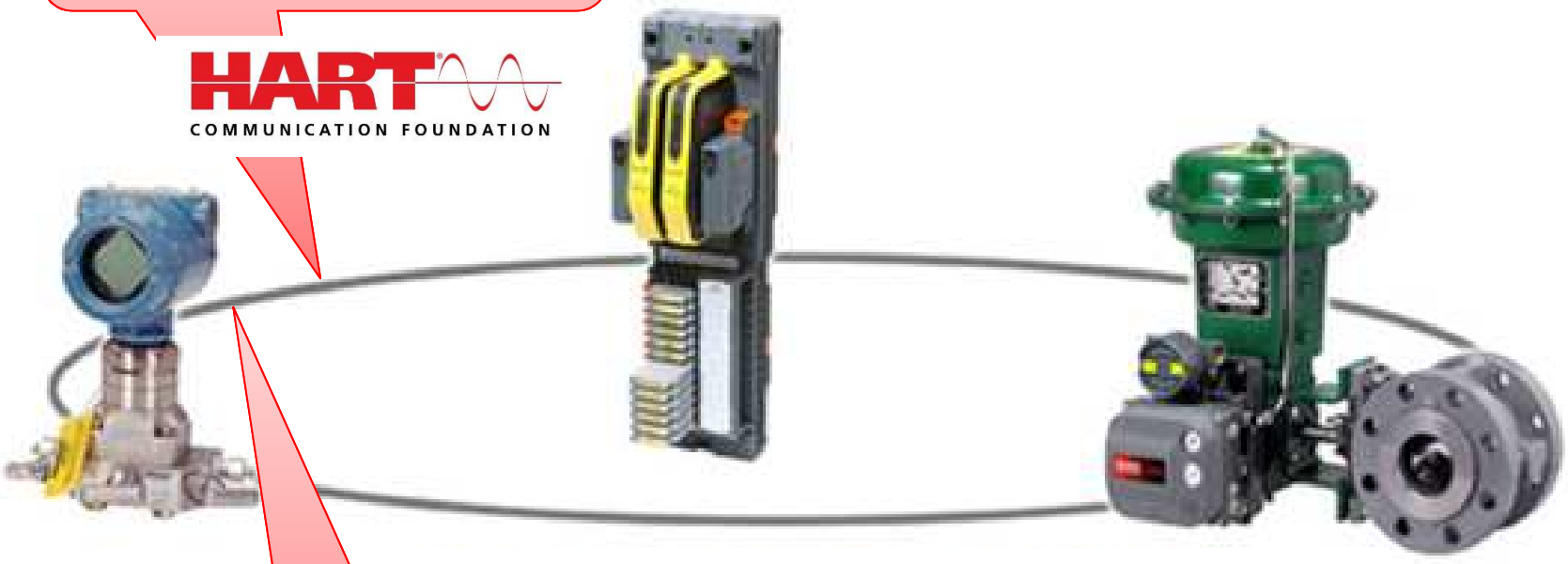
Trip Limit is 17 mA

EMERSON
Process Management

External comparison – HART PV

HART Data
PV, SV, TV, FV

Primary Variable sent digitally = 12.7 Bar



4-20mA signal

$$PV = \frac{(mA - 4)}{16} \times range + offset$$

EMERSON
Process Management

Why do we need 3 Pressure Transmitters?

- Transmitter Requirements
  - Must be suitable for the process application
  - Must meet SIL target – SIL3 typically requires hardware fault tolerance (HFT=1)
  - Must not shutdown the pipeline unnecessarily (no spurious trips) if a single device fails
  - Must be able to test, maintain and repair
- 2oo3 (2 out of 3) voting arrangement
  - Hardware Fault Tolerance 1 = “can tolerate 1 dangerous failure and SIF still operates”
  - Single PT failure to safe state does not cause spurious trip
  - With one PT out of service for maintenance we still have HFT=1 – provided we switch to 1oo2 voting

2 out of 3 architecture (2oo3)

Pressure	PT-A	PT-B	PT-C	Votes to trip	Valves
Normal	Good	Good	Good	0	Open
High	**Trip**	**Trip**	**Trip**	3	Shutdown
High	**Trip**	**Trip**	Failed-DU	2	Shutdown

