
The HART Revolution

# Secure Access to Field Device Data Holds the Key to Digitization and Optimized Maintenance

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How plant operators can use diagnostic data from Highway Addressable Remote Transducer (HART)-based field devices without safety or security risks to reduce operating costs and increase the availability and productivity of plants.

# If field devices could speak

“Field Instruments Supporting Digital Transformation” was the motto of the main Namur meeting in 2018.[1] Two things became evident during this meeting of key personalities in the process industry, which was dedicated to the role of field devices in digital transformation. Firstly, the process industry wishes to and has to encourage the digitization of production even more than before. This is only in this way that plant operators will be able to cope with current mega trends in the process industry. These mega trends include customization, which leads to ever smaller batches, quicker innovation cycles, and merging of chemical and biotechnological processes. Long-term success on the global marketplace is only possible for those who successfully digitize their processes.

The second finding from the meeting was that digitization of field devices offers plant operators huge opportunities to reduce operating costs and increase productivity. After all, field devices act as “eyes and ears” to record all kinds of useful data directly on machines and plant systems. A look at the modern process industry shows that a large proportion of the available data remains unused. Measuring transducers installed today can do considerably more than just transmit measured values via a 4…20-mA signal. Diagnostic data even remains unused for the majority (85%) of HART-capable devices present in processes.

Why is the digitization of process engineering production becoming so significant for field devices in general and, in particular, for those that use the HART protocol? It’s partly because of the enormous potential: With over 40 million field devices installed and support from leading instrument suppliers, the HART communication protocol is the most widely used digital communication technology in the process industry. Although the HART signal has been primarily used for parametrization so far, it can also enable continuous device monitoring and diagnosis as well as providing multivariable process information with the corresponding tools. If this data is collected and converted into usable information, it provides considerable added value over the complete plant lifecycle – from planning and installation through to operation and maintenance.[2] Another factor is that this data is theoretically relatively easy to access. This makes seamless integration into IIoT solutions possible, potentially via the HART protocol and gateway solutions.[3] HART technology means that corresponding field devices have huge potential where the vertical networking of plants and the transition to intelligent factories and Industry 4.0 are concerned.

The digitization of the field level is, however, not all that straightforward. As the process industry is designed for long cycles and is highly regulated, new technologies gain acceptance more slowly here compared to other sectors.

1 Heinrich Engelhard (Bayer) and Sandra Rubart (Endress+Hauser), Field instruments supporting digital transformation, 81. Main NAMUR meeting on 8/9 November 2018 https://www.namur.net/de/publikationen/news-archiv/detail/article/field-instruments-supporting-digital-transformation81-namur-hauptsitzung-am-89-november-20.html

2 Suzanne Gill, Control Engineering Europe, HART holds its own in the race to Industry 4.0, 04 September 2018, http://www.controlengeurope.com/article/139367/HART-holds-its-own-in-the-race-to-Industry-4-0.aspx

3 Dr. Jörg Kempf, Process, exclusive interview at the main Namur meeting: Endress+Hauser-CEO Matthias Altendorf: “The IIoT is becoming more tangible”, 17 September 2018, https://www.process.vogel.de/endresshauser-ceo-matthias-altendorf-das-iiot-wird-greifbarer-a-756111/

This is the case for security-related applications in particular, where steps have traditionally been taken with great care. The topic of diagnostics is also becoming more important in safety-critical applications, as sensors and actuators are vital for seamless plant operation. This is the case for applications in SIL protective devices, in particular. Alongside the SIL diagnoses and safety routines, the possibility of diagnosing the state of health of the device at the points involved in the process is also important. This is because device shutdowns can have severe consequences in safety-critical applications. Unnecessary plant shutdowns, for example, result in very high costs.

## Crucial point: Data from safety-focused applications

There is an increased interest among plant operators in acquiring, interpreting, and recording (in the long term) diagnostic data from SIL safety devices.[4] Plant operators today no longer want field devices to merely provide measurements such as pressure and temperature, which only allow conclusions regarding the product characteristics, the process state and the state of the measurements indirectly. Direct statements concerning the quality of the process connection, the sensor and the electronics are becoming increasingly important.

It was previously difficult or even impossible to get close to truly useful data in safety-related applications. However, this data is necessary to make the periods for the repeat tests more flexible or to extend them, according to NAMUR NE106.[5] The problem: Although a large number of field devices are now equipped with the HART protocol, it is only used for commissioning in most cases. Conventional HART communication also involves risks in terms of manipulation, and the configuration of the field devices is very prone to error, particularly during operation.

