**White Paper**
November 2020

# DeltaV SIS™ HART Capabilities

This whitepaper describes the benefits of using HART information in safety systems, the various capabilities that can be used within DeltaV SIS™ as well as best practices for the implementation of HART diagnostics.


DELTAV™

EMERSON™

www.emerson.com/deltavsis

## Table of Contents

**Introduction** .... 3
**Benefits from Using HART in Safety Applications** .... 3
**Detecting Abnormal Conditions in DeltaV SIS** .... 4
Built-in HART Device Status Signals .... 4
Additional HART Parameters .... 6
HART Information from Emerson Devices .... 7
**Device Alerts** .... 11
**Securing HART Communication** .... 13
DeltaV Lock Functionality .... 13
Preventing Device Changes via Hand-helds .... 13
**Other Best Practices** .... 13
**Conclusions** .... 14
**References** .... 14

## Introduction

HART-capable field devices have been used for many years in safety instrumented systems (SIS). HART diagnostics provide much more information on the health of a field device than can be determined from a standard 4-20 mA signal. Due to the increased diagnostics, it is possible to early detect abnormal conditions that could eventually lead to a failure. For example, while the 4-20mA signal can be used to flag a failure on the temperature sensor by configuring the alarm direction in the temperature transmitter, the issue is only reported until the sensor has failed. Temperature sensors often drift before they fail. A drifting sensor is not reporting an accurate measure which could impact the safety function. Early detection of abnormal conditions allows for correction before those conditions become bigger issues. Using field diagnostics data assumes that the field device is able to communicate detected failures to the SIS and that the SIS is able to either process or transfer that information. Traditional safety systems do not have the capability to use the HART diagnostics within the safety logic or even sending HART information to the Basic Process Control System (BPCS). Instead, those legacy systems simply use HART multiplexers to strip off the HART signal, usually on a Field Termination Assembly (FTA), and then sending the HART signal to a separate asset management system (AMS) to alert the maintenance group of unhealthy devices. Some newer safety systems have HART-capable I/O cards but still the HART data is only forwarded to the AMS. Even these newer systems do not have the capability of using the HART diagnostics directly in the safety logic or easily sharing the HART information with the BPCS for efficient use within graphics, alarms or historical charts.

This document reviews benefits from using HART information and provides best practices to fully realize the capabilities of smart instrumentation. This document also illustrates the capabilities from Emerson field devices.

## Benefits from Using HART in Safety Applications

DeltaV SIS has the capability to either pass on the HART data to the AMS or the BPCS or even to use the diagnostics information within the safety logic. These capabilities have many added benefits over traditional SIS:

- **Automatic response to field device issues.** If a field device is unhealthy, the user can predefined the proper action for the system to take. For example, the system could remove the device from voting or even initiate a trip if required. Alternatively, the bad status could simple generate an alarm either in a DeltaV screen at the maintenance shop or via AMS. This last option (AMS alarm), it is typically the only option for systems without full HART integration.
- **Automatic device configuration.** HART communication enables the ability to configure the devices from a configuration standard (e.g. device configuration template). The ability to configure field devices based on a configuration template not only reduces configuration time, it also increases consistency, eliminates manual errors, and facilitates the use of advanced functionality within the field device.
- **Automatic device verification.** HART transmitters can use an identification tag which could be automatically compared with the tag defined at the I/O channel to confirm that the right device is connected to the right place. Traditional safety systems without the ability to interrogate the device can not use this type of verification. DeltaV SIS can verify the field device based on either the HART tag (up to 8 characters), the HART long tag in HART 7 devices (up to 32 characters), or the message field in HART 5 devices (up to 32 characters). Typically, the tags used within a safety system are 16 characters or less which is the maximum allowed for DeltaV SIS. However, DeltaV SIS can define tag rules to handle tags longer than 16 characters. The typically example is a prefix added to all the device tags for a particular site. While this prefix is useful for tracking the device on a global management system, the prefix is not needed (and typically not configured in the SIS tag). DeltaV SIS can automatically ignore the prefix during device identification.
- **Smart Commissioning.** Combining the device verification, the device configuration via a template (AMS Device Manager), and the ability to automatically perform loop tests, it is possible to perform the complete pre-commissioning process with one click. While this automatic verification does not replace the end-to-end functional test, it verifies the device is ready for that final test which avoid unnecessary trips to the field.

