

# Rosemount™ 3051S Series Pressure Transmitter

## with FOUNDATION™ Fieldbus Protocol

Overview .....	page 1
Configuration .....	page 2
Installation .....	page 5
Operation and maintenance .....	page 5
Troubleshooting .....	page 5
Advanced Pressure Diagnostics for Foundation Fieldbus .....	page 10

## 1.0 Overview

This manual is intended to be used as a supplement to the Rosemount™ 3051S Series Pressure Transmitter with FOUNDATION™ Fieldbus Protocol Reference Manual when option code IT6 has been selected. This manual supplement provides information on configuring, installing, operating, maintaining, and troubleshooting the Rosemount 3051S Series Pressure Transmitter with FOUNDATION Fieldbus communications. See [Table 1](#) and [Figure 1](#).

**Table 1. Device Driver Information**

Release date	Device identification			Device driver identification		Review instructions	Review functionality
	NAMUR hardware revision <sup>(1)</sup>	NAMUR software revision <sup>(1)</sup>	FOUNDATION Fieldbus software revision	FOUNDATION Fieldbus universal revision	Device revision <sup>(2)(3)</sup>	Manual document number	Change description
July-17	1.0.xx	1.0.xx	3.00.01	6.1.2	24	<a href="#">00809-0200-4801</a>	Updated Field Diagnostics, Mass Flow Removed
Dec-08	N/A	N/A	1.11.9, 2.1.2	5.0.1	23	<a href="#">00809-0200-4801</a>	Multi-bit Alert Reporting, Block Instantiation, Common Software Download
Sep-01	N/A	N/A	1.0.3	4.01	20	<a href="#">00809-0200-4801</a>	Initial Product Release

1. NAMUR Revision is located on the hardware tag of the device. Differences in level 3 changes, signified above by xx, represent minor product changes as defined per NE53. Compatibility and functionality are preserved and product can be used interchangeably.
2. FOUNDATION Fieldbus device revision can be read using a FOUNDATION Fieldbus capable configuration tool. Value shown is minimum revision that could correspond to NAMUR Revisions.
3. Device driver file names use device and DD revision. To access new functionality, the new Device Driver must be downloaded. It is recommended to download new Device Driver files to ensure full functionality.

**Figure 1. Transmitter Data Flow**



## 1.1 Product recycling/disposal

Recycling of equipment and packaging should be taken into consideration and disposed of in accordance with local and national legislation/regulations.

## 2.0 Configuration

- For complete configuration details using Fieldbus, reference the [Rosemount 3051S FOUNDATION Fieldbus Reference Manual](#).

### 2.1 Device configuration

#### Display configuration

The following configuration items are found in the LCD display Transducer Block.

The transmitter features a three-line display. The first line of five characters displays the output description, the second line of seven digits displays the actual value, and the third line of six characters displays engineering units. The LCD display meter can also display diagnostic messages.

Each parameter configured for display will appear on the LCD display for a brief period before the next parameter is displayed. Up to four different variables may be shown on the display.

The LCD display meter is preconfigured to show the measured variables that correspond to the transmitter configuration. It can be configured to display any measured or calculated value that has a status parameter with it (i.e. FOUNDATION Fieldbus DS-65 parameter type). Configure each parameter for display as stated below.

#### Display parameter select

The display of each configured parameter can be turned on or off by editing the Display Parameter Select parameter. Parameter options include pressure, module temperature, bar graph, and scaled variable.

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#### Note

The scaled variable configuration allows the user to create a relationship/conversion between the pressure units and user-defined/custom units.

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#### Block type

Enter the *Block Type* for the block that contains the parameter to be displayed.

#### Block tag

Enter the *Block Tag* of the block that contains the parameter to be displayed.

## Parameter index

Enter the *Block Index* of the parameter to be displayed.

## Custom tag

Enter up to five characters to be displayed on the top line of the LCD display when this parameter is displayed.

## Units type

Select **auto** when the parameter to be displayed is pressure or percent. The units of the parameter will be read and automatically displayed on the LCD display.

Select **custom** to display up to six characters as configured in the *Custom Units* parameter.

Select **none** if the parameter is to be displayed without associated units.

## Custom units

If the Units Type is set to **custom** specify up to six characters to be displayed with the configured parameter.

## 2.2 Device capabilities

### General block information

- Reference information on the process control function blocks can be found in the [Function Block Reference Manual](#).

### Link active scheduler

The Rosemount 3051S can be designated to act as the backup Link Active Scheduler (LAS) in the event that the LAS is disconnected from the segment. As the backup LAS, the Rosemount 3051S will take over the management of communications until the host is restored. The host system may provide a configuration tool specifically designed to designate a particular device as a backup LAS.

### Capabilities

There are a total of 20 Virtual Communication Relationships (VCRs). One is permanent and 19 are fully configurable by the host system. Twenty-five link objects are available. See [Table 2](#) and [Table 3](#) on [page 4](#).

**Table 2. Network Parameters**

Network parameter	Value
Slot Time	6
Maximum Response Delay	4
Maximum Inactivity to Claim LAS Delay	5
Minimum Inter DLPDU Delay	7
Time Sync class	4 (1ms)
Maximum Scheduling Overhead	10
Per CLPDU PhL Overhead	4
Maximum Inter-channel Signal Skew	0
Required Number of Post-transmission-gap-ext Units	0
Required Number of Preamble-extension Units	1

## Host timer recommendations

T1 = 96000

T2 = 9600000

T3 = 480000

**Table 3. Block Execution Times**

Block	Time (in ms)
Analog Input	20
PID	25
Arithmetic	20
Input Selection	20
Signal Characterizer	20
Integrator	20
Output Splitter	20
Control Selector	20

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## 3.0 Installation

- For complete configuration details using Fieldbus, reference the [Rosemount 3051S FOUNDATION Fieldbus Reference Manual](#).

## 4.0 Operation and maintenance

- For operation and maintenance details using Fieldbus, reference the [Rosemount 3051S FOUNDATION Fieldbus Reference Manual](#).

## 5.0 Troubleshooting

- For complete troubleshooting details using Fieldbus, reference the [Rosemount 3051S FOUNDATION Fieldbus Reference Manual](#).

### 5.1 Overview

This section provides summarized troubleshooting suggestions for the most common operating problems on the Rosemount™ 3051S Series Pressure Transmitter with FOUNDATION Fieldbus.

If a malfunction is suspected despite the absence of any diagnostic messages on the communicator display, follow the procedures described to verify transmitter hardware and process connections are in good working order. Always deal with the most likely and easiest-to-check conditions first.

### 5.2 Safety messages

Procedures and instructions in this section may require special precautions to ensure the safety of the personnel performing the operations. Information that raises potential safety issues is indicated by a warning symbol ( ⚠ ). Refer to the following safety messages before performing an operation preceded by this symbol.

#### **⚠ WARNING**

##### **Explosions could result in death or serious injury.**

- Do not remove the transmitter cover in explosive atmospheres when the circuit is live.
  - Before connecting an Emerson™ Field Communicator in an explosive atmosphere, make sure the instruments in the segment are installed in accordance with intrinsically safe or non-incendive field wiring practices.
  - Verify the operating atmosphere of the transmitter is consistent with the appropriate hazardous locations certifications.
  - Both transmitter covers must be fully engaged to meet flameproof/explosion-proof requirements.
-

**⚠ WARNING**

**Failure to follow these installation guidelines could result in death or serious injury.**

- Make sure only qualified personnel perform the installation.

**Electrical shock could cause death or serious injury.**

- If the sensor is installed in a high-voltage environment and a fault or installation error occurs, high voltage may be present on the transmitter leads and terminals.
- Use extreme caution when making contact with the leads and terminals.

**Static electricity can damage sensitive components.**

- Observe safe handling precautions for static-sensitive components.

## 5.3 Measurement troubleshooting

The transmitter provides a means to display the current process variables. If the process variable reading is unexpected, this section provides the symptoms and possible corrective actions. See [Table 4](#) on page 6.

**Table 4. Unexpected Process Variable (PV) Readings**

Symptom	Corrective action
High PV Reading, Erratic PV Reading, Low or no PV reading	Primary element <ul style="list-style-type: none"> <li>• Check for restrictions at the primary element.</li> <li>• Check the installation and condition of the primary element.</li> <li>• Note any changes in process fluid properties that may affect output.</li> </ul>
	Impulse piping <ul style="list-style-type: none"> <li>• Check to ensure the pressure connection is correct.</li> <li>• Check for leaks or blockage.</li> <li>• Check to ensure that blocking valves are fully open.</li> <li>• Check for entrapped gas in liquid lines or for liquid in gas lines.</li> <li>• Check to ensure the density of fluid in impulse lines is unchanged.</li> <li>• Check for sediment in the transmitter process flange.</li> <li>• Make sure that process fluid has not frozen within the process flange.</li> </ul>
	Power supply <ul style="list-style-type: none"> <li>• Check the output voltage of the power supply at the transmitter. It should be 9 to 30 V dc (9 to 17.5 V dc for FISCO)</li> </ul>
	Sensor module <ul style="list-style-type: none"> <li>• Check for obvious defects, such as a punctured isolating diaphragm or fill fluid loss, and if replacement is needed, contact the nearest Emerson Service Center.</li> <li>• Check for proper fill fluid characteristics.</li> </ul>

## 5.4 Communication troubleshooting

Some host systems may ask for the device's capability level during commissioning. If prompted, the correct value to enter for the 3051S is 1.

**Note**

Use this section if other devices appear on the segment, communicate, and remain on the segment. If other devices don't appear on the segment, communicate, or stay on the segment, the electrical characteristics of the segment should be checked. See [Table 5 on page 7](#).

