Fieldbus Diagnostics
Agenda

- Introduction
- Level of Diagnostics
- Function Block Diagnostics
- Resource Block Diagnostics
- Transducer Block Diagnostics
Fieldbus brings dramatic savings in installation and commissioning, but the real value is seen during plant operation...
Elimination of “Unneeded” Trips to the field: Transmitter Diagnostics

- 63% of trips to the field can be eliminated

Source: Dow Chemical
Diagnostics Definitions

Level 3 Operations
- Make Up Water
- Turbine
- Generator
- Boiler
- Pulveration

Level 2 Loop
- Drift

Level 1 Device
- µP
- Plugged Impulse Line
- Electronics Diagnostics
- Sensor Drift
- Communications Diagnostics

Control Loop Knowledge Base
Device Maintains Statistics For Communication Diagnostics

Fieldbus Device Communication Statistics

- **PhysDevTag**: Physical Device Tag
  - Value: PDT1_3244

- **State**: State
  - Value: Commissioned

### Statistics

- **RequestsSent**: 26300
- **AbortsRxd**: 0
- **IntsSent**: 1
- **IntPostConRxd**: 1
- **IntNegConRxd**: 0
- **AbortsSent**: 0
- **AbortPosConRxd**: 0
- **AbortNegConRxd**: 0
- **PctTimeoutsRxd**: 0
- **RejectsRxd**: 0
- **NumFasAborts**: 0
- **LastAbortLocal**: 0
- **LastAbortReason**: 0
- **NumDILDpduSent**: 26295
- **NumDILDpduReceived**: 45543
- **NumDILDTransferTimeouts**: 0
- **NumStackReceiveQFulls**: 0
- **NumDILDRetrys**: 0
- **Negative Conf**: 0
- **LocalStackEn**: 0
- **MissedViewListScan**: 31730
- **NumLiveListAppearances**: 1

Control Loop Knowledge Base
Diagnostic Examples

- Transmitter generates an alert when
  - the sensor degenerates
  - the device has exceeded factory maximum field temperature usage

- Cycle Counter
- Valve Signature
- Dynamic Error Band

- O2 Sensor creates alert when the sensor fouls
Using Device Intelligence

The Device Detects Process Conditions

Impulse Lines Plug

Control Loop Knowledge Base
Devices Provide Predictive Diagnostics

Provide Information On Life Expectancy and Performance Degradation

[Diagram showing a graph of device performance with a predictive alarm and a failure point.]
Diagnostics are Utilized in Fieldbus Blocks for Measurement and Control

PV is Marked ‘Uncertain’ or ‘Bad’ if Abnormal

and propagated
Event is Time Stamped At The Source!
Failed Electrode Signal Fault
 Communications Failure
Failed Maintenance
Advisory Maintenance
Sensor Calibration

FT-101
Inlet 3, Cooling Tower 1

Conditions of FT-101

Recommended Action: Perform recommended sensor/wiring checks

Electrode Signal Fault Detected
The flow signal has been compromised. The process variable is likely reading less than expected.

1. Remove any moisture or contamination in the flowtube terminal block or, if applicable, the sealed electrode compartments.

WARNING! The electrode compartment may contain line pressure. Removing the cover before depressurizing may result in death or serious injury.

2. Perform flowtube electrical resistance tests. Confirm the resistance reading between coil ground (ground symbol) and coil (1 or 2) is infinity. Confirm the resistance reading between electrode ground (17) and an electrode (18 or 19) is greater than 2 kohms and rises. For more detailed information, consult the flowtube product manual.

3. Verify flowtube is electrically connected to the process with grounding electrode, grounding rings with grounding straps, or lining protector with grounding straps.

4. Verify transmitter electronics with Model 8714 reference standard. The dial on the 8714 should be set at 9.1 m/s (30 ft/s). The transmitter should be set up with the nominal flowtube calibration number (10000150100000000) and 5 Hz coil drive frequency.