- **Remote partial proof tests.** The purpose of the proof test is to ensure field devices are operating properly. While comprehensive proof-tests (also known as full tests) cannot be perform remotely, some field devices allow using HART for remote partial proof tests. These partial proof-tests do not replace the comprehensive tests, however they allow extending the interval between comprehensive tests and better accommodate turn around schedules. Partial proof test on Digital Valve Controllers are well known (partial stroke test), however other instruments (e.g. level transmitters) have partial proof test capabilities.
- **Easier data visualization.** The HART diagnostics reported via alarms can be displayed in different ways. Alarm can be displayed on DeltaV stations, AMS Device Manager stations or even mobile devices using DeltaV Mobile or PlantWeb Optics. Normally, device alarms in DeltaV are filtered out from the operator screens and they are only visible in a workstation at the maintenance shop. Alternatively, thanks to the tight integration with AMS Device Manager, user can handle alarms using AMS Device Manager Alert Monitor.
- **Accessibility to advanced tools.** The ability to pass HART data to AMS Device Manager enables the use of specialized tools called snap-on as well as PlantWeb Optics. An example of a snap-on application is Valvelink which is used for advanced configuration and diagnostics of DVC6200SIS. Another example of a snap-on application is QuickCheck, which improves productivity during interlock checkout. QuickCheck also provide powerful reporting capabilities, for example, with QuickCheck is very easy to get a report of devices that are write protected at the device level. Other parameters such as units and ranges are also easily retrievable using QuickCheck
- **Consolidated records.** Historization of HART alarms and events can be recorded with the same tool as the BPCS and SIS alarms. Alarms, events, and even audit trail records from both DeltaV and AMS are available on a integrated system covering both BPCS and SIS.
- **Utilize the multi-variable capabilities on smart instruments.** Different HART variables can be used to monitor multiple signals from the device without the requirement to run separate wiring for those signals - resulting in significant cost savings.

## Detecting Abnormal Conditions in DeltaV SIS

### Built-in HART Device Status Signals

The DeltaV SIS automatically monitors various HART status signals from transmitters and the DVC6200SIS series positioner. The system can also determine device health based on other HART parameters. The system response to bad status or unhealthy conditions is configurable:

- Impact on voting – If a transmitter is determined to be bad via these built-in HART status signals, the SIS can either remove the transmitter from the voting logic (i.e. a 2oo3 voted group of transmitters degrades to 1oo2 or 2oo2 with the bad transmitter viewed as faulty) or simply alarm via operator graphics or an screen at the maintenance shop.
- Impact on trip – While unlikely to be used due to availability concerns, the built-in HART device status signals can be used to initiate a trip. For improve usability, DeltaV SIS provide the option to easily define a time delay before the command to trip. In this way, users have a reasonable time to address the issue, but if it is not resolved within the allocated time, the system will initiate an automatic response.

The following built-in HART device status signals are used:

- PV out of limits
- Loop Current Disparity
- PV output saturated
- PV output fixed
- Loss of digital communications
- Field device malfunction.

It is up to the end user to determine the impact of these status signals and whether the above conditions signals should be used for transmitter voting degradation, trip initiation or other pre-configured response.

Users can configure how the HART status impact the safety logic via DeltaV Explorer. After creating a HART-enabled channel in a CHARM Smart Logic Solver (CSLS), drill down into the channel and double click on the HART_ERRORS parameter. By default, the CSLS will ignore all of the built-in status signals which means the condition do not contribute to bad status of the associated function block.

**PV Out of Limits** – The HART instrument is reporting that the primary variable read by the transmitter is outside of the 4-20 mA range. This signal can be used to detect open/short circuits in the transmitter wiring.

**Loop Current Disparity** – The system is detecting a difference between the analog 4-20 mA signal and the digital PV signal. This functionality can be used to determine a earth leakage in the home run cable to the instrument or an intermittent device failure. If a ground loop exists in the loop, the trip limit of the device may never be reached even under trip conditions due to earth leakage. This diagnostic should detect the difference and the SIS can perform the required action (trip or alarm).