Given this background, many users ask: How do I as a plant operator efficiently access the data gathered by field devices? How can I guarantee safety and security during this process? How can I filter valuable information out of the huge quantity of available data? This white paper answers these questions by presenting a unique solution which heralds a new era of HART communication. This solution makes genuine predictive maintenance in the field of safety engineering in the process industry possible for the first time. This white paper also shows how plant operators can use the data from intelligent HART-based field devices in an efficient and secure way with this solution to reduce operating costs and increase productivity.

4 Dr. Jörg Kempf, Process, Device Diagnosis - Meaningful predictive maintenance thus becomes possible for the first time, 25 April 2018, https://www.process.vogel.de/so-wird-erstmals-aussagekraeftige-vorausschauende-wartung-moeglich-a-709779/index3.html

5 Sabine Mühlenkamp, Intelligent Door Opener – Diagnosis for PCE safety devices, process edition 9-2018, p. 34 ff.

# Digitization of field devices: the first step is always the hardest

Plant operators face a range of challenges when using conventional HART communication for safety-focused field devices. HART communication, as it is normally used in the process industry today (communication via a separate HART multiplexer or by separate tunneling), involves significant safety risks. This is due to the fact that the safety system is more or less completely bypassed and doesn't notice the HART communication. As a result, potential cybersecurity risks arise, as employees may be able to change instrument parameters of field devices unintentionally or hackers may do so deliberately, which can endanger the safety and availability of a plant. If a limit value for an SIF (Safety Integrated Function) within the safety control is set to 75% of a measurement range of 0 - 10 bar (corresponding to 4 – 20 mA) and someone changes this range ONLY within the sensor from 0 - 100 bar, the corresponding response is only triggered once a measurement value of 75 bar is reached. This means the SIF does not fulfill its function and can cause considerable safety and production problems.

The high expenditure required for configuration, maintenance and testing is an additional weak point in conventional HART installations. Service technicians often check the state of field devices with handheld equipment or make configuration changes. If systems are not networked, there may be gaps in documentation if changes are performed manually, and this can lead to the safety issues described above. In addition, it is only possible to bring about customer-specific evaluations, statistics, and reports with an asset management system and a disproportionate amount of effort.

The dilemma is shown in the example of safety devices with flow meters. The effort involved in checking on a calibration system is huge. For this purpose, it is necessary to remove the devices, test them on the calibration system, and then put them back into operation on the safety device. The plant operator must document the test in line with a predetermined test procedure and show the outcome.

Measurement systems are often complex, and detailed tests of the electronics and the sensor are not possible without special test instruments. The process industry needs a simple and safe test in the installed state with a comprehensive degree of diagnostic coverage and an error-free test procedure that is highly automated.

For many decades, great efforts have been made in process diagnostics to create reproducible physical parameters which allow a clear conclusion on the state of the process or device in corrosive or abrasive applications. In this case, the diagnostic parameters should be independent of other processes or ambient conditions to enable a  accuratetrend analysis in continuous process operation. The absence of these clear diagnostic parameters and the great effort involved in the interpretation of the available diagnostic data previously made the implementation of predictive maintenance difficult. The transfer of comprehensive device data from the field and its provision in the control system was for a long time only possible with considerable engineering input due to the largely proprietary provision of parameters in the field devices, particularly if safety-focused field devices with additional increased requirements were involved.[6]

In this context, particularly close attention should be paid to the testing of field devices in process control engineering (PCE). These must be tested at regular intervals in accordance with IEC 61511 and VDI/VDE 2180. The repeat test in accordance with the worksheet NAMUR NE106 should be stated here; it was recently revised and the previous regulations were extended with the concept of the "flexible test." The aim of the innovation is to ensure the longest possible plant operation – uninterrupted by tests – with simultaneous maintenance of the necessary safety integrity of the installed PCE safety devices. In this process, the previous fixed test interval is extended. An additional test method features shorter test intervals and reduced test contents within a PCE safety device.[7]

The point of the repeat test is to ensure the seamless function of the safety device. The repeat tests of these SIL safety devices, which may befrequent, represent a risk during continuous process plant operation, while adding costs and the potential for plant outages. Statistics show that up to 25% of systematic errors emanate from parametrization and 15% from other maintenance work.[8]

The technical boundary conditions stated and solutions available on the market thus far have resulted in valuable data acquired by field devices largely remaining unused, as use via the asset management system was either too time consuming or completely impossible. A new HART solution, however, solves many of the problems of conventional systems.