5. Properly connect the wiring between the flowtube and the transmitter on the flowtube. Corresponding terminal black numbers in the flowtube and transmitter must be connected.

To turn off electrode signal fault detection, go to the diagnostic screen in the transducer block properties.

Control Loop Knowledge Base
Process plants can be tough on field devices!
Internal Diagnostics

- Sensor failure
- Sensor malfunction
- Sensor disconnected
- Electronic Board failure
- Bad grounding
- Operating conditions out of specifications
Process Diagnostics

- Plugged line
- Empty pipe
- Statistical Process Monitoring
- Vibration
- Valve travel integration
- Noise
- Drift
- Flame instability

Control Loop Knowledge Base
Diagnostic Examples

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  * the sensor degenerates
  * the device has exceeded factory maximum field temperature usage

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Variability Index provides additional insight into Loop Performance

Variability Index Diagnostic

\[ \text{Variability Index} = \frac{\text{Measured Standard Deviation}}{\text{Minimum Expected Standard Deviation}} \]

Is Detected with Variability Index

DeltaV Inspect Identifies Under-performing Loops

Take Corrective Action
Plugged Impulse Line Diagnostic

Manifold

Sensing Line

Clog

Flow

PV (V)

Both Open
HP Closed
LP Closed
Both Closed

Time (min)

Control Loop Knowledge Base
Statistical Process Monitoring

Control Loop Knowledge Base
Proof Using SPM Prevents Plant Damage

Statistical Process Monitoring data coming from 3051 ADB helped predict catalyst problem 30 min in advance.

Source: ExxonMobil Baytown, Tx Refinery
All connectable variables have STATUS.

Value: 234.5 m$^3$/h
Status: Good, Bad or Uncertain
Sub-Status: (more status details)
Limit: High, Low, Constant or not limited

Status can be used in the control strategy to switch a controller to Manual when the variable goes to a Bad status.
### Status

<table>
<thead>
<tr>
<th>Quality</th>
<th>Sub-status</th>
<th>Process Variable</th>
</tr>
</thead>
<tbody>
<tr>
<td>Good (NC)</td>
<td>Non-specific</td>
<td>X</td>
</tr>
<tr>
<td>Good (NC)</td>
<td>Active Block Alarm</td>
<td>X</td>
</tr>
<tr>
<td>Good (NC)</td>
<td>Active Advisory Alarm</td>
<td>X</td>
</tr>
<tr>
<td>Good (NC)</td>
<td>Active Critical Alarm</td>
<td>X</td>
</tr>
<tr>
<td>Good (NC)</td>
<td>Unack Block Alarm</td>
<td>X</td>
</tr>
<tr>
<td>Good (NC)</td>
<td>Unack Advisory Alarm</td>
<td>X</td>
</tr>
<tr>
<td>Good (NC)</td>
<td>Unack Critical Alarm</td>
<td>X</td>
</tr>
<tr>
<td>Uncertain</td>
<td>Non-specific</td>
<td>X</td>
</tr>
<tr>
<td>Uncertain</td>
<td>Last Usable Value</td>
<td>X</td>
</tr>
<tr>
<td>Uncertain</td>
<td>Substitute / Manual Entry</td>
<td>X</td>
</tr>
<tr>
<td>Uncertain</td>
<td>Initial Value</td>
<td>X</td>
</tr>
<tr>
<td>Uncertain</td>
<td>Sensor Conversion not Accurate</td>
<td>X</td>
</tr>
<tr>
<td>Uncertain</td>
<td>Engineering Unit Range Violation</td>
<td>X</td>
</tr>
<tr>
<td>Uncertain</td>
<td>Sub-normal</td>
<td>X</td>
</tr>
<tr>
<td>Bad</td>
<td>Non-specific</td>
<td>X</td>
</tr>
<tr>
<td>Bad</td>
<td>Device Failure</td>
<td>X</td>
</tr>
<tr>
<td>Bad</td>
<td>Sensor Failure</td>
<td>X</td>
</tr>
<tr>
<td>Bad</td>
<td>No Comm, with LUV</td>
<td>X</td>
</tr>
<tr>
<td>Bad</td>
<td>No Comm, no LUV</td>
<td>X</td>
</tr>
<tr>
<td>Bad</td>
<td>Out of Service</td>
<td>I</td>
</tr>
</tbody>
</table>