Single SAFE Failure does not cause spurious trip

Single Dangerous Failure does not prevent SIF from operating

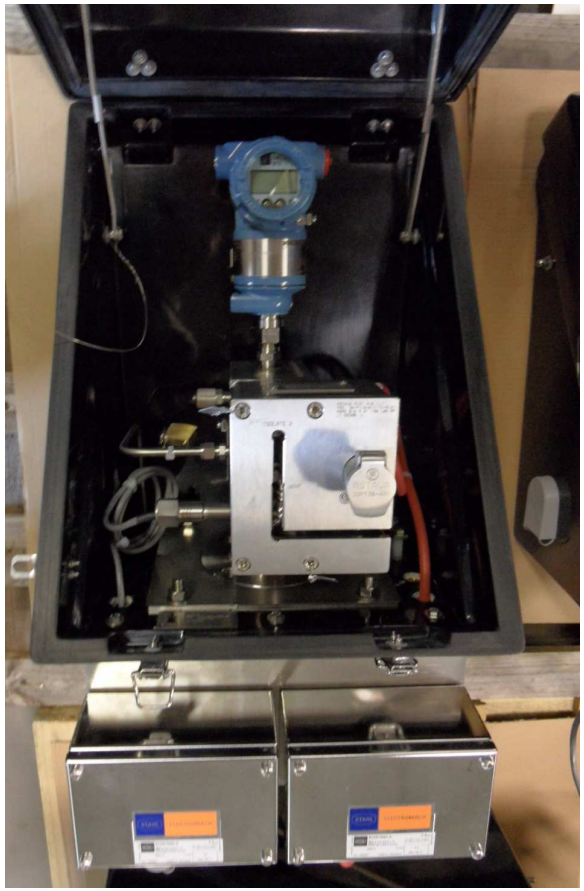
EMERSON
Process Management

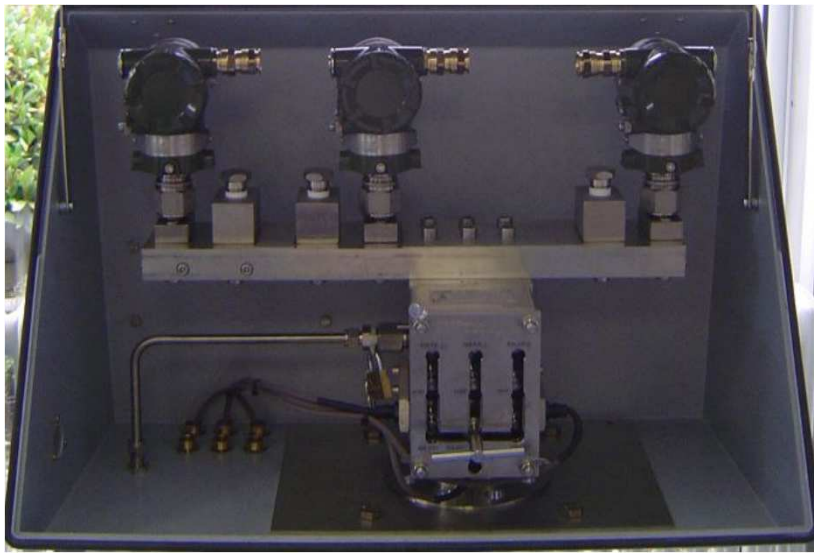
Proof testing requirements

- Proof Test Interval (Frequency)
- Type of Proof Test
  - Different tests have different coverage of potential DU Faults
- Plan should make clear which tests are required and when
- Non-disruptive test of electronics only is safer for workers, and reduces time taken
  - But does not test the pressure cell
- Removing the Transmitter introduces risks
- Test in place is preferred

EMERSON
Process Management

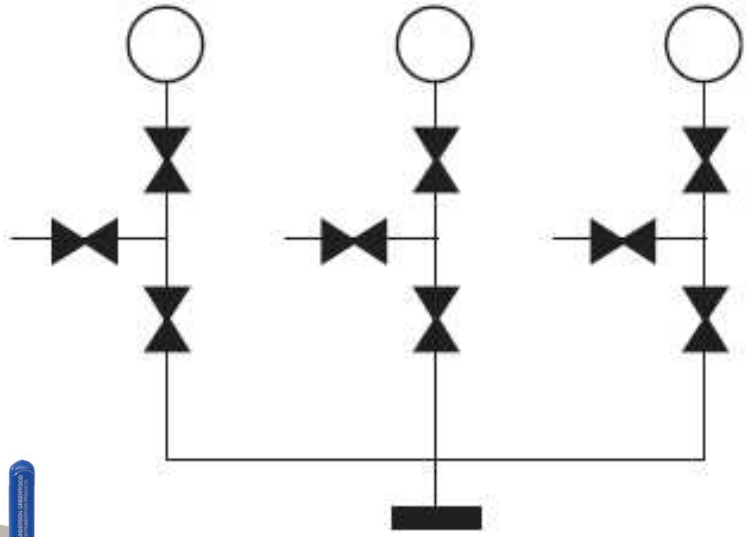
Process Connection – Manifold Block-Bleed-Block(-Test)