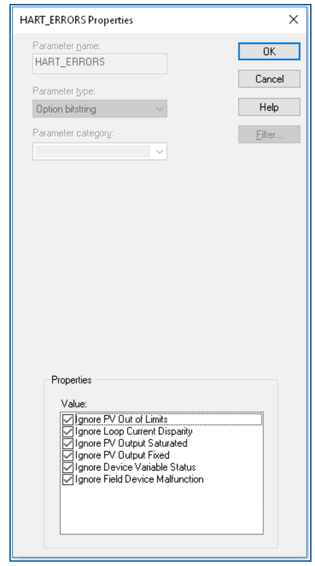


*Figure 1 - Configuration for HART errors detection*

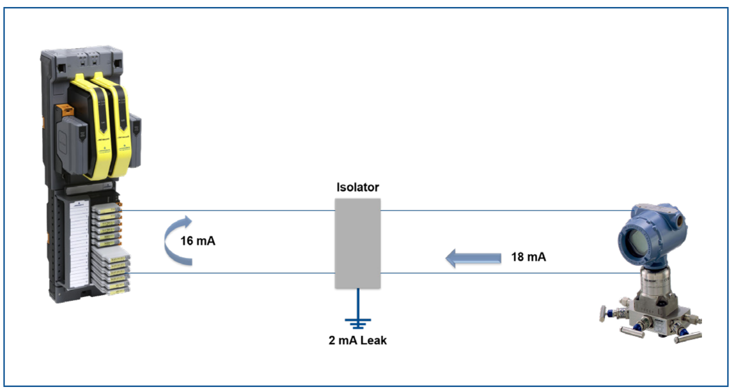


*Figure 2 - Measurement errors due to earth leakage*

**PV Output Saturated** – If the process variable goes outside of the 4-20 mA range, the HART transmitter will drive the mA output and the PV to the saturation values, but no further. Therefore, the process variable no longer represents the true applied process. The transmitter will clamp the analog output and PV to the saturation values (not the 4 and 20 mA values). PV's between the 4-20 mA limits and the saturation limits may still be valid signals.

The diagram in Figure 3 is taken from a Rosemount 3051S pressure transmitter user manual. The low and high saturation (3.9 mA and 20.8 mA respectively in the Alarm Level) are the saturation setpoints. The 3.75 mA and 21.75 mA values are the transmitter failure setpoints:

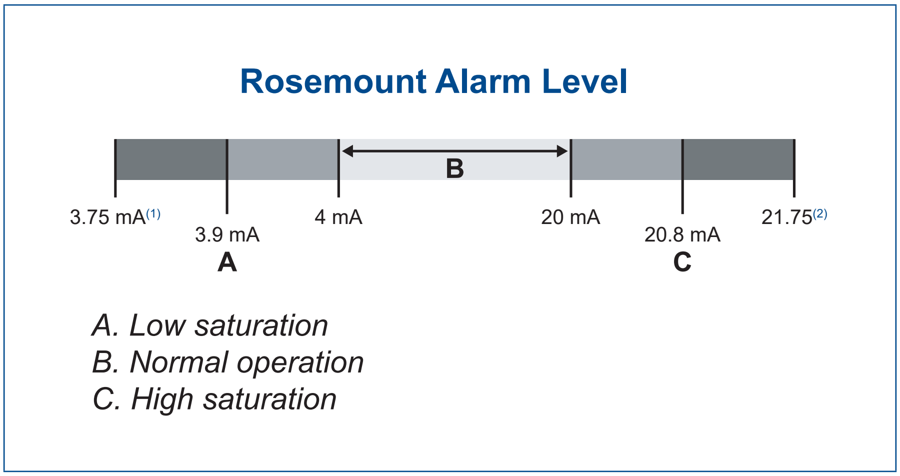


*Figure 3 - Alarm thresholds for Rosemount transmitters*

It should be noted that this is a digital HART alarm that is separate from the open/short circuit detection performed by monitoring the 4-20 mA analog signal in the CSLS. Usually, SIS transmitters are configured in the CSLS to detect faulty transmitters (open/short circuit) by monitoring the 4-20 mA analog signal and removing a transmitter from a voting configuration when that analog signal is outside of a specified range. It is good engineering practice to set the faulty transmitter ranges for the 4-20 mA analog value in the CSLS equal to the failure alarm setpoints from the HART device. If the transmitter detects an error, it will send the PV to the failure alarm setpoint. Values within the low/high saturation areas are still valid values according to the transmitter. If faulty transmitter setpoints using the 4-20 mA signal in the CSLS are set within the saturation range, spurious trips of the process may occur even though the transmitter may not be faulty.

**PV Output Fixed** – The analog and digital signals for the Process Variable are held at the requested value. They will not respond to the applied process. The output is fixed when a transmitter has been taken out of service during calibration or maintenance (changing a range, for example). Unless the transmitter has been put back in service, the outputs will continue to be fixed indefinitely. Using this status bit, it is possible to detect if a device was unintentionally left in out of service after being served.

**Loss of Digital Comms** – This status bit is set when the HART digital communications with the device is lost. The 4-20 mA analog signal may still be valid, but the digital HART signal is not available.

**Field Device Malfunction** – The device has detected a hardware error or failure on the device. This pertains to a variety of errors that can occur. Malfunctions in the memory, A/D converters, CPU, etc are covered under this status bit.

## Additional HART Parameters

In addition to the built-in HART status bits, several other HART variables can be used. These HART variables are dependent on the type of device. While the status signals can be used directly in the SIS logic, these additional HART parameters only pass through the SIS to the BPCS and AMS where can be utilized.

**It should be noted that HART is not a safety-rated platform.** You should NEVER substitute HART signals for hardwired signals when the hardwired signal is being used to detect a hazardous condition with a SIL rating. Field device changes via HART can impact the safety function, for example, a change in the device range will lead to a different reading which can impact the safety function. As explained later in this document, DeltaV SIS provides the ability to restrict field device configuration changes via HART while the system is in operation.

## HART Information from Emerson Devices

The following sections illustrate some HART capabilities on Emerson field devices and provide some guidelines for integration with DeltaV SIS.