**Table 5. Troubleshooting Guide**

Symptom	Recommended actions <sup>(1)</sup>
Device does not show up on segment	Device power 1. Cycle power to device. 2. Ensure the device is connected to the segment. 3. Check voltage at terminals. There should be 9-30 V (9-17.5 V for FISCO). 4. Ensure the device is drawing current. There should be approximately 17 mA.
	Segment 1. Remove other devices from segment to check for interfering devices.
	Incompatible network settings 1. Change host network parameters. Refer to host documentation for procedure.
	Electronics failing 1. Electronics board or terminal block loose in housing. 2. Replace electronics.
Device does not stay on segment	Signal levels 1. Check for two terminators. 2. Check for excess cable length. 3. Check for bad power supply or conditioner.
	Segment noise <sup>(2)</sup> 1. Check for incorrect grounding. 2. Check for correct shielded wire. 3. Tighten all wiring and shield connections on the affected part of the segment. 4. Check for corrosion or moisture on terminals.
	Electronics failure 1. Check for loose electronics board in housing. 2. Check for water in the terminal housing. 3. Replace electronics.

1. The corrective actions should be done with consultation of the system integrator.

2. Refer to wiring and installation 31.25 kbit/s, voltage mode, wire medium application guide AG-140 available from the FieldComm Group.

## 5.5 Alarms and conditions

Detailed tables of the possible messages that will appear on either the LCD display, a Field Communicator, or a PC-based configuration and maintenance system are listed below. Use [Table 6](#), [Table 7](#), [Table 8](#), and [Table 9](#) to diagnose particular status, maintenance, and function messages.

**Table 6. Failure–Fix Now**

Alert label	LCD display message	Description	Recommended action
Electronic Circuit Board Failure	FAIL BOARD ERROR	Failure has been detected in the electronic circuit board	1. Replace the electronic circuit board.

**Table 6. Failure–Fix Now**

Alert label	LCD display message	Description	Recommended action
Sensor Module Failure	FAIL SENSOR ERROR	Failure has been detected in the sensor module	1. Replace the sensor module.
Sensor Module Communication Failure	SNSR COMM ERROR	Electronic circuit board has stopped receiving updates from the sensor module	1. Verify the device is receiving adequate supply voltage. 2. Remove front housing cover (considering hazardous location requirements) and check the cable and cable connection between sensor module and electronic circuit board. 3. Replace the electronic circuit board. 4. Replace the sensor module.
Sensor Module Incompatibility	SNSR INCOMP ERROR	Sensor module is not compatible with the electronic circuit board	1. Replace the sensor with a compatible single variable sensor module.

**Table 7. Out of Specification–Fix Soon**

Alert label	LCD display message	Description	Recommended action
Pressure Out of Limits	PRESS LIMIT	Pressure has exceeded the transmitter's maximum measurement range	1. Verify conditions of the process where the transmitter is installed. 2. Check transmitter pressure connection to make sure it is not plugged and isolating diaphragms are not damaged. 3. Replace the sensor module.
Module Temperature Out of Limits	SNSRT LIMIT	Module temperature sensor has exceeded its normal range	1. Check process and ambient temperatures where the transmitter is installed to ensure they are within specifications. 2. Replace the sensor module.

**Table 8. Maintenance Required**

Alert label	LCD display message	Description	Recommended action
Plugged Impulse Line Detected	ADB ALERT	Plugged impulse line has been detected by the Advanced Diagnostics Block	1. Verify there is a plugged line. 2. If this is a false trip, reconsider the trip values and restart the diagnostic.
Statistical Process Monitor Trip	ADB ALERT	Statistical process monitor has detected either a mean variation or high or low dynamics in the process	1. Verify the condition of the process being monitored by the SPM. 2. If this is a false trip, reconsider the SPM configuration.



**Table 8. Maintenance Required**

Alert label	LCD display message	Description	Recommended action
Display Update Error	LCD UPDATE ERROR	Electronic circuit board has lost communication with the display	<ol style="list-style-type: none"> <li>1. Remove front housing cover (considering hazardous location requirements) and check the 4-pin connector between the display and electronic circuit board.</li> <li>2. Check cable and cable connection between the sensor module and electronic circuit board.</li> <li>3. Replace the display.</li> <li>4. Replace electronic circuit board.</li> </ol>

**Table 9. Function Check**

Alert label	LCD display message	Description	Recommended action
Check Function	N/A	Transducer block mode is not in auto	<ol style="list-style-type: none"> <li>1. Check if any transducer block is currently under maintenance.</li> <li>2. If no transducer block is under maintenance, follow site procedures to change affected transducer block's actual mode to auto.</li> </ol>

## 5.6 Service support

To expedite the return process outside of the United States, contact the nearest Emerson representative.

Within the United States, call the Emerson Instrument and Valves Response Center using the 1-800-654-RSMT (7768) toll-free number. This center, available 24 hours a day, will assist with any needed information or materials.

The center will ask for product model and serial numbers, and will provide a Return Material Authorization (RMA) number. The center will also ask for the process material to which the product was last exposed.

### **⚠ CAUTION**

Individuals who handle products exposed to a hazardous substance can avoid injury if they are informed of and understand the hazard. If the product being returned was exposed to a hazardous substance as defined by OSHA, a copy of the required Safety Data Sheet (SDS) for each hazardous substance identified must be included with the returned goods.

Emerson Instrument and Valves Response Center representatives will explain the additional information and procedures necessary to return goods exposed to hazardous substances.

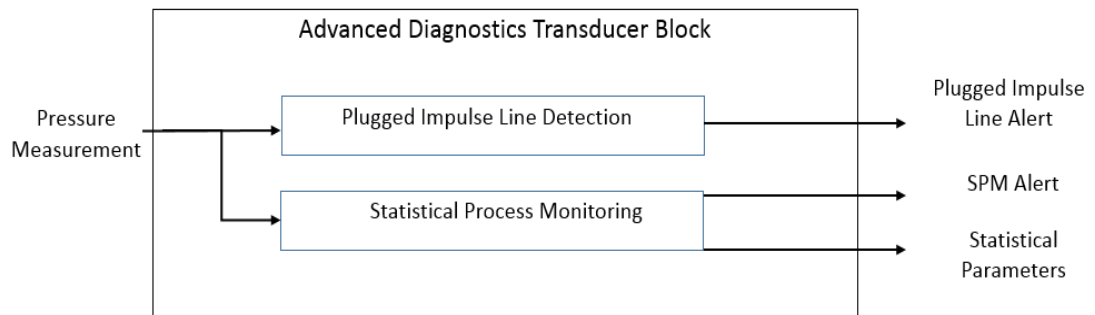
## 6.0 Advanced Pressure Diagnostics for FOUNDATION Fieldbus

### 6.1 Overview

The Rosemount 3051S FOUNDATION Fieldbus Pressure Transmitter with Advanced Diagnostics Suite is an extension of the Rosemount 3051S Scalable™ Pressure Transmitter and takes full advantage of the architecture. The Rosemount 3051S SuperModule™ Platform generates the pressure measurement. The FOUNDATION Fieldbus Feature Board is mounted in the Plantweb™ housing and plugs into the top of the SuperModule. The Advanced Diagnostics Suite is an order option on the FOUNDATION Fieldbus feature board, and designated by the option code “D01” in the model number.

The Advanced Diagnostics Suite has two distinct diagnostic functions, Statistical Process Monitoring (SPM) and Plugged Impulse Line Detection (PIL), which can be used separately or in conjunction with each other to detect and alert users to conditions that were previously undetectable, or provide powerful troubleshooting tools. Figure 2 illustrates an overview of these two functions within the Fieldbus Advanced Diagnostics Transducer Block.

Figure 2. Advanced Diagnostics Transducer Block Overview



### 6.2 SPM

The Advanced Diagnostics Suite features SPM technology to detect changes in the process, process equipment or installation conditions of the transmitter. This is done by modeling the process noise signature (using the statistical values of mean and standard deviation) under normal conditions and then comparing the baseline values to current values over time. If a significant change in the current values is detected, the transmitter can generate an alert. The SPM performs its statistical processing on the pressure measurement of the field device. The statistical values are also available as secondary variables from the transmitter via AI Function Blocks if a user is interested in their own analysis or generating their own alarms.

### 6.3 PIL diagnostics

The Advanced Diagnostics Suite also implements a plugged impulse line detection algorithm. PIL leverages SPM technology and adds some additional features that apply SPM to directly detect plugging in pressure measurement impulse lines. In addition to detecting a change in the process noise signature, the PIL also provides the ability to automatically relearn new baseline values if the process condition changes. When PIL detects a plug, a “Plugged Impulse Line Detected” Plantweb alert is generated. Optionally, the user can configure the PIL to, when a plugged impulse line is detected, change the

pressure measurement status quality to “Uncertain” to alert an operator that the pressure reading may not be reliable.

**Important**

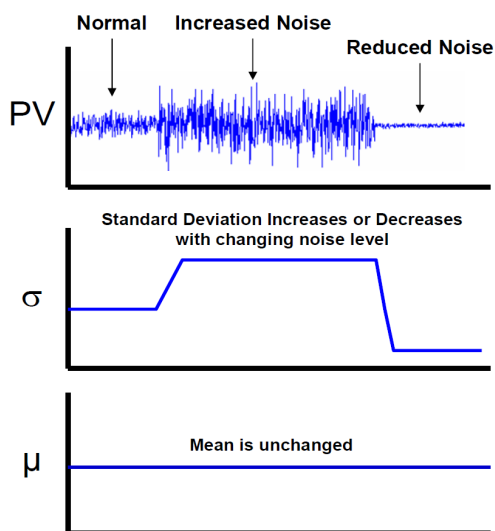
Running the Advanced Diagnostics Block could affect other block execution times. We recommend the device be configured as a basic device versus a Link Master device if this is a concern.