EMERSON
Process Management

Process Connection – Manifold Block-Bleed-Block(-Test)



Open position

Closed position

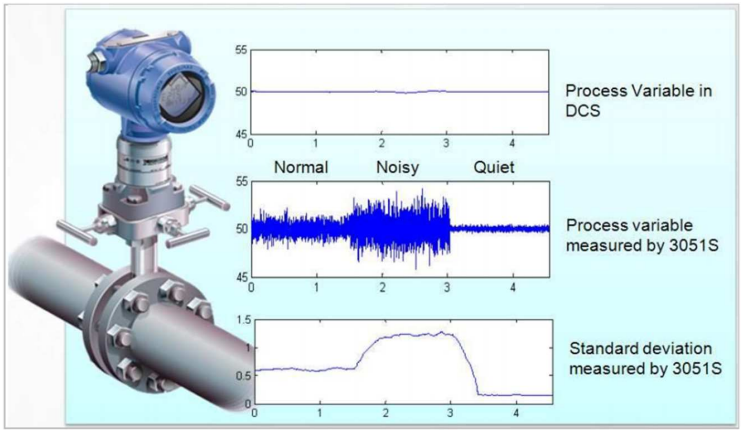
EMERSON
Process Management

Process connection

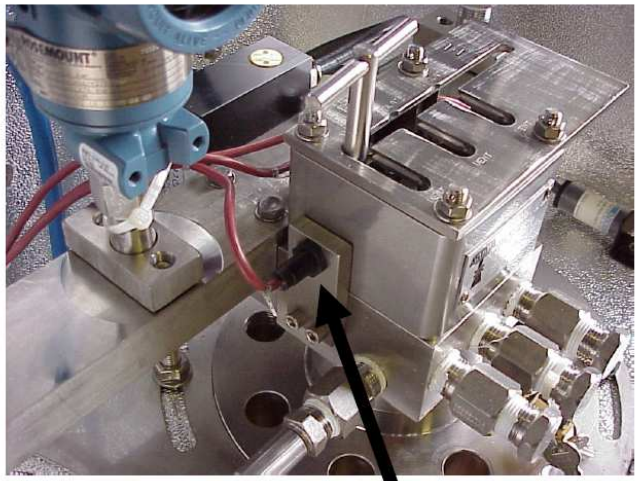
- What is the purpose of the manifold block
  - Safe way to disconnect pressure transmitters for test
    - Keep the process safe – maintain hardware fault tolerance
    - Safe for the technician who must do the test
  - Prevent disconnection of more than one PT at any time
  - Enable pressure transmitter proof test in situ
    - Avoid the risks of disconnecting the PT
    - Reduces the time the PT is unavailable
- Why do we need to know if a PT is isolated ?

EMERSON
Process Management

Can the sensor see the process?



Open position



Proximity switches for interlocking manifold

EMERSON
Process Management

Options when a Pressure Transmitter is isolated

	Injected test pressure	Remaining voting algorithm	Remaining HFT	Consequences	
Force isolated transmitter to the trip state	Above or below trip limit – does not affect outcome	1oo2	HFT=1	Single dangerous failure does not defeat the SIF	Single safe failure will cause a spurious trip. Likelihood of failure during very short test duration is extremely low
Keep the isolated transmitter in the voting algorithm	Below trip limit	2oo2	HFT=0	Single dangerous failure means the SIF will fail	No spurious trip on single safe failure
	Above trip limit	1oo2	HFT=1	Single dangerous failure does not defeat the SIF	Spurious trip on single safe failure

EMERSON
Process Management

HIPPS Sensors Pressure Transmitters

Andy Crosland

BDM – Safety Instrumented Systems

16 February 2016

EMERSON.
Process Management