**Fisher DVC6200SIS Series Positioner**

Most HART field devices use the HART_PV, HART_SV, HART_TV, and HART_FV variables to send configurable device information to the DeltaV and DeltaV SIS. The Fisher DVC6200SIS series positioner sends four configurable slot variables in addition to the HART variables (which are not configurable in the DVC6200SIS series positioner). The available HART variables are:

- HART_PV – Loop Current, mA or %
- HART_SV, HART_TV, and HART_FV are user configurable with the following options:
  - Travel %
  - Travel Setpoint %
  - Pressure Port A PSI, Bar, KPa, Kg/cm2
  - Pressure Port B PSI, Bar, KPa, Kg/cm2
  - Pressure A-B PSI, Bar, KPa, Kg/cm2
  - Supply Pressure PSI, Bar, KPa, Kg/ cm2.
  - Drive Signal %
  - Analog Input mA, %

The four additional HART variables (slot variables) are also user configurable with the following options:

- Analog input
- Internal temperature
- Pressure port A
- Travel
- Drive signal
- Pressure port B
- Travel setpoint
- Differential pressure
- Supply pressure
- Implied valve position
- Primary feedback
- Friction
- Deadband
- Stroke time

**Partial Stroke Testing (PST)** – Initiating a partial stroke test and the retrieving the result of the partial stroke test can be done via HART in the DVC6200SIS series positioner. The partial stroke test can be initiated in the DeltaV SIS, AMS Device Manager, an operator graphic, or via a HART handheld device. The test is run in the DVC6200SIS series positioner and the success/failure of the test is sent back to the SIS and/or AMS to be shown on operator graphics or for historization. It is a good engineering practice to include the requirement for a successful partial stroke test during any commissioning process for a valve with a DVC6200SIS series positioner. The max and min travel in addition to the outgoing and incoming ramp rates are configurable in the DVC6200SIS.

**Automatic Test Interval** – The DeltaV SIS and the DVC6200SIS series positioner can be used to automatically start partial stroke tests at required intervals. An alarm can be created to alert the operator that a partial stroke test is about to occur. In addition, the last successful partial stroke test time can be displayed on operator graphics, as well as the time until the next partial stroke test is due.

**DVC6200SIS Output** – The DVC6200SIS has an output that can be configured either as a switch or position transmitter. When configured as a switch it can be set to act as a limit switch, alert switch or test a solenoid. The output is capable of SIL2.

**Stroke Time** – The DVC6200SIS calculates the demand and reset stroke time in the device and compares it against user established thresholds to generate a stroke time alert.

**Air Supply Pressure** – Air supply pressure can be configured in the DeltaV SIS as a slot code variable (code # 8) that can be read in the DeltaV. The pressure value can be used to detect low and high air supply pressure and possible plugging of the air supply line via water, oil, or particulate matter.

**PST Evaluation** – Every PST is evaluated against user defined thresholds and a PST Pass/ PST abnormal is generated. The criteria used to evaluate include Pressure, Friction and breakout thresholds.

