DeltaV™ pre-engineered control module templates and operator faceplates to facilitate development and use of SPM diagnostics originating in Rosemount pressure instruments

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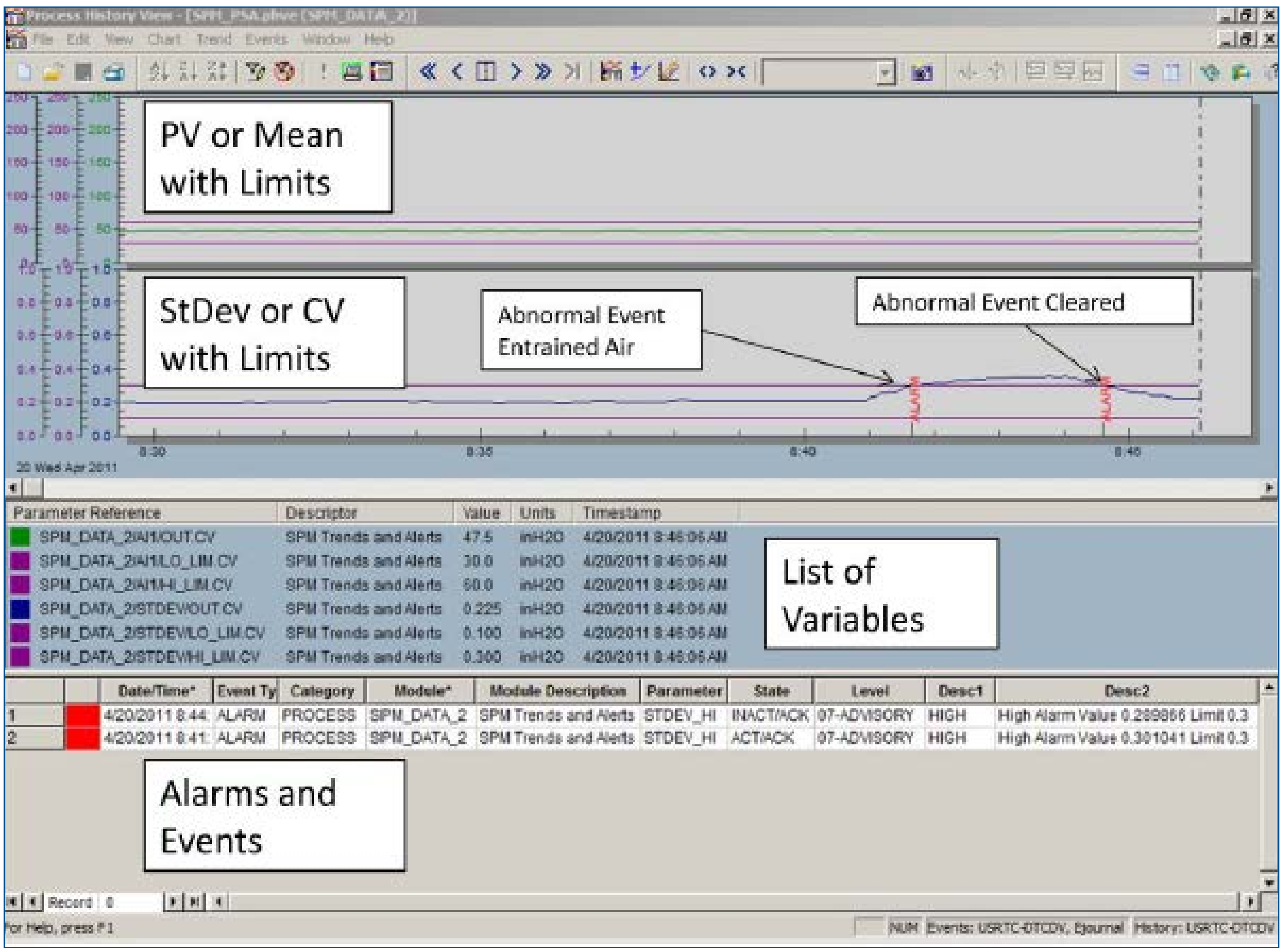

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Introduction

Statistical Process Monitoring (SPM) can be a powerful tool to characterize the process in both normal and abnormal conditions. Once the process is characterized SPM can be used to monitor and give early warning of existing or developing abnormal conditions.

Despite the power of SPM as an analytical and predictive tool, it's currently underutilized. The primary reason is the engineering time and detailed knowledge needed to design and implement an effective and operator friendly SPM monitoring solution.

Emerson is addressing this challenge by developing pre-engineered control module templates and operator faceplates for SPM. The control module templates contain all the necessary blocks, logic, alarming and alarm management, and historian configuration needed to quickly configure a SPM monitoring point. The operator faceplate provides easy viewing, alarming and alarm management, and single keystroke access to support information such as historian information, device faceplates, and other operator displays.

The faceplates can reduce the initial engineering time by orders of magnitude, and reduce individual monitoring point configuration time by a factor of 3 or more. Faceplates also substantially reduce the detailed engineering knowledge needed to design and implement the SPM monitoring strategy. Operator faceplates reduce operator learning time by presenting a consistent user interface, and by intelligently managing alarming and access to related information.

This white paper assumes a basic familiarity with DeltaV function block configuration, configuration templates, data historian and operator faceplates. Detailed knowledge of the configuration process is not assumed and is not necessary to understand this white paper.

Brief Review of the Implementation and Use of Statistical Process Monitoring (SPM)

Each analog process variable has process noise associated with it. A noisy process variable can lead to excess correction by the control algorithm, and excess travel by the final control element. This can degrade control, and lead to excess wear in the final control element. Traditionally, the process variable is filtered to eliminate process noise.

Process noise actually contains a great deal of information on both process and equipment performance and health. As process or equipment performance change, the noise generated by them will also change. This noise can be analyzed statistically to determine if everything is operating normally, or if abnormal process or equipment conditions exist, and can even help identify the specific type of process or equipment abnormality. It's important to remember that abnormal conditions can exist even if the process variable is at setpoint and stable.

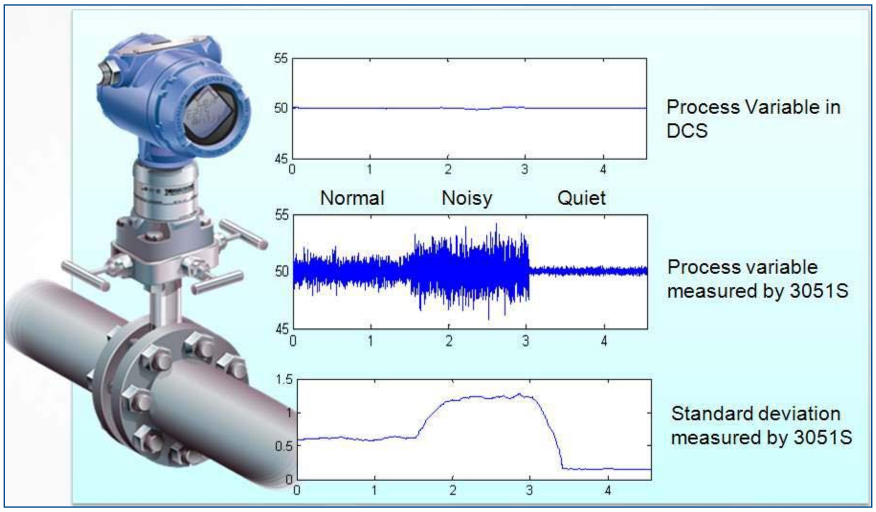

Figure 1 — *SPM monitoring is best done in the field device. The top graph shows the filtered process variable as seen on the DCS. The middle graph shows the process variable as seen on the 3051S pressure transmitter. The bottom graph shows the standard deviation as calculated in the pressure transmitter. In the middle graph, the left 1/3 is a normal process. The middle 1/3 shows the noise when one impulse leg plugs. The right 1/3 shows the noise when both impulse legs are plugged.*

Rosemount pressure instruments used in pressure, level, and flow applications perform SPM with the raw, High Frequency sensor data. The raw, unfiltered process variable is sampled 22 times per second by the 3051S. Control hosts generally sample a filtered process variable 1 or 2 times per second. The filtering and slower sampling rate removes most of the statistical information from the process variable.

Calculated statistical parameters include mean, standard deviation and, with some diagnostics configurations, the coefficient of variation (CV). The coefficient of variation is the ratio of standard deviation to mean. SPM alarms can also be configured in the pressure transmitter. Finally, short term, real time trending of the process is provided by the 3051S pressure transmitter.