6 Dr. Jörg Kempf, Process, Device Diagnosis - Meaningful predictive maintenance thus becomes possible for the first time, 25 April 2018, https://www.process.vogel.de/so-wird-erstmals-aussagekraeftige-vorausschauende-wartung-moeglich-a-709779/index3.html

7 NA 106, 06 September 2018, https://www.namur.net/publikationen/news-archiv/detail/article/na-106-ist-ueberarbeitet-worden.html

8 Chemie Technik, Systematically correct – Automated repeat test of SIL safety devices, 27 March 2018, https://www.chemietechnik.de/automatisierte-wiederholpruefung-von-sil-sicherheitseinrichtungen/

# New HART solution provides comprehensive opportunities for diagnosis

A new HART solution using HIMA's HIMax® system enables comprehensive diagnostic possibilities at the field level for the first time. This solution allows important information to find its way to the asset management system and the user program from field devices via HART protocol. This intelligent data diagnosis helps prevent outages and thus increases plant availability. Accessing HART parameters via the HIMax safety system makes it possible for the operator to process device diagnosis and trend information (e.g., concerning potential impending outages) within the user application logic. Although this information is not safety relevant, it can be used within the user application logic to increase the availability of the connected field devices in particular and contribute to the overall availability of the plant without endangering safety. Gas sensors can report an impending outage via HART, for example, and give plant staff the opportunity to react at an early stage (predictive maintenance)

In addition, the channeling of the HART communication via the HIMax safety control – the "listening" of the HART communication – and the possibility of limiting or stopping undesired communication at SIL quality ensures secure and protected asset management. This is more or less comparable to the "Deep Packet Inspection" function of an Ethernet firewall. Channeling ensures that the device values can only be changed via the safety PLC (with the exception of handheld devices). This is the only solution on the market with complete control of the HART communication traffic with SIL 3 quality in accordance with IEC 61508, IEC 61511, and IEC 62061. The additional possibility of monitoring changes to configuration, e.g., on site with the device or with handhelds, allows manipulations to be prevented or at least detected so that an appropriate action can be taken. This extra degree of cybersecurity eliminates risks when using HART devices in safety applications, which were previously common. It is also possible to initiate and administer proof tests such as partial stroke tests for valves or complete proof test routines for sensors from the safety system.

The innovative solution consists of the HIMax module X-HART 32 01 (figure 1) and the HIMax-HART package (figure 2). The 32-channel HART module can be installed alongside any AI/AO without additional wiring requirements. It enables centralized access to the HART information of the field devices connected to the HIMax system. The module can be inserted in any slot of a HIMax base plate, with the exception of those for system bus modules. It can be combined with analog input or output