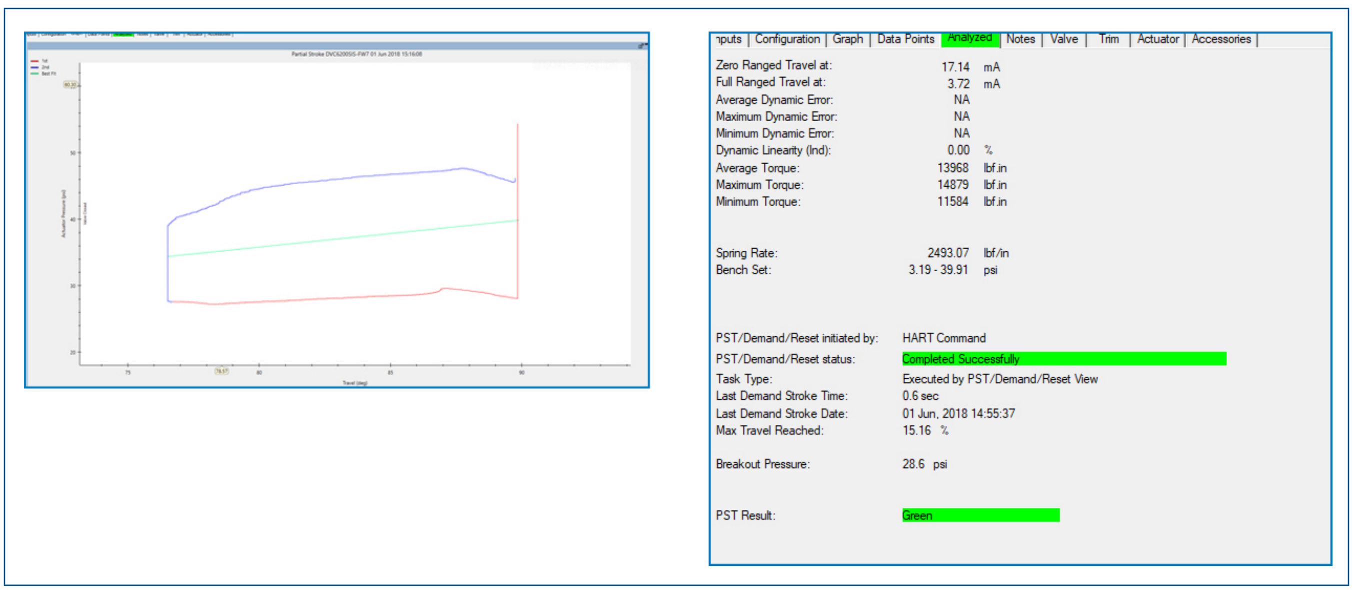


*Figure 4 - Partial Stroke Test Results*

**Safety Certified Rosemount 3051S Pressure Transmitter**

**Impulse Line Plugging** – One of the HART diagnostics for the 3051S is detection of impulse line plugging. The 3051S determines a plugged impulse line by monitoring the normal deviations in pressure. Under normal conditions, slight deviations or noise in the pressure will be present on a millisecond scale. As flow decreases or plugging occurs in the impulse line, these deviations will decrease to a minimum value. Care should be taken when using this diagnostic to ensure that that plugged impulse line alarms are masked or transmitter failure actions are cancelled when there is no flow in the process (such as when the unit is shutdown or when minimum flow conditions exist). Additional logic may be required to mask this alarm during no or low flow conditions.

**Damping** – Damping is a configurable value in HART transmitters that introduces a delay in the output of a transmitter. This parameter is used to smooth variations in output readings when sharp, rapid changes to the process input occurs. The factory default value is 3.2 seconds. Care should be taken when using this variable in SIS loops. SIS applications sometimes have a delay timer in logic (usually around 500 msec to 1 sec) to avoid spurious trips when short spikes occur with the process variable. The SIS should be engineered to ensure that the damping in the transmitter coupled with the delay timer in the SIS logic does not exceed Process Safety Time requirements for the Safety Instrumented Function (SIF).

**Terminal Temperature** – Terminal temperature is a measure of the temperature on the transmitter. It is not a measure of the process temperature. The sensor temperature can be read in the system via a HART parameter (default is the HART_SV parameter) and can be used as a check to determine that heat tracing is functioning properly. This parameter could also be used as an aid to determine if impulse lines have plugged in processes where plugging occurs when heat tracing has failed.

**Safety Certified Rosemount 3144P Temperature Transmitter**

**Sensor Redundancy (thermocouple or RTD)** – The 3144P has redundant sensors. This redundancy can reduce the number of spurious trips that occur due to the fact that the secondary sensor can supply the temperature measurement if the primary fails. Dual sensors can also be used to detect a sensor drift due to extreme temperature swings, high vibration or platinum element contamination. There are several different variations of the 3144P that can be ordered. SIS applications will generally use the U2 (Average Temperature with Hot Backup and Sensor Drift Alert – Warning Mode) or U3 (Average Temperature with Hot Backup and Sensor Drift Alert – Alert Mode).

**Sensor Drift Alert** – One of the best methods of detecting sensor drift and subsequent failure is via deviation alarming. This capability is a built-in, configurable feature in the 3144P. If deviation alarming is used in the transmitter as a HART alarm or in the SIS as a programmed alarm in logic, this credit should be used in the SIL calculations.

**Damping** – See the damping description for the 3051S. The default damping in the 3144P is 5 seconds.

**Terminal Temperature** – See terminal temperature description for the 3051S.

**Sensor Types** – Different sensor types, such as a RTD and a thermocouple, can be used when the dual sensor configuration is chosen. This can reduce the amount of common cause in the sensor and should be reflected in the SIL calculations.

**Micro Motion Coriolis MVD Single Variable Flow Transmitter Model 1700**

**Mass or Volume Total** – Mass or volume total can be used, particularly in tank farms, pipelines, and terminal management applications, when the total amount of material that has passed through the transmitter in a period of time is requested.

**Micro Motion Coriolis MVD Multivariable Flow and Density Transmitter Model 2700**

**Temperature** – Temperature can be used for deviation alarming with other temperature transmitters nearby in the process to detect faulty temperature transmitters if the deviation becomes too large.

**Density** – Density can be used for detection of dual phase liquids or for the detection of foreign material that may not be desired in the process flow. Density can be used to check the quality of the process material or to detect plugging in the flow tube.

**Tube Frequency** – Coriolis meters detect flow by measuring the vibration frequency of the piping in which the process flows. By monitoring for low tube frequency, a plugged flow line can possibly be detected. In addition, an unusually high tube frequency can indicate sensor erosion.