## 6.4 SPM technology

SPM is a unique technology developed by Emerson that provides a means for early detection of abnormal situations in a process environment. The technology is based on the premise that virtually all dynamic processes have a unique noise or variation signature when operating normally. Changes in these signatures may signal that a significant change will occur or has occurred in the process, process equipment, or transmitter installation. For example, the noise source may be equipment in the process such as a pump or agitator, the natural variation in the DP value caused by turbulent flow, or a combination of both.

The sensing of the unique signature begins with the combination of a high speed sensing device, such as the Rosemount 3051S Pressure Transmitter, with software resident in a FOUNDATION Fieldbus Feature Board to compute statistical parameters that characterize and quantify the noise or variation. These statistical parameters are the mean and standard deviation of the input pressure. Filtering capability is provided to separate slow changes in the process due to setpoint changes from the process noise or variation of interest. Figure 3 shows an example of how the standard deviation value ( $\sigma$ ) is affected by changes in noise level while the mean or average value ( $\mu$ ) remains constant. The calculation of the statistical parameters within the device is accomplished on a parallel software path to the path used to filter and compute the primary output signal the pressure measurement used for control and operations). The primary output is not affected in any way by this additional capability.

**Figure 3. Effects of Process Noise or Variability**



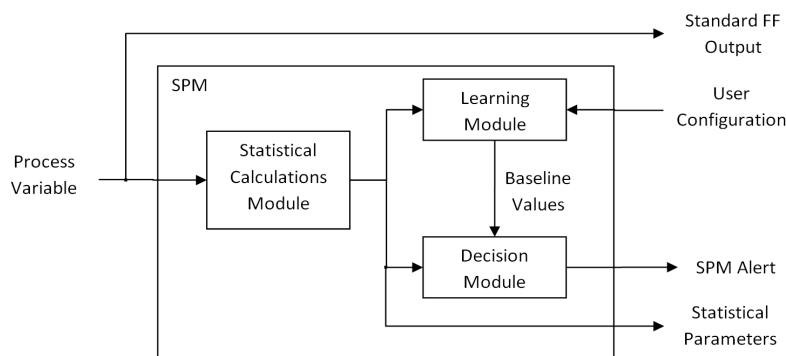
The device can provide the statistical information to the user in two ways. First, the statistical parameters can be made available to the host system directly via FOUNDATION Fieldbus communication protocol or FOUNDATION Fieldbus to other protocol converters. Once available, the system may make use of these statistical parameters to indicate or detect a change in process conditions. In the simplest example, the statistical values may be stored in the DCS historian. If a process upset or equipment problem occurs, these values can be examined to determine if changes in the values foreshadowed or indicated the process upset. The statistical values can then be made available to the operator directly, or made available to alarm or alert software.

Additionally, the device has internal software that can be used to baseline the process noise or signature via a learning process. Once the learning process is completed, the device itself can detect significant changes in the noise or variation, and communicate an alarm via Plantweb alert. Typical applications are change in fluid composition or equipment related problems.

## 6.5 SPM functionality

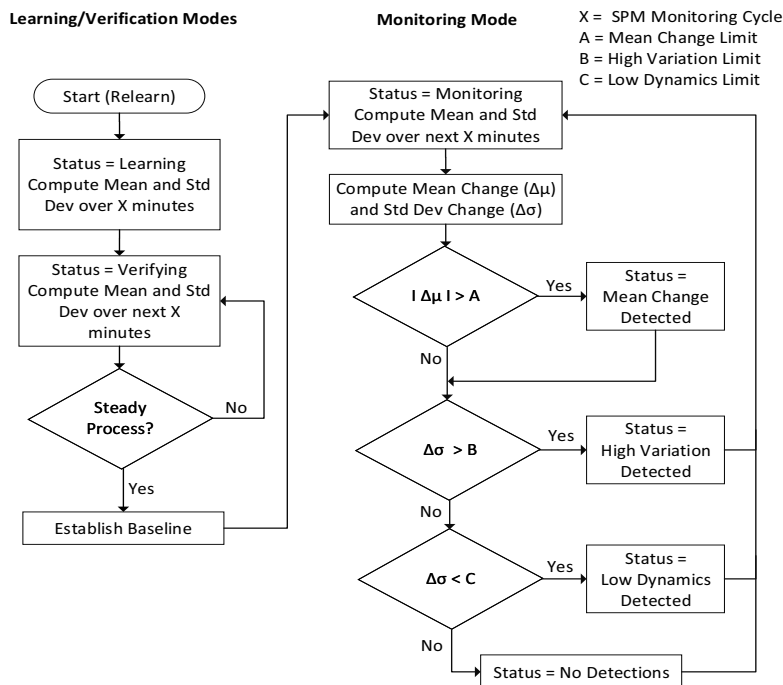
A block diagram of the SPM diagnostic is shown in Figure 4. The process variable (the measured pressure) is input to a Statistical Calculations Module where basic high pass filtering is performed on the pressure signal. The mean (or average) is calculated on the unfiltered pressure signal, the standard deviation calculated from the filtered pressure signal. These statistical values are available via handheld communication devices like the field communicator, asset management software, or distributed control systems with FOUNDATION Fieldbus.

Figure 4. Rosemount 3051S FF Statistical Process Monitoring



SPM also contains a learning module that establishes the baseline values for the process. Baseline values are established under user control at conditions considered normal for the process and installation. These baseline values are made available to a decision module that compares the baseline values to the most current values of the mean and standard deviation. Based on sensitivity settings and actions selected by the user via the control input, the diagnostic generates a device alert when a significant change is detected in either mean or standard deviation.

**Figure 5. Statistical Process Monitoring Flow**



Further detail of the operation of the SPM diagnostic is shown in the Figure 5 flowchart. This is a simplified version showing operation using the default values. After configuration, SPM calculates mean and standard deviation, used in both the learning and the monitoring modes. Once enabled, SPM enters the learning/verification mode. The baseline mean and standard deviation are calculated over a period of time controlled by the user (SPM Monitoring Cycle; default is 5 minutes). The status will be “Learning”. A second set of values is calculated and compared to the original set to verify that the measured process is stable and repeatable. During this period, the status will change to “Verifying”. If the process is stable, the diagnostic will use the last set of values as baseline values and move to “Monitoring” status. If the process is unstable, the diagnostic will continue to verify until stability is achieved.

In the “Monitoring” mode, new mean and standard deviation values are continuously calculated, with new values available every few seconds. The mean value is compared to the baseline mean value, and the standard deviation is compared to the baseline standard deviation value. If either the mean or the standard deviation has changed more than user-defined sensitivity settings, an alert is generated via FOUNDATION Fieldbus. The alert may indicate a change in the process, equipment, or transmitter installation.

**Note**

The SPM diagnostic capability in the Rosemount 3051S FOUNDATION Fieldbus Pressure Transmitter calculates and detects significant changes in statistical parameters derived from the input pressure. These statistical parameters relate to the variability of and the noise signals present in the pressure measurement. It is difficult to predict specifically which noise sources may be present in a given measurement or control application, the specific influence of those noise sources on the statistical parameters, and the expected changes in the noise sources at any time. Therefore, Emerson cannot absolutely warrant or guarantee that SPM will accurately detect each specific condition under all circumstances.

## 6.6 SPM configuration and operation

The following section describes the process of configuring and using the SPM diagnostic.

(optional) SPM\_MONITORING\_CYCLE = [1 – 1440] minutes (see “Other SPM settings” on page 14)

(optional) SPM\_BYPASS\_VERIFICATION = [Yes/No] (see page 14)

Apply all of these above changes to the device. Finally, set

SPM\_ACTIVE = Enabled

After SPM is enabled and SPM\_USER\_COMMAND is set to **Learn**, it will spend the first five (or whatever the SPM\_MONITORING\_CYCLE is set to) minutes in the learning phase, and then another five minutes in the verification phase. If a steady process is detected at the end of the verification phase, the SPM will move into the monitoring phase. After 5 minutes in the monitoring phase, SPM will have the current statistical values (e.g. current mean and standard deviation), and will begin comparing them against the baseline values to determine if an SPM Alert is detected.

## 6.7 Other SPM settings

Additional information on other SPM settings is shown below:

### SPM\_BYPASS\_VERIFICATION

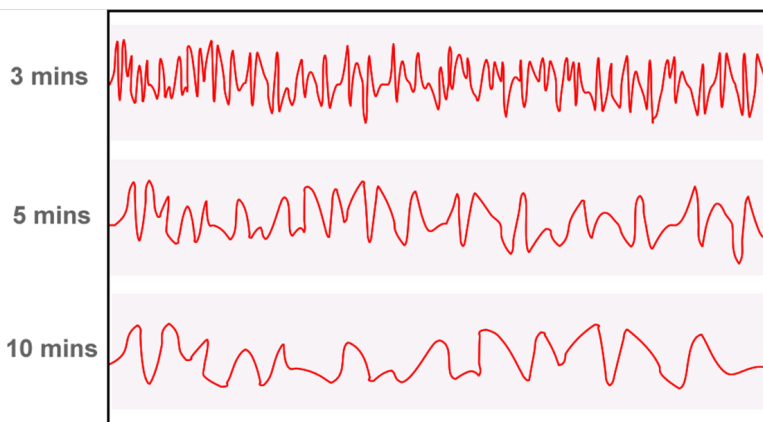
If this is set to “Yes”, SPM will skip the verification process, and the first mean and standard deviation from the learning phase will be taken as the baseline mean and standard deviation. By skipping the verification, the SPM can move into the monitoring phase more quickly. This parameter should only be set to “Yes” if you are certain that the process is at a steady-state at the time you start the Learning. The default (and recommended) setting is “No”.