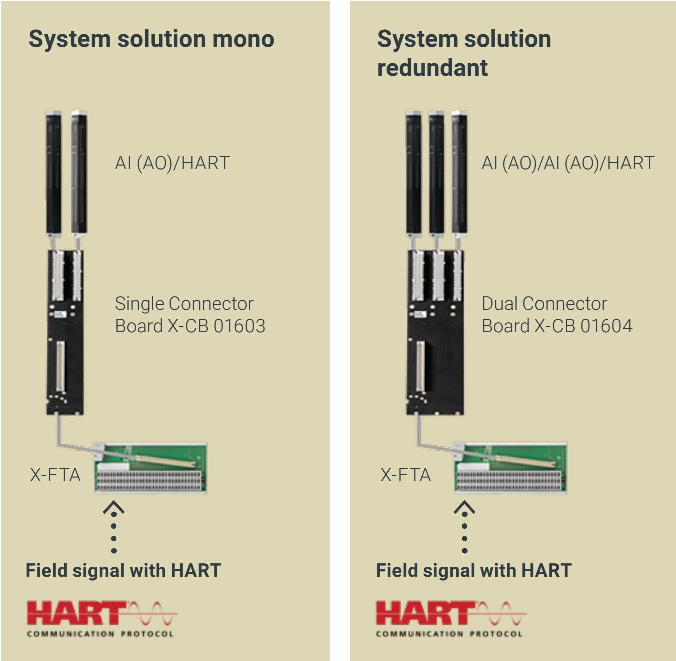



Figure 1

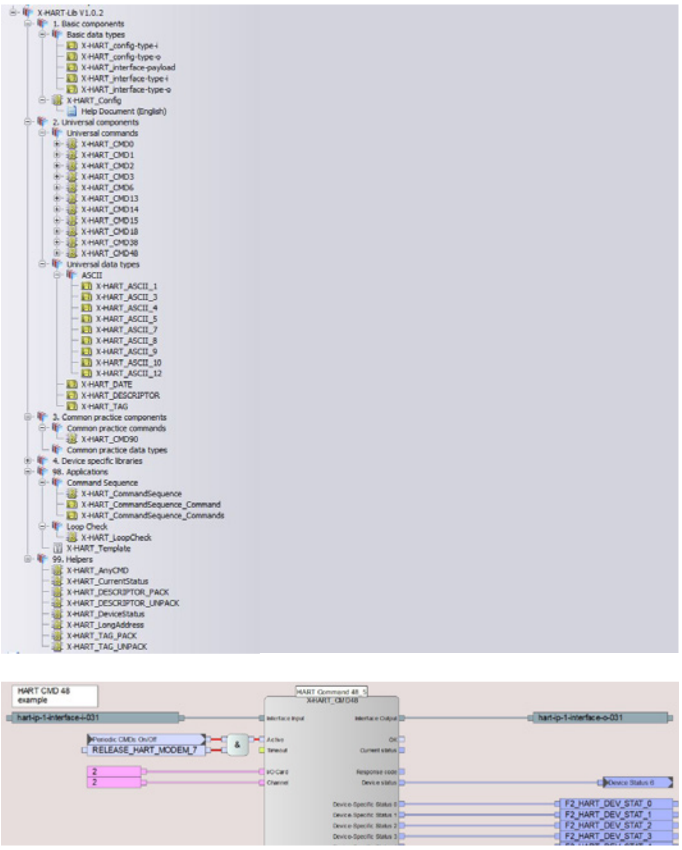


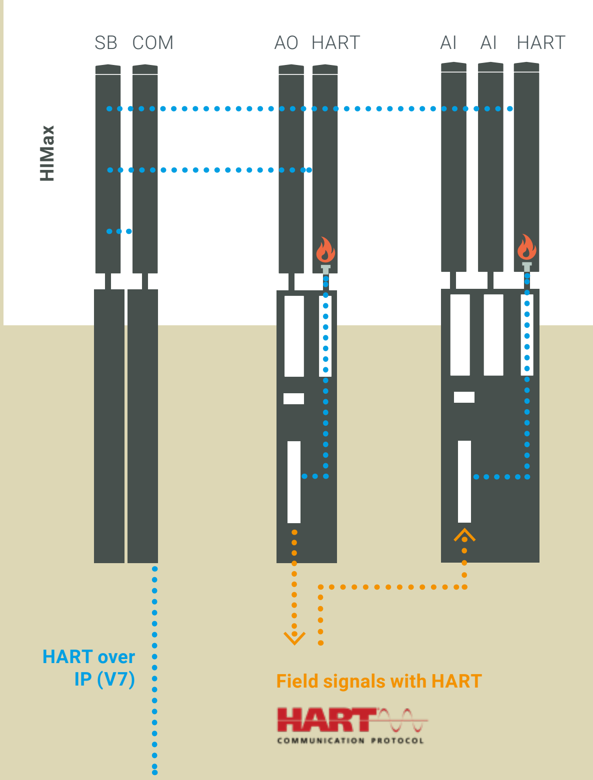
Figure 2: Device-specific function blocks

modules in a mono or a redundant version through the use of connector boards (figure 1). HART communication for up to 3,200 inputs/outputs is possible for each HIMax system.

The HIMax HART software package allows HART data to be utilized in the user program, supplies a predefined function library, and can be extended with further libraries. It includes import files for predefined HART variables via a preprogrammed communication driver plus a predefined block library for selected standard HART commands (15 are implemented at present). Specific commands of each device manufacturer can be implemented quickly. Tasks such as individual evaluations and reports, which were previously very time-consuming, are considerably easier. Complex command sequences can also be shown. The software package provides a straightforward basis for creating distinct command blocks at the application level, including the possibility of creating complex command sequences (figure 2).

HART data from field devices is channeled via HIMax for increased safety and security (figure 3). In this process the data is transmitted from the X-HART modules via the internal system bus to the assigned X-COM module. From there, they find their way into the asset management system or the HART-OPC server via HART over IP protocol. The security features of the safety controller make it possible to achieve a security concept in accordance with IEC 62443 for HART device access. These features include separate communication pathways in the system for secure and non-secure data as well as clearly defined communication ports. They also contain an integral HART filter in SIL 3 quality, which "listens" to the data traffic and can be controlled to only allow read access to the field devices, or it can block all write commands. This combination of complete flexibility and security features makes the automatic repeat test possible via the safety control, even for SIL locked devices in protective devices in an installed state.