X = Permitted Status  
I = Initial status

*Table 6 – Parameter Status Attribute*
Diagnoses are Utilized in Fieldbus Blocks for Measurement and Control

PV is Marked ‘Uncertain’ or ‘Bad’ if Abnormal

and propagated
Event is Time Stamped At The Source!
PlantWeb alerts

Route to appropriate plant organization
Recommended Action
Troubleshooting guide
Electrode Signal Fault Detected

The flow signal has been compromised. The process variable is likely reading less than expected.

1. Remove any moisture or contamination in the flowtube terminal block or, if applicable, the sealed electrode compartments.

WARNING! The electrode compartment may contain line pressure. Removing the cover before depressurizing may result in death or serious injury.

2. Perform flowtube electrical resistance tests. Confirm the resistance reading between coil ground (ground symbol) and coil (1 or 2) is infinity. Confirm the resistance reading between electrode ground (1 or 2) and an electrode (10 or 19) is greater than 2 kohms and rises. For more detailed information, consult the flowtube product manual.

3. Verify flowtube is electrically connected to the process with grounding electrode, grounding rings with grounding straps, or lining protector with grounding straps.

4. Verify transmitter electronics with Model 8714 reference standard. The dial on the 8714 should be set at 9.1 m/s [30 ft/s]. The transmitter should be set up with the nominal flowtube calibration number (1000150100000000) and 5 Hz coil drive frequency.

5. Properly connect the wiring between the flowtube and the transmitter on the flowtube. Corresponding terminal block numbers in the flowtube and transmitter must be connected.

To turn off electrode signal fault detection, go to the diagnostic screen in the transducer block properties.
Operation

- Devices are identified by Tag
- Variables are identified by: TAG.Desired Parameter

No need to remember the Transmitters Hardware Address.

**FT102A, not CTL01C03A01**
Transducer, Resource and Function Blocks

- Every Field device has to have a Resource Block and one or more Transducer blocks.
- Function Blocks are desirable, but not mandatory.
- Resource Block contains information about the device resources: hardware and software.
- Transducer blocks control access to Input and Output interfaces such as sensors, switches, actuators etc.
- Transducer decouples the process interface from the Function Blocks. They can run as fast as they can.
- Transducer blocks also allow calibration and access to diagnostics.
Resource Block

- Hardware and Software resources.
- When Mode is Out of Service, all other blocks will be Out of Service.
- Allow Device resetting, including resetting with Default values.
- All Emerson devices have a common Resource Block, with very small variations.
Pressure Resource Block - Identification

Configuration of 3051LEVEL [3051 Fieldbus Pressure Transmitter Rev. 20]

- Manufacturer: Rosemount Inc.
- Device Type: 3051 pressure
- Device Revision: 20
- DD Revision: 2
- Tag: RESOURCE
- Tag Description:

Private Label Distributor: Rosemount
Hardware Revision: 3
Software Revision: 1.0.0 10:16:00 Thu
Output Board Serial Number: 10007035
Final Assembly Number: 0
ITK Version: 4

Time: Current
OK Cancel Apply Help

Control Loop Knowledge Base
Pressure Resource Block - Hardware

**Configuration of 3051LEVEL [3051 Fieldbus Pressure Transmitter Rev. 20]**

- **Memory Size**: 16 Kbytes
- **Free Time**: 0.000000 %
- **Free Space**: 22.786501 %
- **Min Cycle Time**: 1600 1/32 ms
- **Min NV Cycle Time**: 230400000 1/32 ms