### SPM\_MONITORING\_CYCLE

This is the length of the sample window over which mean and standard deviation are computed. A shorter sample window means that the statistical values will respond faster when there are process changes, but there is also a greater chance of generating false detections. A longer sample window means that mean and standard deviation will take longer to respond when there is a process change. The default value is 5 minutes. For most applications, a Monitoring Cycle ranging from 1 to 10 minutes is appropriate. The allowable range is 1 to 1440 minutes.

Figure 6 illustrates the effect of the SPM Monitoring Cycle on the Statistical Calculations. Notice how with a shorter sampling window there is more variation (e.g. the plot looks noisier) in the trend. With the longer sampling window the trend looks smoother because the SPM uses process data averaged over a longer period of time.

Figure 6. SPM Monitoring Cycle Effect on Statistical Values



## SPM\_USER\_COMMAND

Select **Learn** after all parameters have been configured to begin the Learning Phase. The monitoring phase will start automatically after the learning process is complete. Select **Quit** to stop the SPM. “Detect” may be selected to return to the monitoring phase.

## SPM\_ACTIVE

The SPM\_ACTIVE parameter starts the Statistical Process Monitoring when “Enabled”. “Disabled” (default) turns the diagnostic monitoring off. Must be set to “Disabled” for configuration. Only set to “Enabled” after fully configuring the SPM.

Enabling SPM applies a high-pass filter to the pressure measurement prior to calculating standard deviation. This removes the effect of slow or gradual process changes from the standard deviation calculation while preserving the higher-frequency process fluctuations. Using the high-pass filter reduces the likelihood of generating a false detection if there is a normal process or setpoint change.

## 6.8 Alert configuration

To have SPM generate a Plantweb alert, the alert limits must be configured on the mean and/or standard deviation. The three alert limits available are:

### SPM\_MEAN\_LIM

Upper and lower limits for detecting a Mean Change

### SPM\_HIGH\_VARIATION\_LIM

Upper limit on standard deviation for detecting a High Variation condition

### SPM\_LOW\_DYNAMICS\_LIM

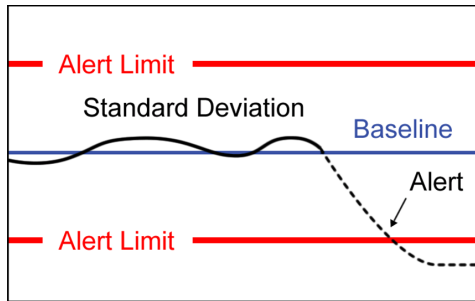
Lower limit on standard deviation for detecting a Low Dynamics condition (must be specified as a negative number)

All limits are specified as a percent change in the statistical value from its baseline. If a limit is set to 0 (the default setting) then the corresponding diagnostic is disabled. For example, if SPM\_HIGH\_VARIATION\_LIMIT is 0, then SPM does not detect an increase in standard deviation.

Figure 7 illustrates an example of the standard deviation, with its baseline value and alert limits. During the monitoring phase, the SPM will continuously evaluate the standard deviation and compare it against the baseline value. An alert will be detected if the standard deviation either goes above the upper alert limit, or below the lower alert limit.

In general, a higher value in any of these limits leads to the SPM diagnostic being less sensitive, because a greater change in mean or standard deviation is needed to exceed the limit. A lower value makes the diagnostic more sensitive, and could potentially lead to false detections.

**Figure 7. Example Alerts for Standard Deviation**



## 6.9 SPM operations

During operation, the following values are updated for the ADB Block

### **SPM\_BASELINE\_MEAN**

Baseline mean (calculated average) of the process variable, determined during the Learning/Verification process, and representing the normal operating condition

### **SPM\_MEAN**

Current Mean of the process variable

### **SPM\_MEAN\_CHANGE**

Percent change between the baseline mean and the current mean

### **SPM\_BASELINE\_STDEV**

Baseline standard deviation of the process variable, determined during the Learning/Verification process, and representing the normal operating condition

### **SPM\_STDEV**

Current Standard Deviation of the process variable

### **SPM\_STDEV\_CHANGE**

Percent change between the baseline standard deviation and the current standard deviation

### **SPM\_TIMESTAMP**

Timestamp of the last values and status for the SPM



## SPM\_STATUS

Current state of the SPM diagnostic. Possible values for SPM status are as shown in [Table 10](#).

**Table 10. SPM Diagnostic Current State**

Status value	Description
Inactive	User Command in "Idle", SPM not Enabled, or the function block is not scheduled.
Learning	Learning has been set in the User Command, and the initial baseline values are being calculated.
Verifying	Current baseline values and previous baseline values are being compared to verify the process is stable.
Monitoring	Monitoring the process and no detections are currently active.
Mean Change Detected	Alert resulting from the Mean Change exceeding the Threshold Mean Limit. Can be caused by a set point change, a load change in the flow, or an obstruction or the removal of an obstruction in the process.
High Variation Detected	Alert resulting from the Stdev Change exceeding the Threshold High Variation value. This is an indicator of increased dynamics in the process, and could be caused by increased liquid or gas in the flow, control or rotational problems, or unstable pressure fluctuations.
Low Dynamics Detected	Alert resulting from the Stdev Change exceeding the Threshold Low Dynamics value. This is an indicator for a lower flow, or other change resulting in less turbulence in the flow.

In most cases, only one of the above SPM status bits will be active at one time. However, it is possible for "Mean Change Detected" to be active at the same time as either "High Variation Detected" or "Low Dynamics Detected" is active.

### 6.10 Plantweb alert

When any of the SPM detections (Mean Change, High Variation, or Low Dynamics) is active, a Fieldbus Plantweb alert in the device "Statistical Process Monitor Trip" will be generated and sent to the host system.

### 6.11 Trending statistical values in control system

SPM mean and standard deviation values may be viewed and/or trended in a Fieldbus host system through the AI function blocks.

An AI Block may be used to read either the mean or the standard deviation from the ADB Block. To use the AI Block to trend SPM data, set the CHANNEL parameter to one of the values in [Table 11](#):

**Table 11. Valid SPM Channels for the AI Block**

Channel	SPM variable
12	Mean
13	Standard Deviation

The SPM Mean and Standard Deviation display units can be changed in the AI function blocks.

## 6.12 SPM configuration with EDDL

For host systems that support Electronic Device Description Language (EDDL), using SPM is made easier with step-by-step configuration guidance and graphical displays. This section of the manual uses AMS Device Manager version 10.5 for illustrations, although other EDDL hosts could be used as well.

The SPM Configuration Wizard can be launched by selecting **Statistical Process Monitoring** from the *Configure > Guided Setup* page.

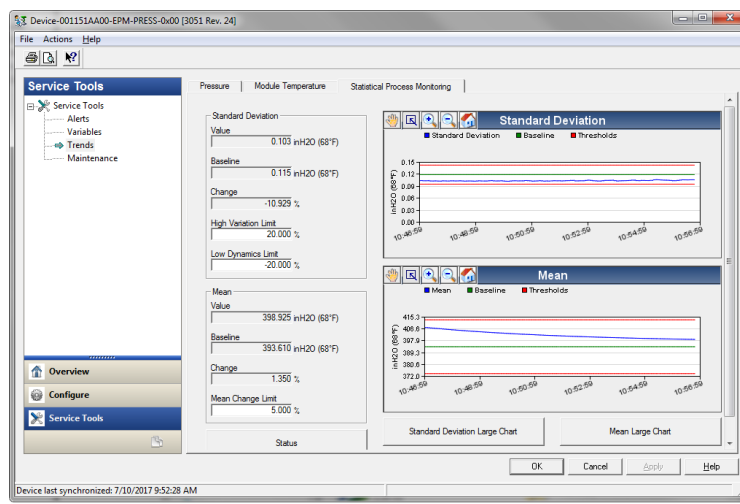
This wizard will take you step-by-step through the parameters needed to configure SPM.

## 6.13 EDDL trending of mean and standard deviation

Once the SPM has been enabled, the EDDL user interface allows for easy viewing and trending of mean and standard deviation. To open up the trending screen, select **Service Tools > Trends > Statistical Process Monitoring**.

The EDDL Screen will show an online trend of mean and standard deviation, along with the baseline values, percent change, and detection limits (Figure 8).

Figure 8. EDDL Trend of Mean and Standard Deviation



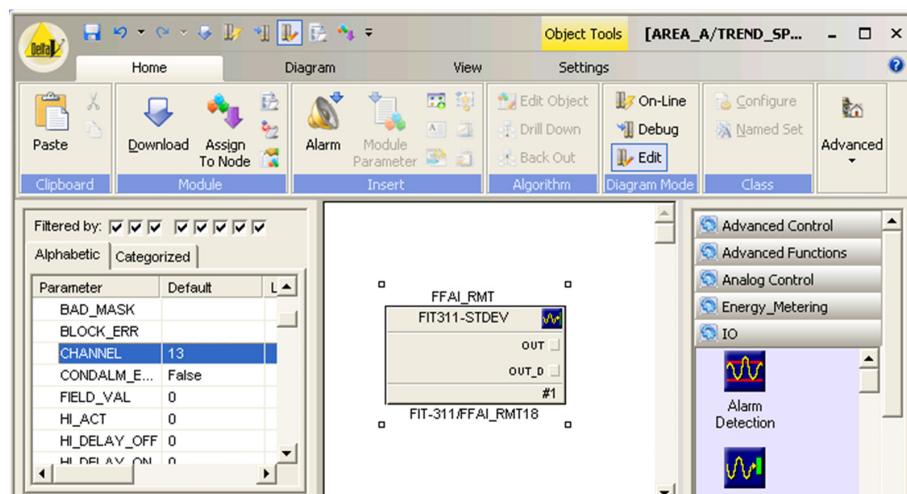
Note that data shown on the EDDL trends are not stored in a process historian or other database. When this screen is closed, all past data in the trends plots are lost. See [“Trending SPM data in DeltaV” on page 18](#) for configuring SPM data to be stored in a historian.