**Drive Gain** – Excessive drive gain can be the result of excessive slug flow (liquid in a gas flow or gas in a liquid flow). Slug flow can be caused by cavitation or flashing of liquids. By monitoring the drive gain, slug flow can be detected. In addition, erratic drive gain can be the result of foreign material caught in the flow tubes.

**External Pressure/Temperature** – External pressure and temperature may indicate the need for pressure/temperature compensation that should be performed.

**Damping** – See the damping description for the 3051S.

## Device Alerts

Device alerts can be applied to all HART devices in the DeltaV SIS. These alerts can be monitored either from AMS Device Manager or in operator graphics (in figure 5). User manuals and other white papers exist that describe these alerts in detail. Therefore, only a brief description of these alerts will be given here.

These alerts can be pulled up by an operator or a maintenance group from the operator graphics. Access to these alerts is from the faceplate for an instrument on an operator graphic. The DeltaV SIS is the only SIS on the market that allows these device alerts to be seamlessly and efficiently displayed to operators and maintenance technicians. Other vendors either require the use of HART multiplexers, an AMS, and a connection between the AMS and the BPCS in order to see the HART alerts on an operator graphic. The system also can historize these alarms in the same SOE recorder or historian as other SIS alarms. This creates one repository for SIS alarms, rather than several different databases between the AMS and the BPCS.