**Hardware Types**
- Scalar Input
- Scalar Output
- Discrete Input
- Discrete Output
Pressure Resource Block - Options

Configuration of 3051LEVEL [3051 Fieldbus Pressure Transmitter Rev. 20]

Block Execution
- Scheduled: Selected: No, Available: Yes
- Block Completion: Selected: No, Available: Yes
- Manufacturer Specific: Selected: No, Available: No

Features
- Unicode: Selected: No, Available: Yes
- Reports: Selected: Yes, Available: No
- Fault State: Selected: No, Available: No
- Soft Write Lock: Selected: No, Available: Yes
- Hard Write Lock: Selected: No, Available: Yes
- Output Readback: Selected: No, Available: No
- Direct Write: Selected: No, Available: No

Download Mode: Run Mode
Write Lock Definition: Everything locked
Write Lock: Not Locked
Start With Defaults: No NV defaults

Time: Current
Pressure Resource Block – Suppressed Alarms

Configuration of 3051LEVEL [3051 Fieldbus Pressure Transmitter Rev. 20]

- **Failed Alarms**
  - Primary Value Failure
  - Secondary Value Failure
  - Sensor Module Memory Failure
  - Memory Failure
  - NV Memory Failure

- **Maintenance Alarms**
  - Primary Value Degraded
  - Secondary Value Degraded
  - Sensor Memory Warning
  - Plugged Impulse Line Detector

- **Advisory Alarms**
  - LOI Failure
  - Process Anomaly Detected (SPM)

Time: Current

Controls: OK, Cancel, Apply, Help
Transducer Blocks

- Transducer blocks provide the interface to sensors, switches, actuators, etc.

- Transducer blocks also allow access to calibration and I/O diagnostics.

- If the Transducer Block is in Out of Service Mode, the Function Blocks will have measurement value with Bad Status.

- Transducer communicates the values to the I/O Function Blocks via Channels.
Transducer

Free Running

Schedule

AI 1

AI 2

AI 3

AI 4

Channel 1

Channel 2

Channel 3

Channel 4

calc

Sensor 1

Sensor 2

Sensor 3

Control Loop Knowledge Base
Important to remember

- AI or AO block has to have the Channel configured accordingly. Channel = 0, no measurement or actuation.

- AI or AO block XD_SCALE parameter has to have the same valid Engineering Unit. Pressure measurement should be inH2O@68F, mbar, psi, etc. Temperature should be deg. C, not C.

- Transducer should be in Auto.
## Pressure Transducer - Process

### Configuration of 3051LEVEL [3051 Fieldbus Pressure Transmitter Rev. 20]

<table>
<thead>
<tr>
<th>Blocks</th>
<th>Process</th>
<th>Sensor</th>
<th>PV</th>
<th>SV</th>
<th>Materials</th>
</tr>
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<tbody>
<tr>
<td>RESOURCE</td>
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<tr>
<td>TRANSUDER 1100</td>
<td></td>
<td></td>
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<tr>
<td>TRANSUDER 1200</td>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>TRANSUDER 1300</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

#### Actual Mode
- [x] Automatic
- [ ] Manual
- [ ] Out Of Service

#### Target Mode
- [x] Automatic
- [ ] Manual
- [ ] Out Of Service

#### Permitted Mode
- [x] Automatic
- [ ] Manual
- [x] Out Of Service

<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Strategy</td>
<td>0</td>
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<tr>
<td>Plant Unit</td>
<td>0</td>
<td></td>
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<tr>
<td>Tag</td>
<td>TRANSUDER</td>
<td></td>
</tr>
<tr>
<td>Tag Description</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Time:** Current

[Control Loop Knowledge Base]
Pressure Transducer - Sensor
Pressure Transducer - PV

Configuration of 3051LEVEL [3051 Fieldbus Pressure Transmitter Rev. 20]

- **Value**: 8.089791 inH2O
- **Status**: Good; NonCascade::NonSpecific; NotLimited
- **Prim Val Type**: differential pressure
- **PV Damping**: 0.000000 Sec