## 6.14 Trending SPM data in DeltaV

Refer to [“Trending statistical values in control system” on page 17](#) for general information about accessing the SPM data through the AI function blocks. This section shows a specific example of how SPM data can be accessed within the DeltaV host system, saved into the process historian, and used to generate a process alert.

1. In DeltaV Control Studio, add an AI function block.
2. Assign the new block to one of the AI function blocks in the Rosemount 3051S Device.
3. Set the CHANNEL to one of the valid SPM channel values from [Table 11 on page 17](#) (e.g. set the CHANNEL to **13** for Standard Deviation, as shown in [Figure 9](#)).

**Figure 9. Example AI Function Block for Trending Standard Deviation in DeltaV**



Set the units and scaling for the function block as desired:

XD\_SCALE = 0 to 1 in H<sub>2</sub>O (68 °F)

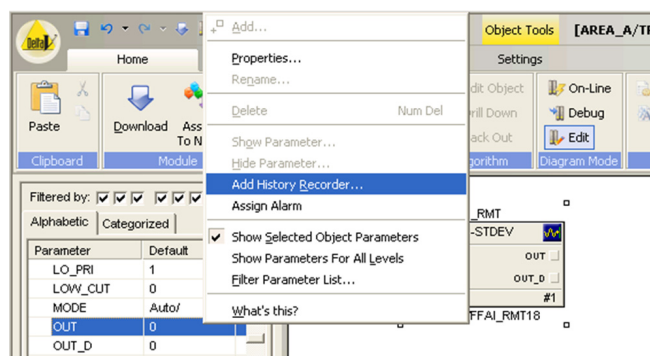
OUT\_SCALE = 0 to 1 in H<sub>2</sub>O (68 °F)

L\_TYPE = **Indirect**

Note that the range set in the OUT\_SCALE parameter will be the range shown by default when the variable is trended in the DeltaV Process History View. Standard deviation typically has a range much narrower than the process measurement, so the scaling should be set accordingly. Also note that the units for XD\_SCALE must be set to in H<sub>2</sub>O (68 °F), but the units for OUT\_SCALE can be set to any desired engineering unit.

If the standard deviation is to be logged to DeltaV Continuous Historian, the appropriate parameter must be added to the historian. Right click on the OUT parameter of the AI Block, and select **Add History Recorder ...** (Figure 10).

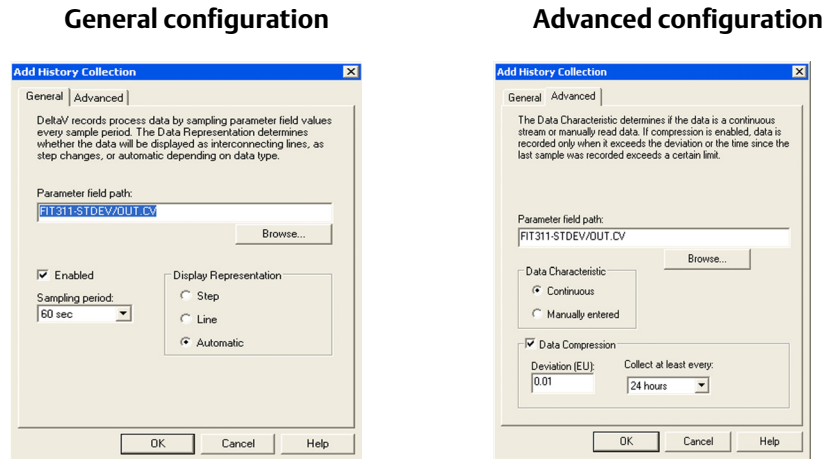
**Figure 10. Adding History Recorder from DeltaV Control Studio**



Follow through the *Add History Collection* dialog (Figure 11), to add the parameter to the DeltaV Historian with the desired sampling period, compression, etc. By default the sampling period is 60 seconds, as shown in Figure 11. However, there are many diagnostics applications where one may want to look at changes in the standard deviation much faster than this. In that case, you will want to set the sampling period to a shorter duration.

When adding a standard deviation for history collection in DeltaV, it is recommended that you not use the default data compression settings. By default, the DeltaV Historian will log a new data point only when the process value deviates by 0.01 or more. There are many diagnostics applications where it is useful to look at changes in the standard deviation that are smaller than this. Therefore, it is recommended that when logging the standard deviation, either the Data Compression should be disabled (by unchecking the appropriate box) or the Deviation (EU) should be set to a much lower value, for example, 0.001 or 0.0001.

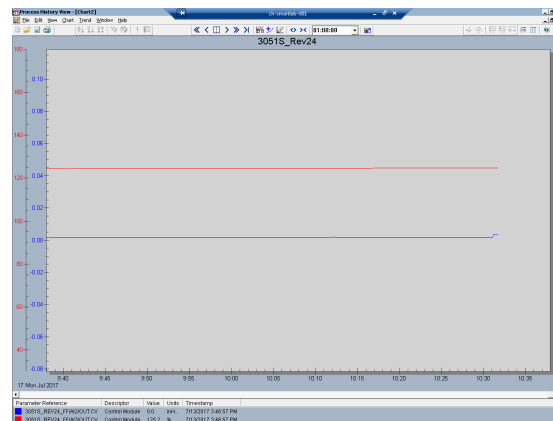
Figure 11. DeltaV Add History Collection



Refer to the DeltaV books online for more details on the DeltaV Continuous Historian.

After the SPM value has been saved to the historian, when the DeltaV Process History View is opened for the selected parameter, the graph will be populated with the historical data currently in the database (Figure 12).

Figure 12. Trend of Standard Deviation in DeltaV Process History View



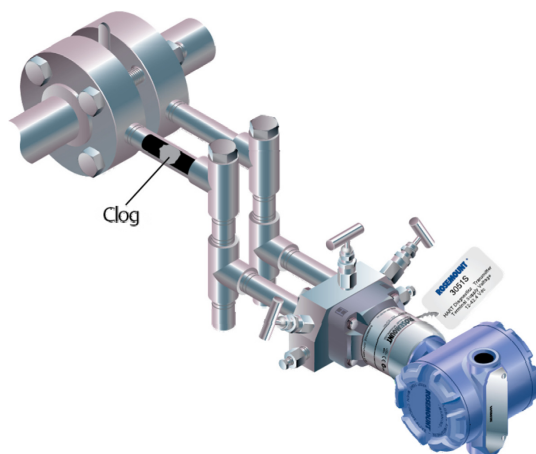
Finally, when the SPM data is trended in DeltaV, it is possible to configure HI and/or LO alarms on the mean or standard deviation via the AI Block. This can be done by right clicking on the AI Function Block in Control Studio, and selecting **Assign Alarm**. The Block Alarm configuration window will let you set up desired alarm limits. Refer to the DeltaV books online for detailed information on configuring alarms.

## 6.15 PIL detection technology

### PIL basics

Pressure transmitters are used in pressure, level, and flow measurement applications. Regardless of application, the transmitter is rarely connected directly to the pipe or vessel. Small diameter tubes or pipes commonly called impulse lines are used to transmit the pressure signal from the process to the transmitter. In some applications, these impulse lines can become plugged with solids or frozen fluid in cold environments, effectively blocking the pressure signals (Figure 13). The user typically does not know that the blockage has occurred. Because the pressure at the time of the plug is trapped, the transmitter may continue to provide the same signal as before the plug. Only after the actual process changes and the pressure transmitter's output remains the same may someone recognize that plugging has occurred. This is a typical problem for pressure measurement, and users recognize the need for a plugged impulse line diagnostic for this condition.

Figure 13. PIL Basics



Testing at Emerson and other sites indicates that SPM technology can detect plugged impulse lines. Plugging effectively disconnects the transmitter from the process, changing the noise pattern received by the transmitter. As the diagnostic detects changes in noise patterns, and there are multiple sources of noise in a given process, many factors can come into play. These factors play a large role in determining the success of diagnosing a plugged impulse line. This section of the product manual will acquaint users with the basics of the plugged impulse lines and the PIL diagnostic, the positive and negative factors for successful plugged line detection, and the do's and don'ts of installing pressure transmitters and configuring and operating the PIL diagnostic.

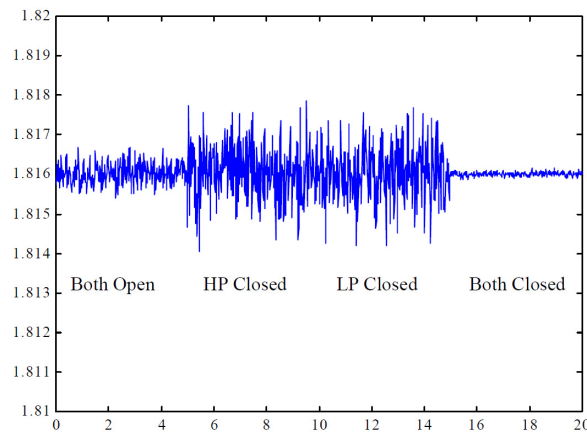
## 6.16 PIL physics

The physics of PIL detection begins with the fluctuations or noise present in most pressure and Differential Pressure (DP) signals. In the case of DP flow measurements, these fluctuations are produced by the flowing fluid and are a function of the geometric and physical properties of the system. The noise can also be produced by the pump or control system. This is also true for pressure measurements in flow applications, though the noise produced by the flow is generally less in relation to the average pressure value. Pressure level measurements may have noise if the tank or vessel has a source of agitation. The noise signatures do not change as long as the system is unchanged. In addition, these noise signatures are not affected significantly by small changes in the average value of the flow rate or pressure. These signatures provide the opportunity to identify a plugged impulse line.