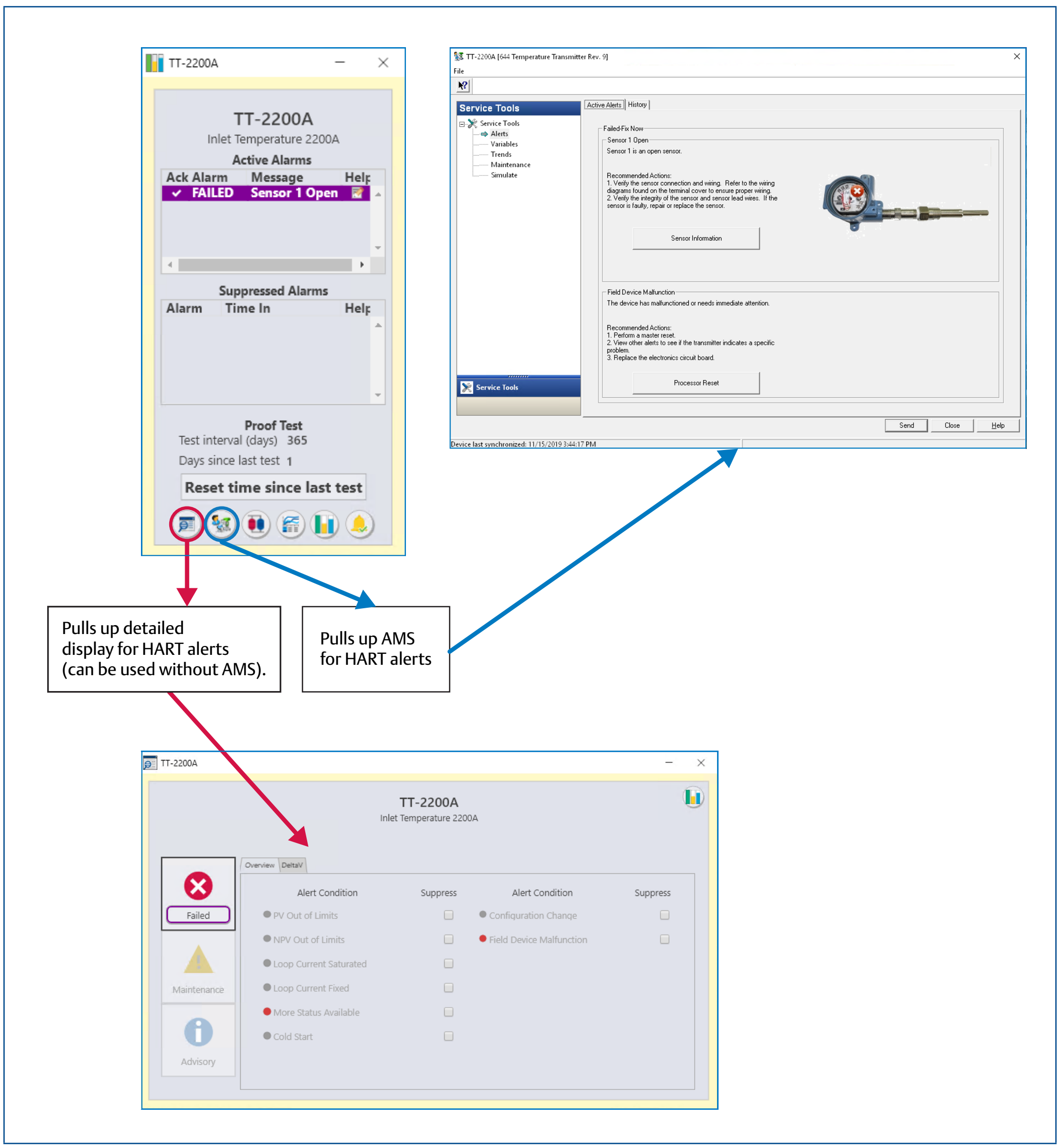


*Figure 5 - Device Alarms*

Device alerts are configurable to allow different alarm priorities for different abnormal conditions. Configuration is performed by selecting the properties for a HART device from Explorer. From there, the alarms can be enabled, and the priorities configured (as shown below). As possible to see in figure 6, alarms are available even for proof test overdue or proof test due soon.

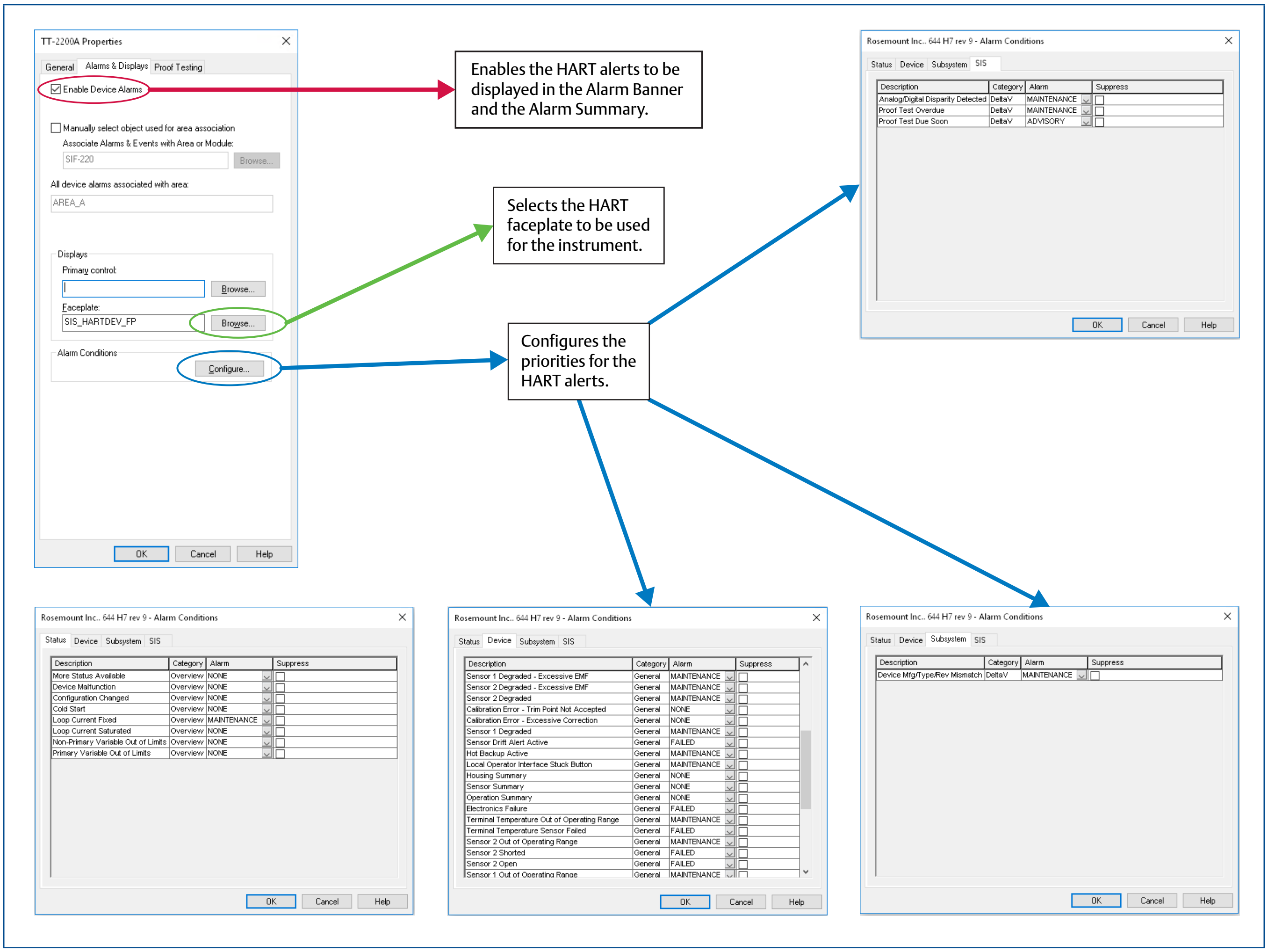


*Figure 6 - Device Alarm Configuration*

## Securing HART Communication

The ability to modify device configuration remotely via HART has multiple benefits. However, it also can also introduced risks due to unauthorized changes or even malicious attacks. Changing the device range or damping settings can impact the measurement value reported by the field device. DeltaV SIS has functionality to prevent unauthorized changes that could impact the safety function.