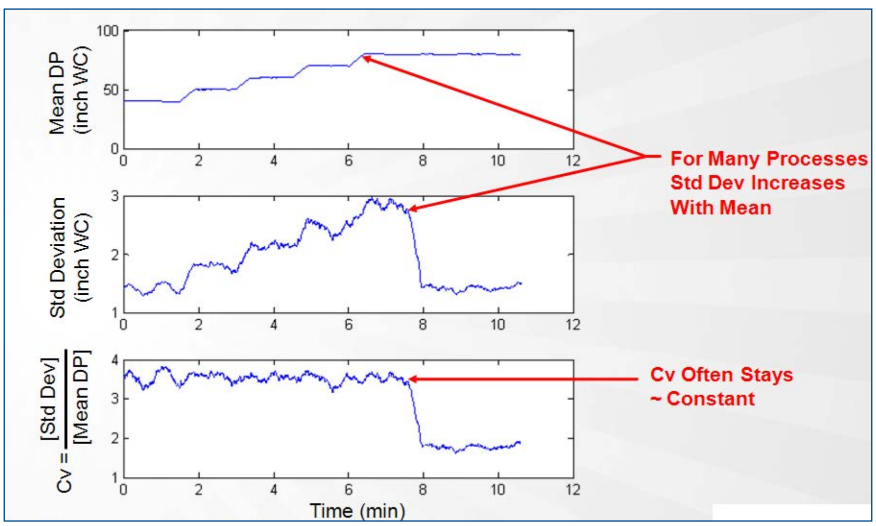

Figure 2 — *Flow loops are frequently best monitored using coefficient of variation. In the figure above, standard deviation is seen to change with mean making abnormal event detection difficult. Coefficient of variation tends to remain constant over a broad range of flow rates. Using CV can make abnormal patterns easier to identify and alarm.*

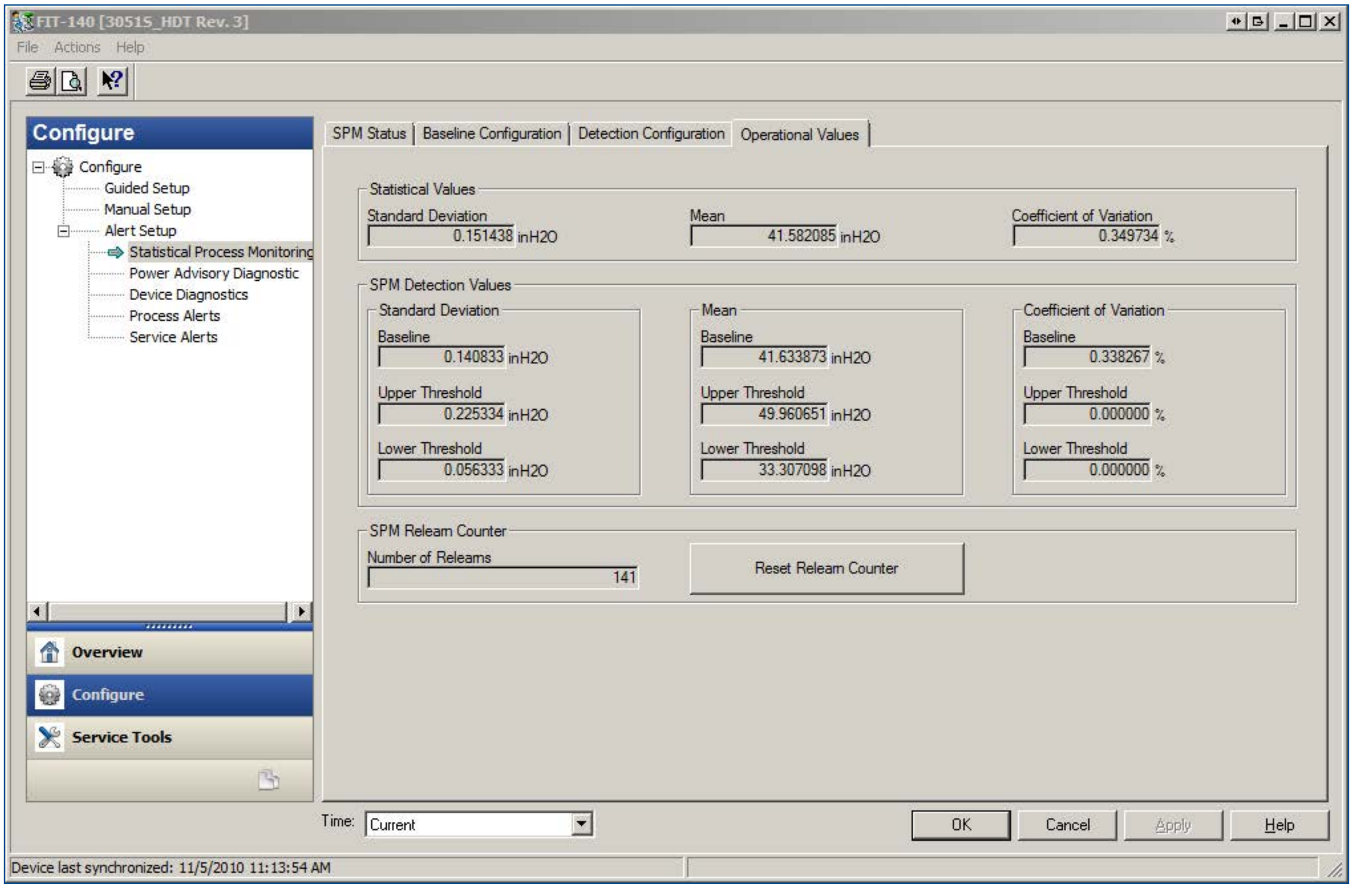

Figure 3 — *The statistical variables of Standard Deviation, Mean, and, in some cases the Coefficient of Variation are provided by the 3051S pressure Transmitter. These variables are linked into DeltaV and used in the control configuration and operator display.*

These parameters are available from both HART and FOUNDATION fieldbus pressure devices using the digital communications capabilities of both protocols. These parameters can be accessed, linked to analog input blocks, and used within DeltaV in a manner similar to any other process parameter.

SPM has been shown to effectively detect a variety of abnormal conditions. Examples include entrained air in liquid lines, liquid in gas lines, pump and valve cavitation, plugged impulse lines, and more. There are a large number of other potential applications ranging from flame instability to column flooding to catalyst slip – stick. Any physical phenomena that would generate or eliminate process noise are potential candidate for SPM.

Primary Users of Pre-engineered Templates and Faceplates

Template and faceplate functionality must be based on the needs, responsibilities, and work practices of the individual users. There are three primary types of users. The first is the control systems engineer who is responsible for configuring the necessary monitoring strategies, faceplates, and historian files needed to effectively use SPM. The second user is the process engineer, reliability engineer, or quality engineer who would use the SPM information to analyze process characteristics, including both normal and abnormal conditions, and implement process improvements. The third user is the operator who would use the information in real time to improve plant reliability or performance. There are other potential users of SPM information, such as maintenance personnel. These users don't generally use the DCS as a primary source of information, and are, therefore, not covered in this white paper.

Functionality and Use of Pre-engineered Templates for Configuration

The pre-engineered faceplates are designed to support the systematic use of SPM for additional process insight. The general steps for implementation are:

- Trend the SPM Data in the DCS
- Analyze the SPM Data (e.g. find the correlation between SPM data and the abnormal event)
- Set the alarms and alarm limits
- Act – Take a useful action based upon the SPM data

Effectively, these DeltaV templates making this "SPM Model" process much easier for the end user.

The control systems engineer must configure the control strategy and logic necessary to provide the SPM information in real time, to generate appropriate alarms based on abnormal process conditions, and to suppress alarms based on appropriate conditions. These functions are supported by appropriate function block templates in DeltaV. The control systems engineer must also store the SPM data in the DeltaV Historian so it can be accessed and used by operators and process, quality, or reliability personnel. Finally, the control systems engineer must provide appropriate faceplates for operators who will be interacting with SPM information in real time.

There are two capability options using HART protocol (Called DA1 and DA2), and one using FOUNDATION fieldbus protocol. All three of these options are provided in control module templates.

Accessing the SPM information

The first task faced by the configuration engineer is accessing the SPM information from the field device. PV, Mean and Standard Deviation are provided by all three 3051S SPM options. Coefficient of Variation (CV) is provided only by HART diagnostics with the DA2 option, and must be calculated for the DA1 HART option and FOUNDATION fieldbus devices. (CV is used for flow applications only and is flow rate divided by standard deviation. It tends to be linear over a wide range of flow rates)

The image below shows the portions of the control module used to access or calculate the appropriate SPM data from the 3051S pressure transmitter.