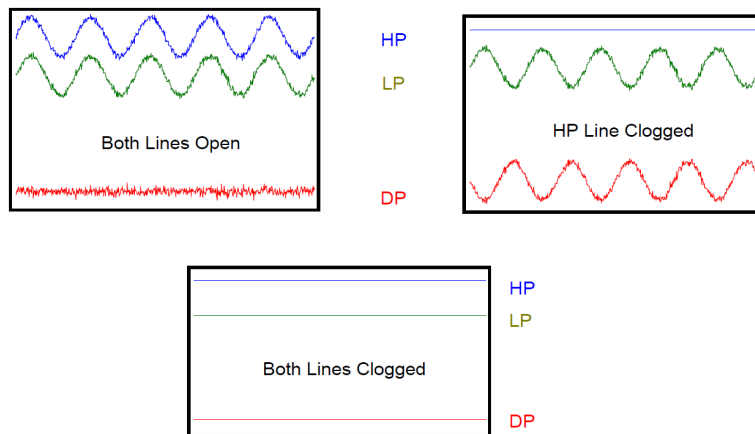
When the lines between the process and the transmitter start to plug through fouling and build-up on the inner surfaces of the impulse tubing or loose particles in the main flow getting trapped in the impulse lines, the time and frequency domain signatures of the noise start to change from their normal states. In the simpler case of a Pressure measurement, the plug effectively disconnects the Pressure transmitter from the process. While the average value may remain the same, the transmitter no longer receives the noise signal from the process and the noise signal decreases significantly. The same is true for a DP transmitter when both impulse lines are plugged.

The case of the Differential Pressure measurement in a flow application with a single line plugged is more complicated, and the behavior of the transmitter may vary depending on a number of factors. First the basics: a differential pressure transmitter in a flow application is equipped with two impulse lines, one on the high pressure side (HP) and one on the low pressure side (LP) of the primary element. Understanding the results of a single plugged line requires understanding of what happens to the individual pressure signals on the HP and LP sides of the primary element. Common mode noise is generated by the primary element and the pumping system as depicted in Figure 14. When both lines are open, the differential pressure sensor subtracts the LP from the HP. When one of the lines are plugged (either LP or HP), the common mode cancellation no longer occurs. Therefore there is an increase in the noise of the DP signal. See Figure 15.

**Figure 14. Differential Pressure Signals under Different Plugging Conditions**



**Figure 15. Differential Pressure (DP) Signals under Different Plugged Conditions**



However, there is a combination of factors that may affect the output of the DP transmitter under single plugged line conditions. If the impulse line is filled with an incompressible fluid, no air is present in the impulse line or the transmitter body, and the plug is formed by rigid material, the noise or fluctuation will decrease. This is because the combination of the above effectively “stiffens” the hydraulic system formed by the DP sensor and the plugged impulse line. The PIL diagnostic can detect these changes in the noise levels through the operation described previously.

## 6.17 Plugged line detection factors

The factors that may play a significant role in a successful or unsuccessful detection of a plugged impulse line can be separated into positive factors and negative factors, with the former increasing the chances of success and the latter decreasing the chances of success. Within each list, some factors are more important than others as indicated by the relative position on the list. If an application has some negative factors that does not mean that it is not a good candidate for the diagnostic. The diagnostic may require more time and effort to set up and test and the chances of success may be reduced. Each factor pair will be discussed.

### Ability to test installed transmitter

The single most important positive factor is the ability to test the diagnostic after the transmitter is installed, and while the process is operating. Virtually all DP flow and most pressure measurement installations include a root or manifold valve for maintenance purposes. By closing the valve, preferably the one(s) closest to the process to most accurately replicate a plug, the user can note the response of the diagnostic and the change in the standard deviation value and adjust the sensitivity or operation accordingly.

### Stable, in-control process

A process that is not stable or in no or poor control may be a poor candidate for the PIL diagnostic. The diagnostic baselines the process under conditions considered to be normal. If the process is unstable, the diagnostic will be unable to develop a representative baseline value. The diagnostic may remain in the learning/verifying mode. If the process is stable long enough to establish a baseline, an unstable process may result in frequent relearning/verifications and/or false trips of the diagnostic.

### Well vented installation

This is an issue for liquid applications. Testing indicates that even small amounts of air trapped in the impulse line of the pressure transmitter can have a significant effect on the operation of the diagnostic. The small amount of air can dampen the pressure noise signal as received by the transmitter. This is particularly true for DP devices in single line plugging situations and GP/AP devices in high pressure/low noise applications. See the next paragraph and “[Impulse line length](#)” on page 24 for further explanation. Liquid DP flow applications require elimination of all the air to insure the most accurate measurement.

### DP Flow and low GP/AP versus high GP/AP measurements

This is best described as a (noise to signal) ratio issue and is primarily an issue for detection of plugged lines for high GP/AP measurements. Regardless of the line pressure, flow generated noise tends to be about the same level. This is particularly true for liquid flows. If the line pressure is high and the flow noise is very low by comparison, there may not be enough noise in the measurement to detect the decrease brought on by a plugged impulse line. The low noise condition is further enhanced by the presence of air in the impulse lines and transmitter if a liquid application. The PIL diagnostic will alert the user to this condition during the learning mode by indicating “Insufficient Dynamics” status.

## Flow versus level applications

As previously described, flow applications naturally generate noise. Level applications without a source of agitation have very little or no noise, therefore making it difficult or impossible to detect a reduction in noise from the plugged impulse line. Noise sources include agitators, constant flow in and out of the tank maintaining a fairly consistent level, or bubblers.

## Impulse line length

Long impulse lines potentially create problems in two areas. First, they are more likely to generate resonances that can create competing pressure noise signals with the process generated noise. When plugging occurs, the resonant generated noise is still present, and the transmitter does not detect a significant change in noise level, and the plugged condition is undetected. The formula that describes the resonant frequency is:

$$f_n = (2n-1) * C / 4L \quad (2)$$

where:

resonant frequency = **f<sub>n</sub>**

mode number = **n**

speed of sound in the fluid = **C**

impulse length (in meters) = **L**

A 10-meter impulse line filled with water could generate resonant noise at 37 Hz, above the frequency response range of a typical Rosemount Pressure Transmitter. This same impulse line filled with air will have a resonance of 8.7 Hz, within the range. Proper support of the impulse line effectively reduces the length, increasing the resonant frequency.

Additionally, long impulse lines can create a mechanical low pass filter that dampens the noise signal received by the transmitter. The response time of an impulse line can be modeled as a simple RC circuit with a cutoff frequency defined by:

$$\tau = RC \text{ and } \tau = 1/2 \pi f_c$$

$$R = 8 v L / \pi r^4$$

$$C = \Delta \text{ Volume} / \Delta \text{ Pressure}$$

where:

Cut-off frequency = **f<sub>c</sub>**

Viscosity in centipoises = **v**

Impulse line length in meters = **L**

Radius of the impulse line = **r**

The “C” formula shows the strong influence of air trapped in a liquid filled impulse line, or an impulse line with air only. Both potential issues indicate the value of short impulse lines. One installation best practice for DP flow measurements is the use of the Rosemount 405 series of integrated compact orifice meters with the Rosemount 3051S Pressure Transmitter. These integrated DP flow measurement systems provide perhaps the shortest practical impulse line length possible while significantly reducing overall installation cost and improved performance. They can be specified as a complete DP flowmeter.



**Note**

The Plugged Impulse Line diagnostic capability in the Rosemount 3051S FOUNDATION Fieldbus Pressure Transmitter calculates and detects significant changes in statistical parameters derived from the input process variable. These statistical parameters relate to the variability of the noise signals present in the process variable. It is difficult to predict specifically which noise sources may be present in a given measurement or control application, the specific influence of those noise sources on the statistical parameters, and the expected changes in the noise sources at any time. Therefore, it is not absolutely warranted or guaranteed the PIL diagnostic will accurately detect each specific plugged impulse line condition under all circumstances.

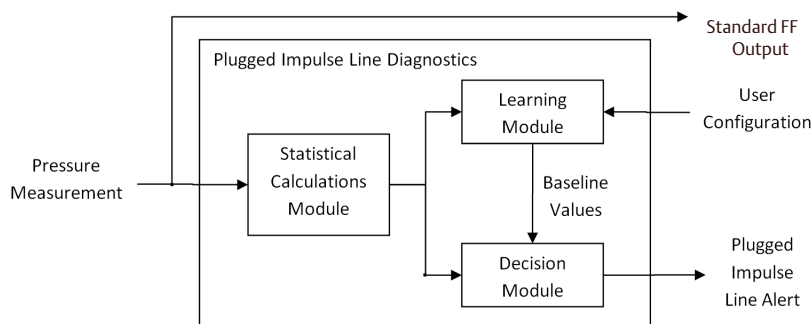
## 6.18 PIL functionality

The Advanced Diagnostics Suite provides the PIL diagnostic, as an easy way to apply SPM technology specifically for detecting plugging in pressure measurement impulse lines. Similar to SPM, PIL also calculates the mean and standard deviation of the pressure measurement and generates an alert when the standard deviation exceeds an upper or lower limit.