### DeltaV Lock Functionality

Each logic solver can be locked to prevent unauthorized changes. The lock state is set by an authorized user from a workstation using a TUV-certified mechanism. Once the logic solver is locked, certain actions are prevented including HART commands that could impact the safety function.

To enforce physical presence before unlocking a logic solver, a physical switch can be used to create a two-step approach for unlocking a logic solver. A user with physical access needs to insert a physical key and turn it to the right position before the same or another user can issue a unlock command from a workstation. Simply turning the key does not unlock the logic solver and the unlock command is only allowed when the physical key is on the right position.

### Preventing Device Changes via Hand-helds

The HART protocol allows for two types of masters, primary masters (e.g. DeltaV SIS) and secondary masters (e.g. hand-helds). DeltaV SIS has the ability to send a HART command to set a lock on a HART 7 field device and prevent that secondary masters could modify the device configuration. When this device lock is in placed, only DeltaV and AMS Device Manager (communicating via DeltaV SIS) can modify the device configuration. Modifications using a handheld are prevented. If in addition, the DeltaV Lock is set for the logic solver, AMS Device Manager is prevented to perform device changes that could impact the safety function. The lock at the device level requires HART 7 while the lock for the logic solver works for both HART 5 and HART 7 devices.

## Other Best Practices

In addition to the best practices outlined in this document, the following items should be addressed when using HART devices.

- Many Rosemount and Fisher user manuals supply diagnostic tests to be used during proof test intervals, including the diagnostic coverage factor. The diagnostic coverage factor should be used in SIL calculations to provide an accurate representation of the percentage of dangerous undetected faults discovered from the diagnostic routine.
- Loss of HART communications will not trip a DVC6200SIS series positioner. If HART communications to the DVC6200SIS series positioner is lost but the 4-20 mA signal is still active, the DVC6200SIS series positioner will still continue to operate the valve. In addition, if HART errors are not ignored (for example, you have chosen to trip the valve if PV output is fixed) the valve will continue to operate if HART communications are lost. This function can be tested by connecting a DVC6000 series positioner to the SIS logic solver and placing a 10 µF capacitor across the + and – terminals. The capacitor will cause HART communications to be lost but will allow the 4-20 mA signal to reach the DVC6200SIS series positioner. The DVC will still continue to operate and keep the valve in the operating position even though HART communications are lost.
- Device alerts for HART devices are only activated when they are enabled via the checkbox in the channel properties dialog box. During FAT, it may be beneficial to disable the device alerts so that fewer alarms will be shown during testing when the actual device is not connected to the DeltaV SIS. Device alerts for HART devices do not require the physical presence of the device in order to be programmed.
- During normal operation, keep logic solvers locked and the key switch on the inhibit position to prevent unauthorized changes in device configuration.

## Conclusions

HART instruments provide very useful information that can increase the safety and availability of the overall safety system. DeltaV SIS not only provide the ability to use and respond on the device diagnostic information, it makes HART information easy to use. There are two main reasons for HART information to be underutilized in traditional safety systems. First, traditional safety systems do not provide the required functionality. Second, in the past, configuring both the instruments and the integrated control and safety system for the proper utilization of HART information is difficult and time consuming in traditional safety systems. DeltaV SIS address both challenges with built-in, powerful HART capabilities that are easy to use.

## References

These White Papers also discuss the use of HART in Emerson systems and may be of value:

1. “Using HART to Increase Field Device Reliability”. Adler, Bud. ISA. 2001.

2. “**Configuring PlantWeb Alerts in a DeltaV System**”. Emerson White Paper.

3. “**DeltaV HART Capabilities**”. Emerson White Paper.

4. “**Retrieving Valve Stroke Time in DeltaV SIS**”

5. “**Advanced Diagnostics, Increased Safety and Lower Operating Costs**” Whitepaper

6. **Plugged Impulse Line Detection**. Technical Note

7. **Smart Commissioning** Whitepaper

8. **Remote Proof-Testing Capabilities**

The Emerson logo is a trademark and service mark of Emerson Electric Co. The DeltaV logo is a mark of one of the Emerson family of companies. All other marks are the property of their respective owners.

The contents of this publication are presented for informational purposes only, and while diligent efforts were made to ensure their accuracy, they are not to be construed as warranties or guarantees, express or implied, regarding the products or services described herein or their use or applicability. All sales are governed by our terms and conditions, which are available on request. We reserve the right to modify or improve the designs or specifications of our products at any time without notice.

**Contact Us**
**www.emerson.com/contactus**

©2020, Emerson. All rights reserved.