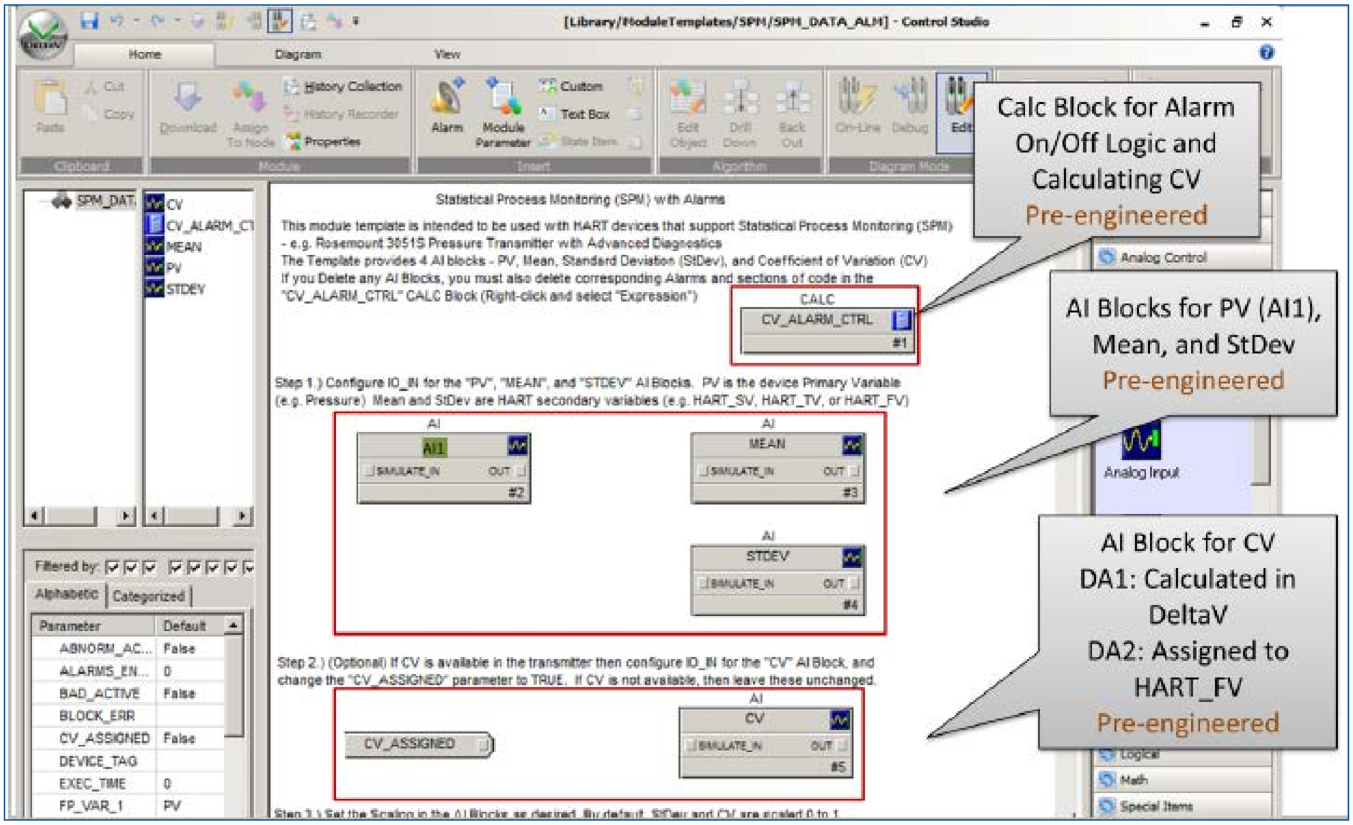

Figure 4 — *The I/O blocks used to link to PV, mean, standard deviation, and CV are shown here. If CV is not provided by the pressure transmitter, a logic calculation is provided to calculate the CV. The configuration engineer links the appropriate parameters from the pressure transmitter to the analog input blocks. If the CV is assigned, the CV analog input block is used. If it's not assigned, the calculated CV is used.*

For HART devices, the AI blocks are located in DeltaV, so alarms are generated directly by the DeltaV AI blocks. FOUNDATION fieldbus AI blocks are located in the field device. The control module has preconfigured and pre-linked alarm detection blocks that generate alarms based on data provided by the field devices. This is shown in the figure below.

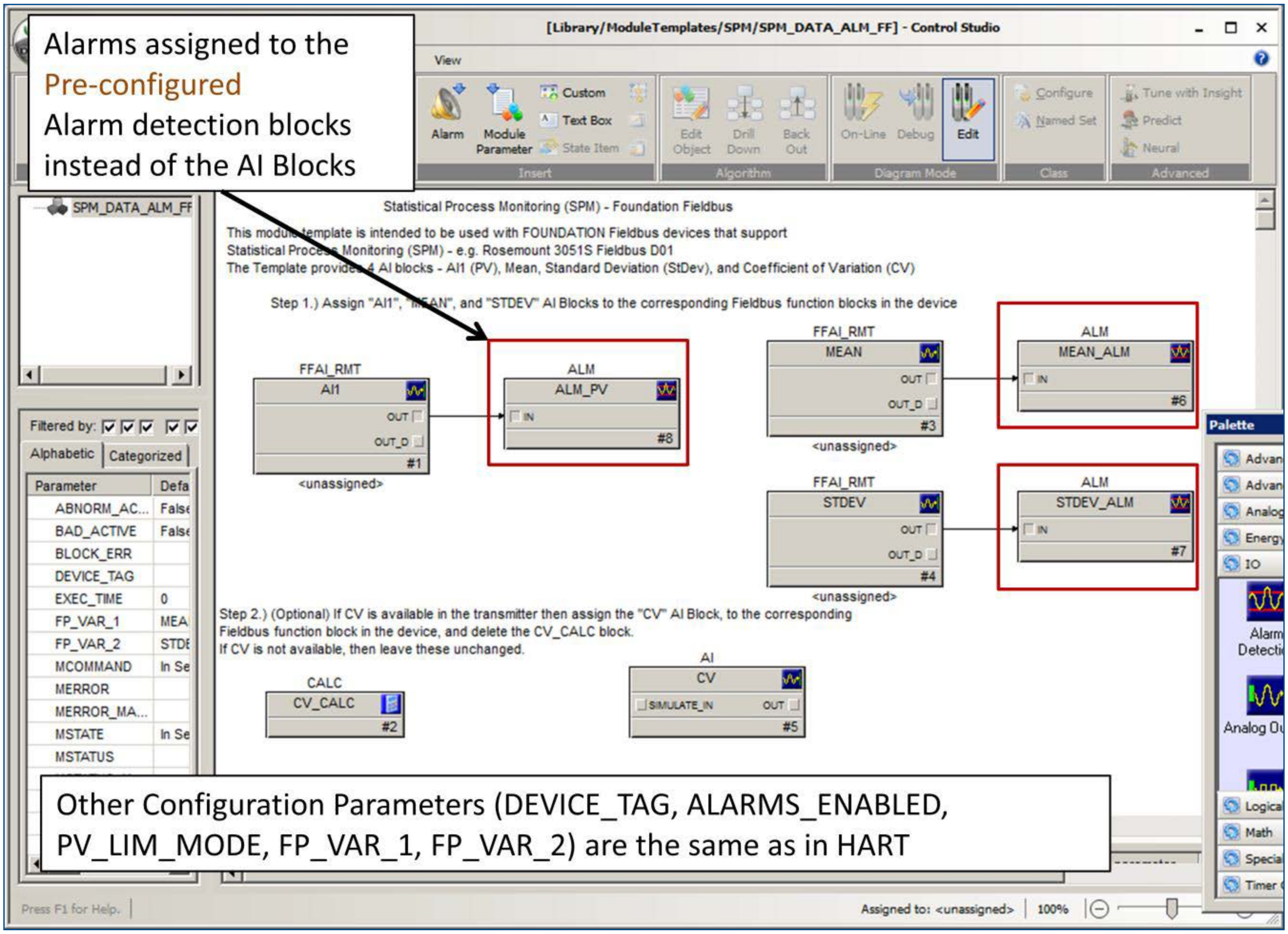

Figure 5 — *The alarm detect blocks used to show device generated SPM alarms for the FF based 3051S pressure transmitter are shown above. Note that where possible, parameters from both HART and FF devices are the same. This enhances usability where both HART and FF protocols are used.*

The SPM information is now accessible in DeltaV. Additional functions including enabling and disabling alarms, defining variables on the operator faceplates, and providing linking to the actual device screens in AMS Device Manager are still needed. In addition, alarm limits must be set, and appropriate parameters and limits must be made available in the DeltaV Data Historian. The configuration of these functions in DeltaV Control studio is shown next.