Figure 16 illustrates a block diagram of the plugged impulse line diagnostic. Notice it is very similar to the diagram for SPM shown in Figure 4. However, there are a couple of notable differences with PIL:

- Statistical values (mean and standard deviation) are not available as outputs
- The Plantweb alert generated specifically indicates “Plugged Impulse Line Detected”

**Figure 16. Overview of Plugged Impulse Line Diagnostics**



PIL also includes some additional features to make it especially suitable for detecting plugging in pressure measurement impulse lines. PIL has the ability to:

- Automatically relearn new baseline values if the pressure measurement changes significantly
- Set the status quality of the pressure measurement to “Uncertain” if a plugged impulse line is detected
- Check for a minimum process dynamics during the learning process
- Adjust the verification settings
- Set separate learning and detection periods

**Figure 20. Plugged Impulse Line Diagnostics Flow**

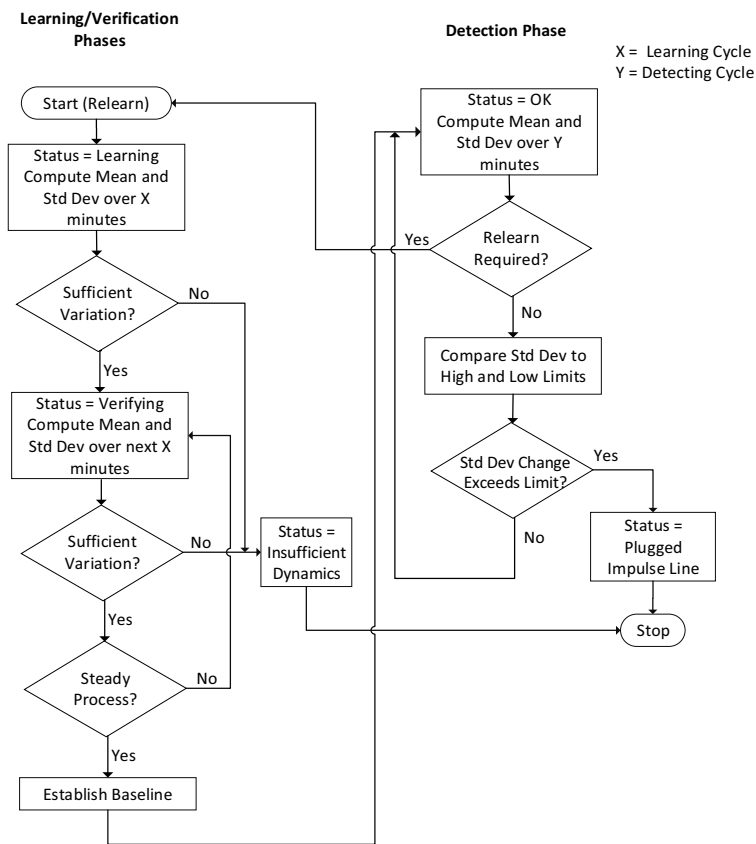


Figure 20 on page 26 shows a flow chart of the PIL algorithm. Note this diagram shows the sequence of PIL steps using the default configuration settings. The specific steps that PIL goes through are as follows:

## 1. Learning phase

PIL begins the learning process when the PIL is *Enabled*, when the User Command is set to “Relearn”, or when a mean change is detected during the Detection Phase. PIL collects the pressure values for five minutes and computes the mean and the standard deviation.

### Note

The length of the learning period is user-adjustable, with five minutes as the default value. During the learning phase, the status is “Learning”.

## 2. Sufficient variation

During the *Learning* and the *Verify* modes, the PIL checks that the noise level (e.g. the standard deviation) is high enough for reliable detection of plugged impulse lines. If the noise level is too low, the status goes to “Insufficient Dynamics”, and the PIL stops. PIL will not resume learning again until a “Relearn” command is given.

## 3. Verification phase

PIL collects the pressure values for an additional five minutes (or same length as learning period) and computes a second mean and standard deviation. During this phase, the PIL status is “Verifying”.

## 4. Steady process verification

At the end of the verification phase, the PIL compares the last mean and standard deviation against the previous mean and standard deviation to determine if the process is at a steady state. If the process is at a steady-state, then the PIL moves into detection phase. If not, then PIL repeats the verification phase.

## 5. Establish baseline

At the end of the verification phase, if the process has been determined to be at a steady state, the last mean and standard deviation are taken to be the “Baseline” values, representative of the normal process operating condition.

## 6. Detection phase

During the detection phase, the PIL collects pressure data for one minute and computes the mean and the standard deviation.

---

### Note

The length of this detection period is user-adjustable, with one minute as the default value.

---

## 7. Relearn required

Automatic relearning only applies if “Auto Relearn” is enabled with a relearn threshold configured. At the end of the detection phase, PIL first compares the current mean with the baseline mean. If the two differ significantly, then the PIL goes back into the learning phase, because the process conditions have changed too much for a reliable detection of a plugged impulse line.

## 8. Compare standard deviations

If no relearn is required, the PIL compares the current standard deviation against the baseline standard deviation to determine if a plugged impulse line is detected. For all sensor types, the PIL checks if the standard deviation has decreased below a lower limit. For DP sensors, the PIL also checks if the standard deviation has increased above an upper limit. If either of these limits is exceeded, the status changes to “Plugged Impulse Line” and the PIL stops, and will not resume again until a “Relearn” command is given. If a plugged impulse line is not detected, the status is “OK” and the detection phase is repeated.

## 6.19 Configuration of PIL detection

This section describes the configuration of the Plugged Impulse Line diagnostic.

## 6.20 Basic configuration

For some plugged impulse line applications there will be a very significant (> 80%) decrease in standard deviation. Examples of this would include a plug in the impulse line of a GP/AP measurement in a noisy process, or a plug in both impulse lines of a DP measurement. In these applications, configuring plugged impulse line detection requires nothing more than turning it on. To do this, set:

**PLINE\_ON = Enabled**

Once the PIL is enabled, it will automatically start the learning process, and move to the detection phase if there is sufficient variation and the process is stable.

Optionally, if, when a plugged impulse line is detected, you want to automatically have the status quality of the pressure measurement go to “Uncertain”, set the parameter:

**PLINE\_AFFECT\_PV\_STATUS = Yes**

By default, the value of PLINE\_AFFECT\_PV\_STATUS is “No”, meaning the quality of the pressure measurement will not be changed if PIL detects a plugged impulse line. Setting this parameter to **Yes** will cause the status quality to change to “Uncertain” when a plugged impulse line is detected. Depending upon the DCS configuration, the “Uncertain” quality could be visible to the operator, or it could affect the control logic.

If you ever want to re-start the PIL learning process, set the parameter:

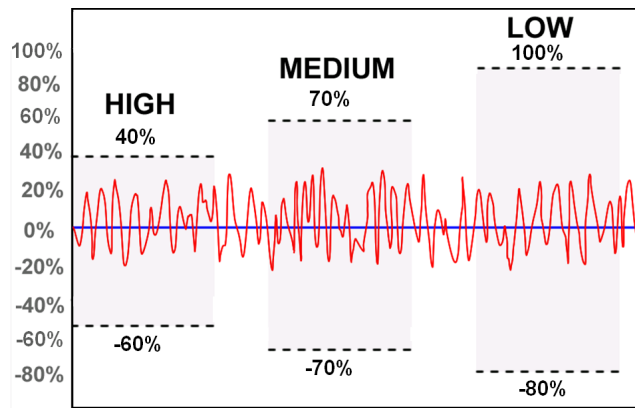
PLINE\_RELEARN = **Relearn**

## 6.21 Configuration of detection sensitivity

Although a few impulse line applications can be configured just by enabling the PIL, the majority of applications will require configuring the detection sensitivity (that is, the upper and/or lower limit on the standard deviation at which an impulse line plug will be detected).

Figure 21 illustrates the basic detection sensitivity setting for PIL. In general, a higher sensitivity means that the PIL is more sensitive to changes in the process dynamics, while a lower sensitivity means that the PIL is less sensitive to process dynamics changes.

**Figure 21. PIL Basic Detection Sensitivities**



Detection sensitivities are specified as a percent change in the standard deviation from the baseline value. Note from Figure 21 that a higher detection limit (% change) actually corresponds to a lower sensitivity, because a greater change in the process dynamics is required to trigger a plugged impulse line alert. Likewise, a lower detection limit corresponds to a higher sensitivity.

In PIL, the Detection Sensitivity is determined by 3 parameters: PLINE\_SENSITIVITY, PLINE\_DETECT\_SENSITIVITY, and PLINE\_SINGLE\_DETECT\_SENSITIVITY.

The PLINE\_SENSITIVITY parameter provides the means to set a basic detection sensitivity (Figure 21). It can be set to the values: High, Medium (default), or Low. Each value has a corresponding upper and lower limit shown in the Table 12. Note that setting the basic sensitivity affects both the upper and the lower detection limits.

**Table 12. Basic PIL Detection Sensitivities**

PLINE_SENSITIVITY value	Upper standard deviation limit	Lower standard deviation limit
High	40%	- 60%
Medium	70%	- 70%
Low	100%	- 80%

So, for example, if the PLINE\_SENSITIVITY is set to *High*, then a plugged impulse line will be detected if the standard deviation either increases by more than 40 percent above its baseline value, or decreases more than 60 percent below its baseline value.

**Note**

For GP/AP sensors, the PIL does not check for an increase in standard deviation, and a plugged impulse line is detected only if the standard deviation goes below the lower limit. For DP sensors, the PIL checks for both an increase and a decrease in standard deviation.

The upper and lower detection limits can be set to custom values, using the following parameters.

**PLINE\_DETECT\_SENSITIVITY**

Adjusts the Lower detection limit. If this value is 0 (default), the Lower limit is determined by PLINE\_SENSITIVITY. If this value is greater than 0, then it overrides the basic sensitivity value. This value can be set in the range 0 – 100%.

**PLINE\_SINGLE\_DETECT\_SENSITIVITY**

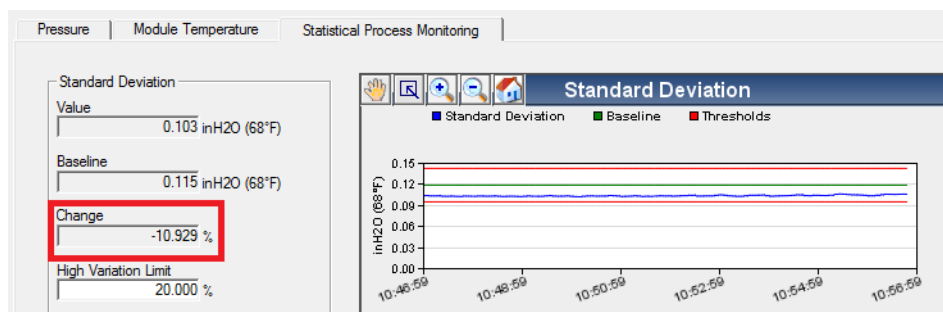
Adjusts the Upper detection limit. If this value is 0 (default), the Upper limit is determined by PLINE\_SENSITIVITY. If this value is greater than 0, then it overrides the basic sensitivity value. This value can be set in the range 0 – 10000%.