**PV Range**
- EU at 100%: 250.000000 inH2O
- EU at 0%: -250.000000 inH2O

**Calibration**
- Cal Pt Hi: 250.000 inH2O
- Cal Pt Lo: 0.000 inH2O
- Cal Min Span: 2.273 inH2O
- Cal Unit: inH2O (68 F)
Pressure Transducer - SV

Value: 22.161926 deg C
SV Unit: deg C
Status: Good_NoneCascade::NonSpecific::NotLimited

ControlLoop Knowledge Base
Pressure Transducer - Materials

Configuration of 3051LEVEL [3051 Fieldbus Pressure Transmitter Rev. 20]

- **Device**
  - Flange Type: Coplanar
  - Flange Material: 316 SST
  - O-ring Material: PTFE
  - Drain Vent Matl: 316 SST

- **Remote Seal**
  - Num Remote Seal: None
  - RS Type: None
  - RS Isoitr Matl: None
  - RS Fill Fluid: None

**Control Loop Knowledge Base**
Pressure Transducer - LCD
Pressure Transducer - LCD

[Diagram of a configuration interface for a pressure transducer system]

Control Loop Knowledge Base
Pressure Transducer – Advanced Diagnostic Block

Control Loop Knowledge Base
Pressure Transducer – Advanced Diagnostic Block
Pressure Transducer - Status

条件为3051LEVEL

推荐操作：无需操作。

传感器

压力故障

- 压力值：7.920857 inH2O
- PV状态：Good_NonCascade::NonSpecific:NotLimited

- 优先值失败

- 选择抑制

- 选择次值失败

温度体故障

- 温度值：22.112488 deg C
- SV状态：Good_NonCascade::NonSpecific:NotLimited

- 选择抑制

- 选择次值失败

- 详细状态：
  - 压力传感器温度超出故障限制
  - 温度传感器未更新

内存故障

- 选择抑制

- 选择内存模块内存故障

详细状态：
- 压力传感器ROM校验和错误
- 压力传感器内存校验和错误
- 压力传感器NV写入错误
- 压力传感器NV工厂数据错误
- 压力传感器NV用户数据错误

温控器

- 选择抑制

- 选择温度传感器未更新

- 详细状态：
  - 压力传感器温度超出故障限制
  - 温度传感器未更新

控制循环知识库

ControlLoop Knowledge Base
Pressure Transducer - Status

Recommended Action: No action required.

Sensor
- ROM Memory Failure
  - Suppress
  - Memory Failure
- Non Voltatile Memory Failure
  - Suppress
  - NV Memory Failure

Electronics Board
- Detailed Status
  - Manufacturing Block Integrity Error
  - ROM (Flash) Integrity Error
Pressure Transducer - Status

Recommended Action: No action required.

Maintenance
- Sensor
  - Pressure Degraded
    - Suppress
    - Primary Value Degraded
  - PV Value: 8.229631 inH2O
  - PV Status: Good
- Body Temperature Degraded
  - Suppress
  - Secondary Value Degraded
  - SV Value: 22.146088 deg C
  - SV Status: Good
- Memory
  - Suppress
  - Sensor Module Memory Warning
- Diagnostics
  - Suppress
  - Plugged Impulse Line Detected

Detailed Status
- Sensor NV Factory Data Warning
- Sensor NV User Data Warning
Pressure Transducer - Status

Recommended Action: No action required.

Advisory
- Local Display:
  - Suppress
  - LOI Failure

Statistical Process Monitoring
- SPM1
  - Block Tag
  - Mean Change Detected
  - High Variation Detected
  - Low Dynamics Detected
- SPM2
  - Block Tag
  - Mean Change Detected
  - High Variation Detected
  - Low Dynamics Detected
- SPM3
  - Block Tag
  - Mean Change Detected
  - High Variation Detected
  - Low Dynamics Detected
- SPM4
  - Block Tag
  - Mean Change Detected
  - High Variation Detected
  - Low Dynamics Detected