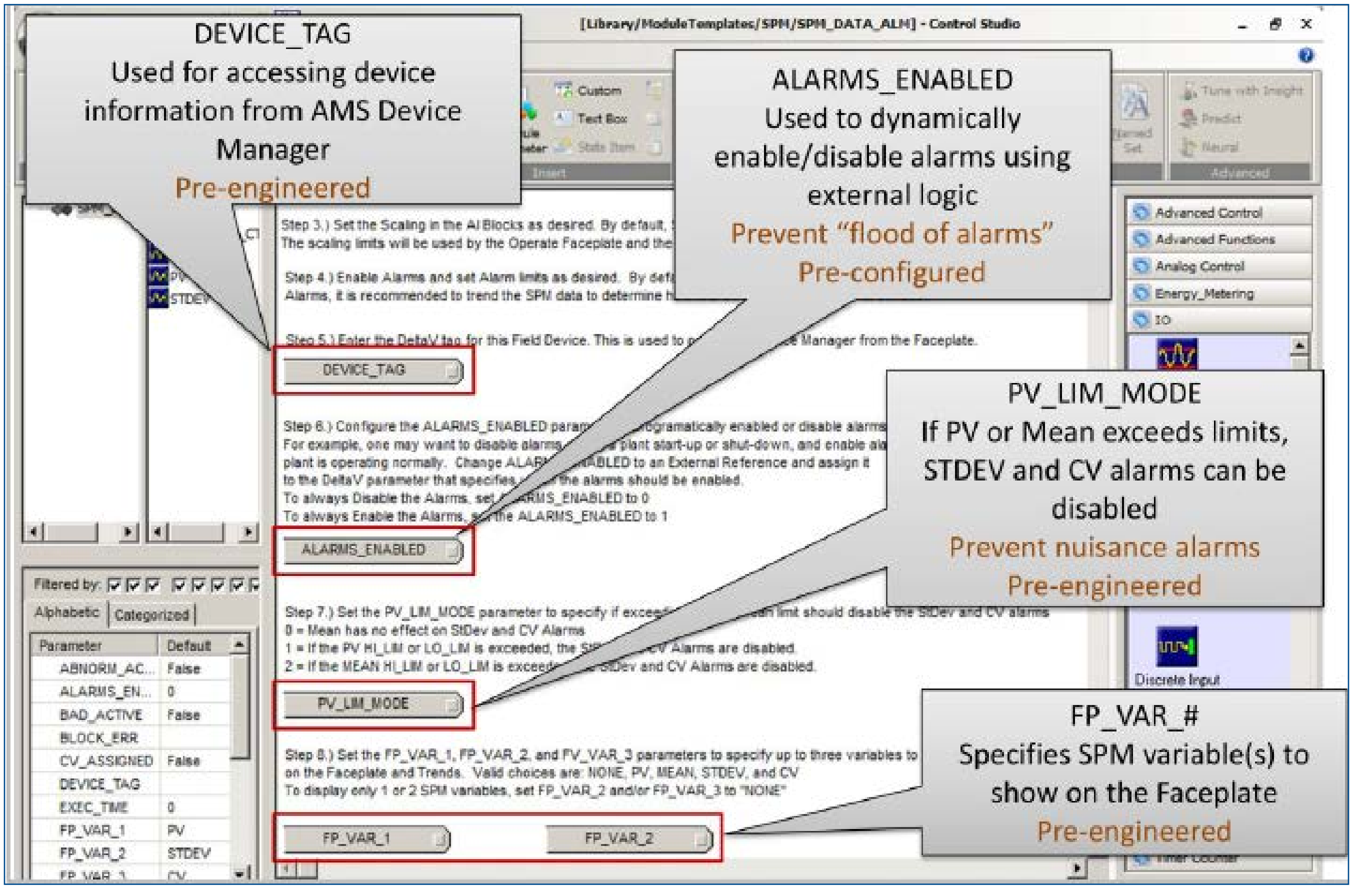

Figure 6 — *Device tag configure the device AMS Device Manager calls up from the operator faceplate. FP VAR # configures the parameters displayed on the operator faceplate. ALARMS ENABLED allows SPM alarms to be disabled from external logic. PV LIM MODE allows alarms for this parameter to be disabled based on PV or MEAN exceeding expected limits.*

The parameters in this part of the module template configure the operator faceplate, and enable or disable alarming. The FP VAR # objects allow the configuration engineer to select the parameters displayed on the two operator faceplate analog display bars. The options are PV or MEAN for the first bar, and Standard Deviation or CV for the second bar.

ALARMS ENABLED and PV LIM MODE provide alarm suppression for two different alarm scenarios. ALARMS ENABLED is a link to an external logic event which disables alarming for this control module. The intent is that external logic such as a toggle could be used to enable or disable a large number of points. This would be used to disable alarms for user initiated "Abnormal Situations" such as a shutdown, a startup, or a grade change where a large number of points could go into alarm, potentially presenting the operator with a flood of unnecessary alarms. PV LIM MODE is provided so the configuration engineer can automatically disable SPM alarms if the monitored point is operated outside normal or expected process ranges. For example, a setpoint may be set substantially above or below typical operating parameters. In this situation, MEAN and STANDARD deviation would be expected to be outside alarm limits. Both ALARMS ENABLED and FP VAR # are optional parameters.

Another configuration task is the definition of alarms, and the configuration of alarm limits. These can be treated as two separate activities. Alarms are automatically configured using information from the analog input blocks, or the CV calculation block. No additional work is necessary to configure the alarms and alarm limits. The default alarm limits may or may not be appropriate for a specific monitoring point. Therefore the default configuration for alarms is "Disabled". Alarms automatically configured from the AI blocks or logic calculations are shown in the figure below. A common question is where to set the alarm limits. The 3051S pressure transmitter has sophisticated logic to determine alarm limits based on actual process dynamics. The first step to optimizing the alarm limits would be to let the 3051S calculate those limits, and then enter those limits into the DeltaV. Alarm limits may need further adjustments based on process experience.

An alternative approach is to enable the default alarms, and as alarms occur, or as abnormal conditions are experienced that don't exceed the alarm limits, adjust the limits accordingly.