**6.22 Determining detection sensitivity**

Determining what values to configure for the upper and lower detection limits can be done by configuring SPM to monitor and trend the standard deviation, and then looking at how the standard deviation changes when impulse line plug is simulated, by closing the transmitter root valves or manifold valves.

First SPM needs to be configured to monitor the pressure as described in “SPM configuration and operation” on page 14. After SPM has been configured, the standard deviation needs to be trended, either in an EDDL-supported host (such as AMS Device Manager, shown in Figure 22), or in the DCS as described in “Trending statistical values in control system” on page 17.

**Figure 22. Trend of Standard Deviation in AMS Device Manager**



After configuring SPM, wait long enough for the SPM to begin updating the percent change in standard deviation. This will be at least two to three times the SPM Monitoring Cycle.

While the standard deviation is being trended, the impulse line valve (e.g. manifold or root) must be manually closed. After the impulse line is closed off, note in the SPM trend how much the standard deviation has changed. In the example in Figure 22 the standard deviation has decreased by 10.9 percent.

This process needs to be repeated for each impulse line plugging condition that needs to be detected. For DP measurements, this should be done for both the high side and the low side impulse line. Optionally, you may also wish to do this for both sides plugged. For GP/AP measurements, this process would be done only for the single impulse line.

Upper and lower detection limits are chosen based on the degree of standard deviation change that was observed when the impulse lines were plugged. These limits should be less than the observed change in standard deviation, but more than changes in standard deviation that happen under normal process conditions. A lower detection limit will result in a plug being detected earlier and more often, but could also lead to false detections. A higher detection limit will reduce the likelihood of false detections, but also increase the probability that an impulse line plug will not be detected.

A good “rule of thumb” is to set the detection limit to half of the observed change in standard deviation, but no less than 20 percent.

## 6.23 Advanced PIL configuration

PIL provides the ability for advanced users to fine-tune some of the algorithm settings.

### **PLINE\_RELEARN\_THRESHOLD**

This adjusts the limit at which the PIL will automatically relearn new baseline values if the process mean changes. By default, this threshold is:

- Two inches of water for DP Range 1 (-25 to 25 inH<sub>2</sub>O) sensors
- Five inches of water for DP Range 2 (-250 to 250 inH<sub>2</sub>O) sensors
- One percent of Upper Range Limit for all other sensors

When PLINE\_RELEARN\_THRESHOLD is at 0 (default) the above values are used for the relearn threshold. When a positive number is entered here, this value (in % of Upper Range Limit) overrides the default relearn threshold values. For example, if the sensor is type DP Range 3 (-1000 to 1000 inH<sub>2</sub>O), and PLINE\_RELEARN\_THRESHOLD is set to 1%, then PIL will relearn if the mean changes by more than 10 inH<sub>2</sub>O.

### **PLINE\_AUTO\_RELEARN**

This can be used to turn off the automatic relearning. If set to “Disabled”, the PIL will not go back into learning mode, even if there is a large mean change. In most cases, this parameter should be kept at “Enabled” because without this check, a large change in a flow rate could also cause a change in the standard deviation, triggering a false detection.

### **PLINE\_LEARN\_LENGTH**

The length of time over which mean and standard deviation are calculated during the learning and verification phases. Default is five minutes. Allowable range is 1-60 minutes. If the process has a periodic change in the mean over time (e.g. a slow oscillation), a longer learning cycle may provide a better baseline.

### **PLINE\_DETECT\_LENGTH**

The length of time over which mean and standard deviation are calculated during the detection phase. Default is one minute. Allowable range is 1-60 minutes. This value should not be longer than the PLINE learning cycle. A shorter value will in general allow a plugged impulse line to be detected more quickly. However, if the process has a dominant cycling or oscillation, this parameter should be set to longer than the period of oscillation.

## PLINE\_Learn\_Sensitivity

The PLINE\_LEARNING\_SENSITIVITY parameter provides very specific adjustments to the sensitivity during the learning phase. Most of the time, it is sufficient to use these default values:

- Insufficient Dynamics Check: Ignores the insufficient dynamic check if not selected. Use only when there is very low process noise. This could result in a plugged impulse line not being detected.
- 10%, 20%, and 30% Stdev. Change Check: Allows for 10, 20, or 30 percent change in standard deviation while in the learning state. If this value is exceeded, the algorithm will stay in the verifying state until the value is not exceeded.
- Three or Six Sigma Mean Change Check: Allows for a three or six standard deviations change in the mean while in the learning state. If this value is exceeded, algorithm will stay in the verifying state until the value is not exceeded.
- 2% Mean Change Check: The mean value of the baseline calculation cannot vary more than two percent during the learning or verifying states. If this value is exceeded, algorithm will stay in the verifying state until the value is not exceeded.

You may want to increase or disable one or more of these learning sensitivity settings, if you find that the PIL continues to stay in the verification phase.

## 6.24 PIL operation

During operation the PLINE\_STATUS indicates the current status of the algorithm. The valid values are shown in [Table 13](#).

**Table 13. Pline Status**

Value	Description
OK	The diagnostic is operating and has not detected a plugged impulse line.
Inactive	The diagnostic is not currently operating.
Learning	The diagnostic is in the learning phase, establishing a baseline mean and standard deviation.
Verifying	The diagnostic is verifying the values established in the learning phase.
Insufficient Dynamics	The diagnostic did not measure enough process noise to establish a baseline value during the learning phase.
Bad PV Status	The input value to the diagnostic has bad status and cannot be used to detect a plugged impulse line.
Plugged Impulse Line	The diagnostic is operating and has detected a plugged impulse line.

PIL also indicates the timestamp of the last detection of a plugged impulse line via these parameters:

### PLINE\_HISTORY\_TIMESTAMP

Timestamp when the last plugged impulse line was detected.

### PLINE\_HISTORY\_STATUS

Indicates whether a plugged impulse line has ever been detected.

## 6.25 PIL configuration in EDDL

Host systems that support EDDL may use labels for the PIL configuration parameters that are slightly different from the FOUNDATION Fieldbus parameter names described previously in this section. [Table 14](#) shows the correspondence between the FOUNDATION Fieldbus parameter names used in this document and the labels used in EDDL hosts, such as AMS Device Manager.

**Table 14. Corresponding EDDL Labels**

Foundation Fieldbus parameter name	EDDL label(s)
PLINE_ON	Plugged Line
PLINE_LEARN_LENGTH	Learning Cycle
PLINE_SENSITIVITY	Detection Limit
PLINE_AFFECT_PV_STATUS	Affect PV Status
PLINE_RELEARN	User Command
PLINE_AUTO_RELEARN	Auto Relearn
PLINE_RELEARN_THRESHOLD	Relearn Threshold
PLINE_LEARNING_SENSITIVITY	Learning Sensitivity
PLINE_DETECT_LENGTH	Detecting Cycle
PLINE_DETECT_SENSITIVITY	Custom Lower Limit
PLINE_SINGLE_DETECT_SENSITIVITY	Custom Upper Limit
PLINE_STATUS	Status
PLINE_HISTORY_STATUS	PIL History Status
PLINE_HISTORY_TIMESTAMP	PIL History Time Stamp

## 6.26 Viewing the indication of a PIL

When a plugged impulse line is detected, a Plantweb alert is generated, and this alert can be seen in AMS Alert Monitor. Also (optionally), using the “Affect PV Status” parameter, the status of the pressure measurement can be made to change from “Good” to “Uncertain” when a plugged impulse line is detected. Dependent upon the DCS configuration, the uncertain status of the measurement may be indicated within the operator interface.





## Global Headquarters

### Emerson Automation Solutions

6021 Innovation Blvd.

Shakopee, MN 55379, USA

+1 800 999 9307 or +1 952 906 8888

+1 952 949 7001

RFQ.RMD-RCC@Emerson.com

## North America Regional Office

### Emerson Automation Solutions

8200 Market Blvd.

Chanhassen, MN 55317, USA

+1 800 999 9307 or +1 952 906 8888

+1 952 949 7001

RMT-NA.RCCRFQ@Emerson.com

## Latin America Regional Office

### Emerson Automation Solutions

1300 Concord Terrace, Suite 400

Sunrise, FL 33323, USA

+1 954 846 5030

+1 954 846 5121

RFQ.RMD-RCC@Emerson.com

## Europe Regional Office

### Emerson Automation Solutions Europe GmbH

Neuhofstrasse 19a P.O. Box 1046

CH 6340 Baar

Switzerland

+41 (0) 41 768 6111

+41 (0) 41 768 6300

RFQ.RMD-RCC@Emerson.com

## Asia Pacific Regional Office

### Emerson Automation Solutions Asia Pacific Pte Ltd

1 Pandan Crescent

Singapore 128461

+65 6777 8211

+65 6777 0947

Enquiries@AP.Emerson.com

## Middle East and Africa Regional Office

### Emerson Automation Solutions

Emerson FZE P.O. Box 17033

Jebel Ali Free Zone - South 2

Dubai, United Arab Emirates

+971 4 8118100

+971 4 8865465

RFQ.RMTMEA@Emerson.com



[Linkedin.com/company/Emerson-Automation-Solutions](https://www.linkedin.com/company/Emerson-Automation-Solutions)



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