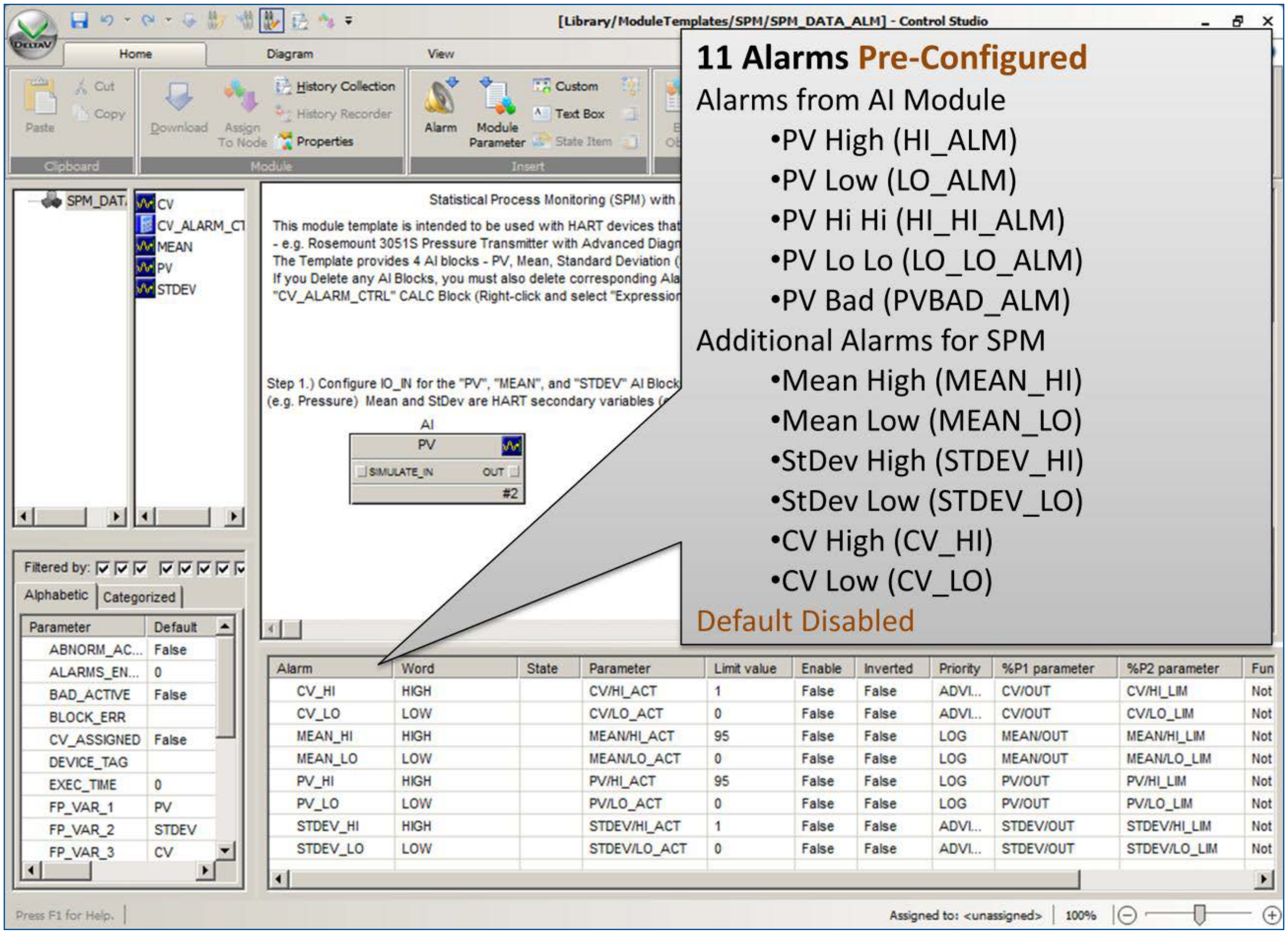

Figure 7 — *Alarms and alarm limits are automatically generated from AI block configuration information. In addition, that information is used to generate the Process History View in the DeltaV Historian.*

Functionality and Use of Pre-engineered Faceplates and Historian Information for Process or Reliability Improvement

The primary tool for the process, reliability, or quality function will usually be the data historian. Generally the SPM parameters will be recorded in the data historian, and a "fingerprint" of the process running correctly will be developed. This fingerprint will serve as a baseline for comparison. When abnormal conditions occur, the historian data can be compared to the baseline to determine the "fingerprint" for a specific abnormal condition. Over time a library of abnormal conditions and the criteria for their early detection will be developed. This criteria and corrective operating procedures, can then be incorporated into the operators' operating procedures. This information can also form the basis for engaging reliability, quality, maintenance, or other functions in corrective action or elimination of systemic causes. An example of an abnormal condition process history view is shown in the next figure. Note the significant change in standard deviation even though the mean is essentially unchanged.

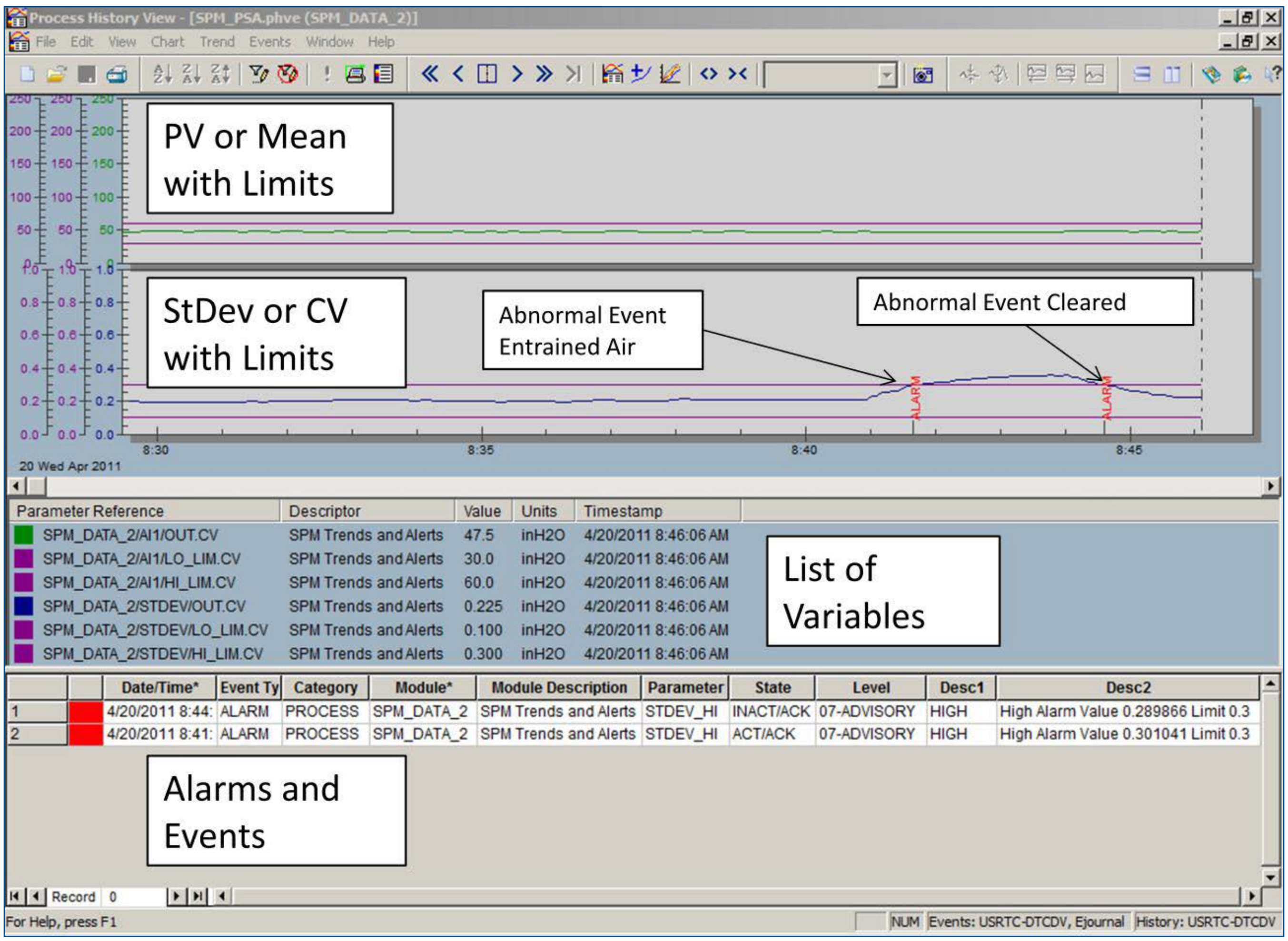

Figure 8 — *The parameters captured by the data historian and shown in the process history view are the parameters configured for operator display in control studio. The process history view shows each parameter and its associated alarm limits and alarm occur and clear time on a trend display. In addition the configured variables and their values are listed, and an alarm / event list for the configured variables is shown.*

Functionality and Use of Pre-engineered Faceplates and Historian Information for Real Time Operation

The primary tools for the operator will generally be the operator faceplate, the detail display, and the data historian. The data historian was described in the previous section. This section will concentrate on the operator faceplate and the detail display.

The operator faceplate can be used as a replacement for the typical monitoring point, faceplate, or in addition to the monitoring point faceplate. If PV is shown on the SPM faceplate, it can be used as a substitute for the standard monitoring faceplate. If standard deviation is shown instead of PV, the operator may wish to use both the typical monitoring faceplate and the SPM faceplate.

The main function of the operator faceplate is visibility to the monitored variables and their associated alarm limits, visibility to alarms, the ability to acknowledge alarms, and quick access to other relevant displays. The operator faceplate is shown below.

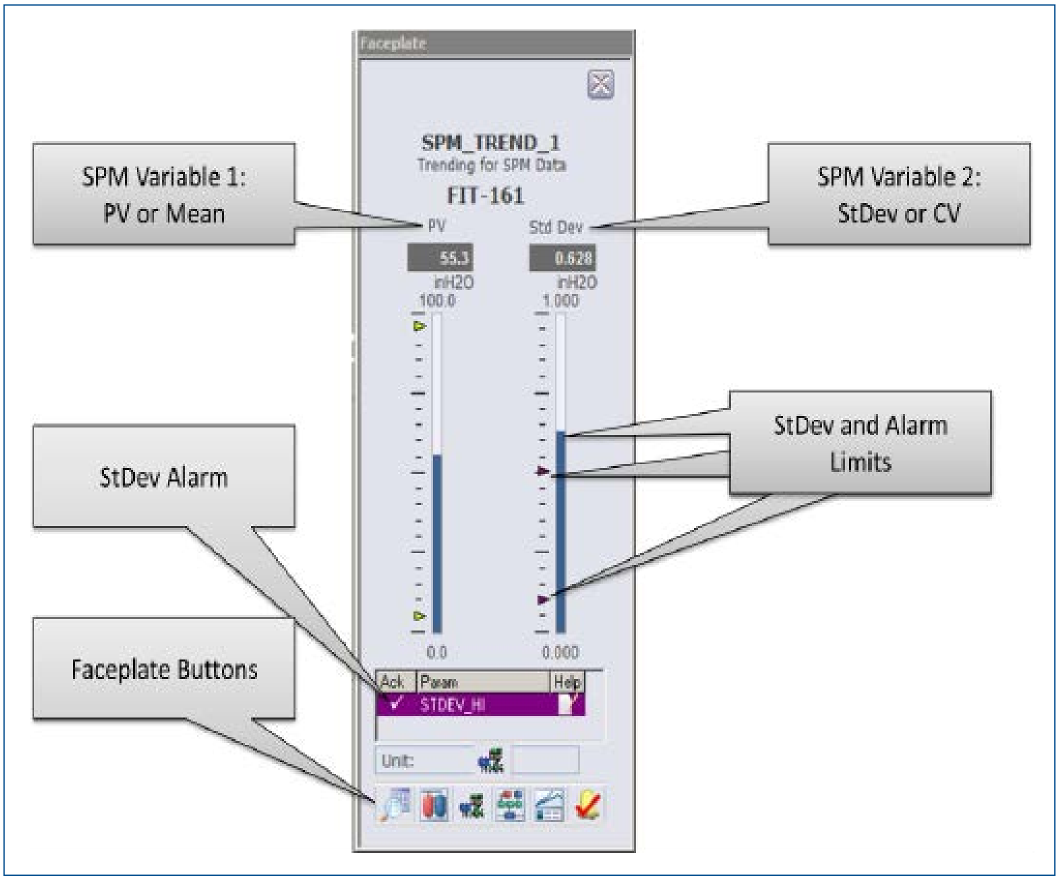

Figure 9 — *The operator faceplate serves two functions. First, it quickly identify this as a monitoring point through the use of color, and shows general process performance with bars, limit indicators, and alarm indication. The second is to provide single- click access to other screens that the operator may wish to reference if an abnormal situation occurs.*

The faceplate buttons provide single-click access to information the operator may find useful in addressing abnormal situations. The buttons and their functions are shown below.

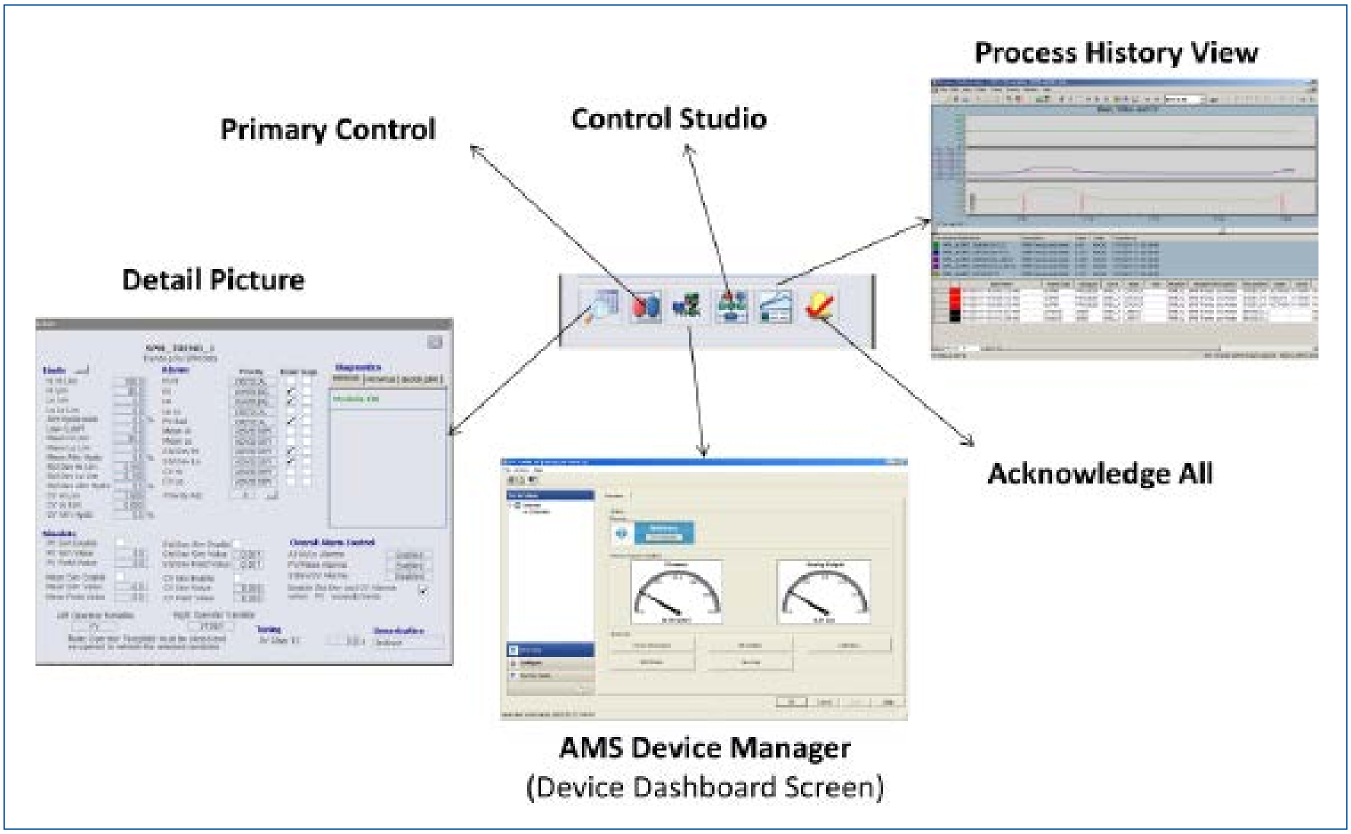

Figure 10 — *The faceplate buttons provide single-click access to additional information on the monitored points.*

The faceplate buttons provide single-click access to the primary operator graphic containing this point, the control studio configuration page for this point, the process history view for this point, and a key to acknowledge all alarms associated with this point. These screens have either been described earlier in this white paper, or are outside of scope.

There are two additional buttons. The first provides access to the monitoring faceplate detail screen. The second provides access to the actual device status screen in AMS Device Manager. These two screens and their functions are described next.

First is the monitoring faceplate detail screen. Operators or configuration engineers would use this screen to fine tune and test faceplate behavior. This screen allows operator configuration of the variables to be displayed, fine and course control of alarming and alarm suppression, and simulate capability to verify faceplate behavior and train operators.

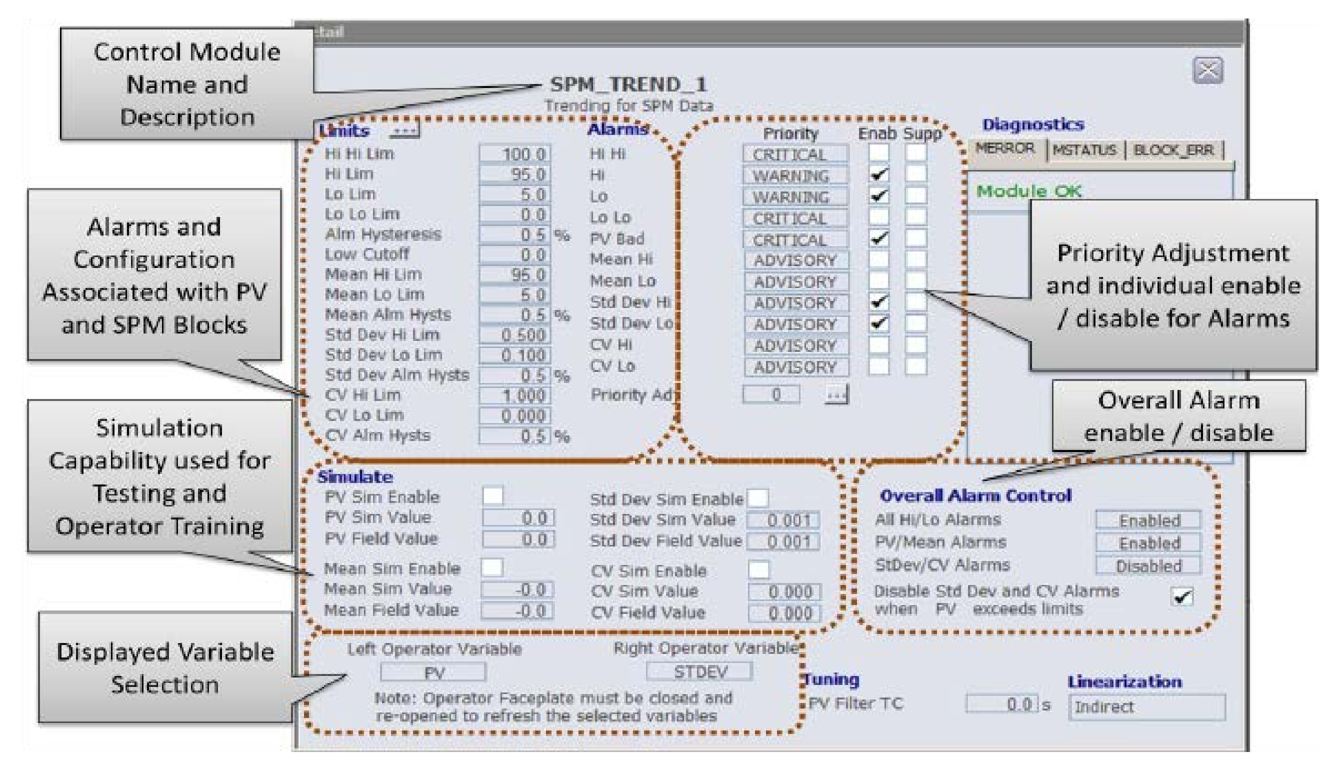

Figure 11 — *The monitoring faceplate detail screen has three main functions. The first is managing alarming. This includes configuring individual alarm limits, and enabling and disabling alarms on either a parameter by parameter basic, by variable displayed on the operator faceplate, or all alarms for this point. The second is simulation capability. Simulation is used to verify the desired behavior has been configured in the faceplate, and for operator training. Finally, the two operator variables to be displayed on the operator faceplate can be selected.*

The final screen is the Device Overview screen provided by the device VIA AMS Device Manager. This screen provides the operator with an overview of the health and performance of the pressure transmitter which is monitoring the process. From the device overview screen the operator can access SPM Status and view device logs with a single keystroke. This will allow the operator to quickly determine or verify device and SPM based diagnostic status.

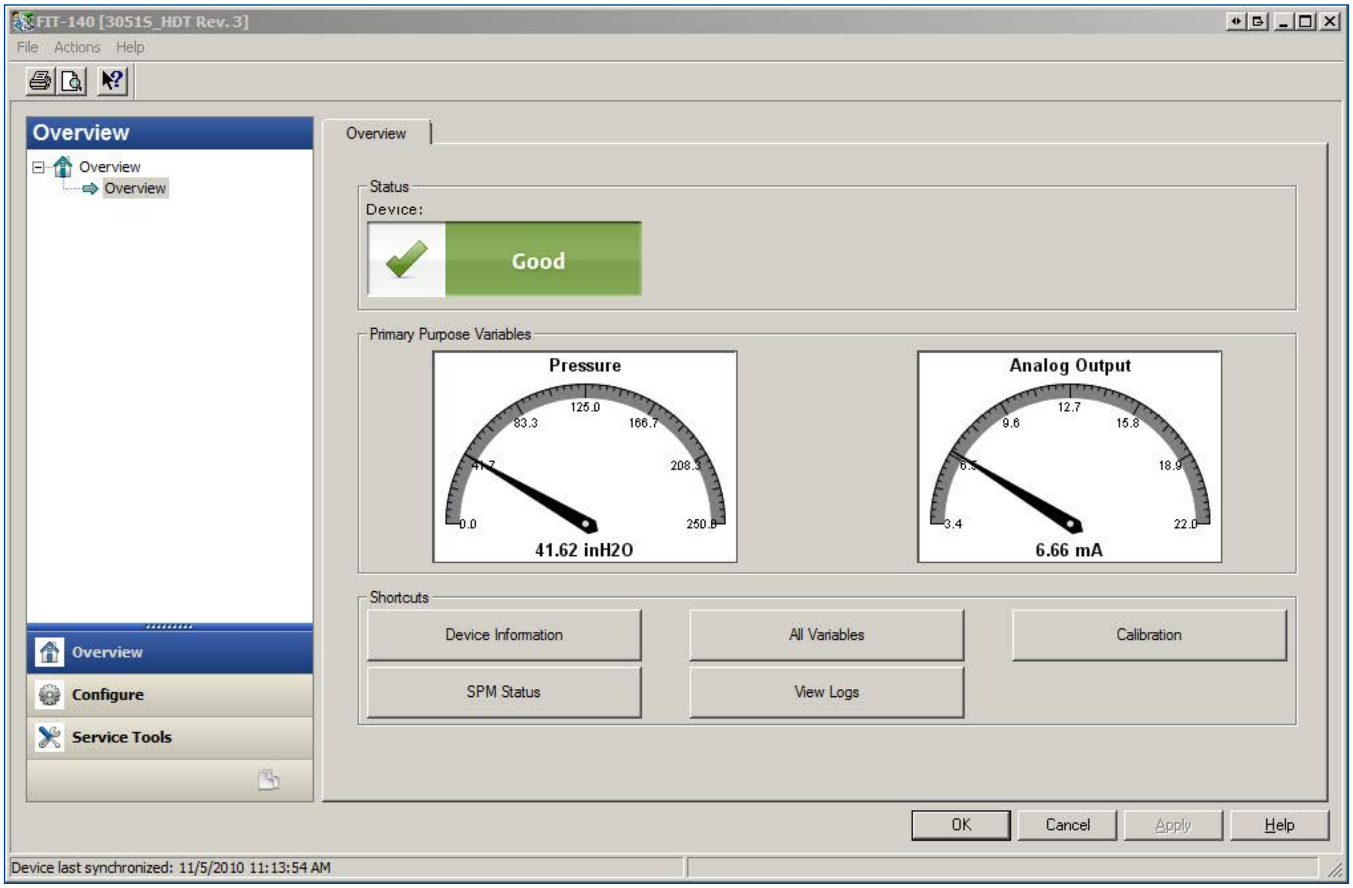

Figure 12 — *The device overview screen provides single-click access to process variables and device status. One additional click provides access to SPM status and View Logs. This allows an operator to verify device operation in a few seconds.*

Some background will be useful in understanding the purpose and use of this screen. Plant operators often have a strong holistic "feel" for how the processes under their control are running. If something feels wrong and the cause is not apparent from the DCS, one of the first things the operator wants to verify is the validity of the process readings. This is usually done by generating a work order and having an instrument technician perform a field check of the device. Most of these checks find the device operating normally, and a faulty device is the cause of the problem in only a minority of cases. The reason the device is checked first, is that it is usually the easiest thing to check, and can be eliminated quickly as the source of a problem. Unfortunately this practice results in a large number of unnecessary device checks.

The device overview screen allows the operator to quickly and easily determine if the device is operating normally. This should result in most device checks becoming unnecessary. Where a device check is still performed, this allows the operator to more easily coordinate with the instrument technician performing the check.

There are two additional device screens that the operator may find useful. The first is the pressure transmitter SPM status screen, and the second is the View Logs screen. These two screens and their uses will be briefly described.

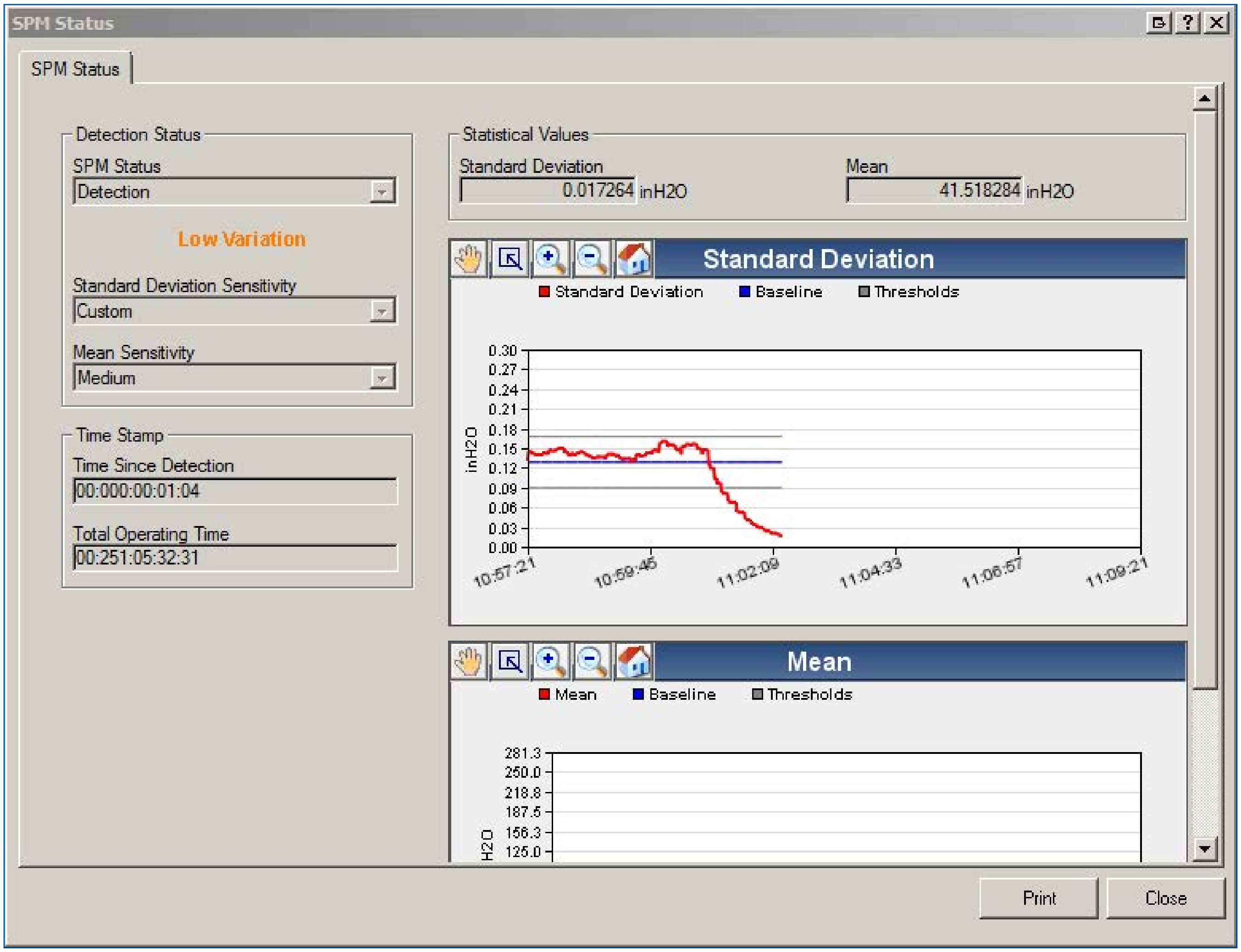

Figure 13 — *The SPM Status display provides real time trending of Mean and Standard Deviation. It also shows the Mean and Standard Deviation values that are provided to DeltaV.*

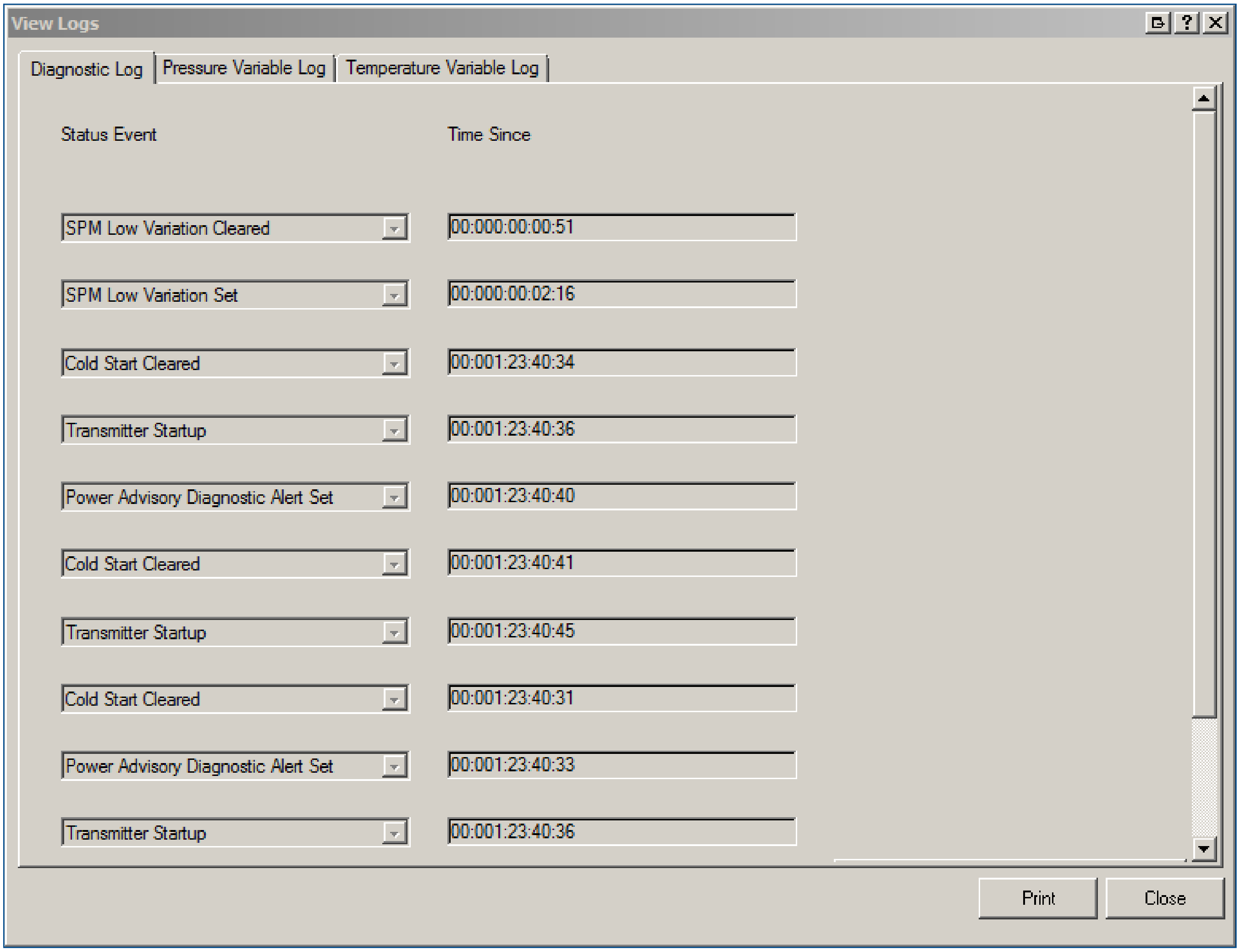

Figure 14 — *The diagnostic log shows a variety of diagnostic and device status events. These events extend beyond SPM events to include device power diagnostics and other events that can aid in identifying device related issues, especially intermittent issues that may be hard to capture. This additional information is useful if device problems are still suspect even if the device overview screen shows good device status.*

How to Get Started with an SPM Program

There are three approaches typically used to get started with an SPM monitoring program. The first approach is to turn on, and start trending SPM data for all pressure devices with SPM. Then, when abnormal situations occur, look at the data and determine if an alarm based on SPM data could have given an early warning.

A second is to take a target application which can be easily justified based on financial return and high detection success rate, and implement that capability broadly. An example of a spreadsheet for plugged impulse line testing and detection is inserted below. Enter your assumptions and view different scenarios.

The third approach is to identify high value assets or processes, identify possible abnormal conditions that could cause asset or production loss, and analyze them for potential SPM signatures that could predict abnormal events.

Color Keys	User Input Field	Calculated Result
Diagnostic Capability vs Probability of failure on demand (PFD)	Solve for PFD	Solve for Test Interval
Diagnostic Capability (% of events detected)	80%	0%
Failure Rate per Year	5.00%	5.00%
Test Interval (years)	4	0.378082192
Diagnostic Inspection Interval (hours)	0.1	
MTTR Hours	96	96
Probability of Failure on Demand	2.006%	1.000%
Length of Analysis (Years)	10	10
Testing conducted over length of analysis	2.50	26.45
Cost per test	100	100
Cost over length of analysis	250.00	2644.93
Diagnostic Capability cost savings over length of analysis	2394.93	

Figure 15 — *Diagnostic test interval and cost savings spreadsheet.*

Author and Contributors

By Tom Wallace, Senior Manager, Rosemount Smart Field Marketing

- Special thanks to John Miller, Principal Engineer – Pressure Technology for developing the SPM templates and faceplates. John's contributions will significantly expand the scope and usability of pressure transmitter based SPM diagnostics for DeltaV users.
- The spreadsheet in figure 10 is based on a formula used by Jody Minor, E/I Reliability Specialist with LyondellBasell. The author of the formula is not known.
- Roger K. Pihlaja Principal Engineer – Process Diagnostics, Emerson Process Management, Rosemount Division provided significant information on process diagnostics. His technical presentation ""Are You A Process Whisperer?" Best Practices For Successful Process Diagnostics With Fast Sampling Pressure Transmitters" was a frequently used source.
- Randy Balentine - For support and expertise on DeltaV, and insight into how users would interact with and use the templates and faceplates.

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