**HIMax-HART data tunneling**




**Supported asset management systems**

- PACTWARE
- FIELDCARE
- Honeywell FDM
- Yokogawa FieldMate
- and others on request

Figure 3: HIMax HART data tunneling

## First application cases confirm potential

**A) Joint HART solutions from HIMA and Endress+Hauser**
Metrology specialists Endress+Hauser and HIMA developed joint solutions for safe HART communication and diagnosis of instrumentation within the framework of the Open Integration partner program.

This combines the HIMA HART solution with the E+H diagnostic technology called Heartbeat (figure 4). With the joint solution it is possible to use the monitoring function of the Heartbeat technology in Proline flow meters (e.g., Promass 300) and read diagnostic data in the SIL loop. This function provides the HBSI (Heartbeat Sensor Integrity) value with which corrosion and deposits can be detected, among other things. The integral HART filter in SIL 3 quality (comparable with the "Deep Packet Inspection" function of an Ethernet firewall) enables an automatic repeat test via the safety controller – even for SIL locked devices in protective devices in an installed state. In this process the safety controller determines the optimum point in time for implementation. The process is fully automated, from unlocking devices via the complete device verification up to the final fresh locking of the devices and is controlled via the HART interface in accordance with NE 154. The concept thus provides the opportunity to extend test cycles.

During the implementation of the test procedure, the SIL sequence in the device is always run so that all safety relevant device settings can be checked. In addition to the test result (passed or not passed), the devices test supplies all the diagnostic values necessary for meaningful trend monitoring. These can then be processed further and used for predictive maintenance. There are now various analytical models available for a detailed evaluation of the parameters so that clear progression curves and trend statements on the state of health of the device can be derived in the respective application. For a specific adaptation for this application, it is even possible to display to the nearest millimeter the thickness of a coating formed in a measuring tube. Any necessary plant purging processes can be initiated in this way.

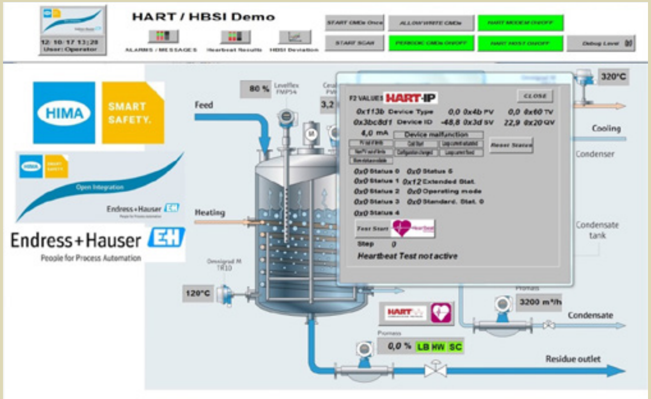



Figure 4: The joint HART solution from HIMA and Endress+Hauser enables significantly optimized maintenance and automated repeat testing of SIL locked protective devices in an installed state.

The automatic proof test implementation for E+H level gauges of the Micropilot FMR6x series is another jointly developed solution. Adaptations to the wiring to connect a measuring device and manual interventions on the device are normally necessary (in keeping with the device safety manual) to unlock it, simulate values, and then to lock it again correctly. These "manual" interventions provide a few sources of errors with regard to "systematic errors." The automation of this proof test while using the HIMax analog input module as a measuring device means that this manual interaction is no longer necessary, thereby reducing costs and minimizing systematic errors.

### Test sequence C

**Preparation**

1. Navigate to: Setup → Extended Setup → Deactivate SIL/ WHG = Reset write protection and enter the corresponding unlocking code (WHG: 7450; SIL: 7452; SIL and WHG: 7454)
2. The SIL operation is deactivated
3. Connect suitable measuring device (recommended accuracy better than ± 0.1 mA) to the power output.
4. Establishment of the safety circuit (limit level or range monitoring).

**Process for limit level monitoring**

1. Navigate to: Expert → Sensor → Sensor diagnosis > Start self-test = Yes
2. Device self-test is carried out
3. Navigate to: Expert → Sensor → Sensor diagnosis > Result self-test = OK
4. This part of the test has only been passed if "OK" is displayed.
5. Navigate to: Diagnosis → Simulation → Assignment of process size = Enter fill level value and enter the value for process size in the value parameter.
6. A fill level immediately below (MAX monitoring) or immediately above (MIN monitoring) of the limit level to be monitored is simulated.
7. Read and record output power and assess for correctness.
8. Simulate a fill level immediately above (MAX monitoring) or immediately below (MIN monitoring) of the limit level to be monitored.
9. The test is passed if the current does not trip the safety function at step 3 but it does trip the safety function at step 5.

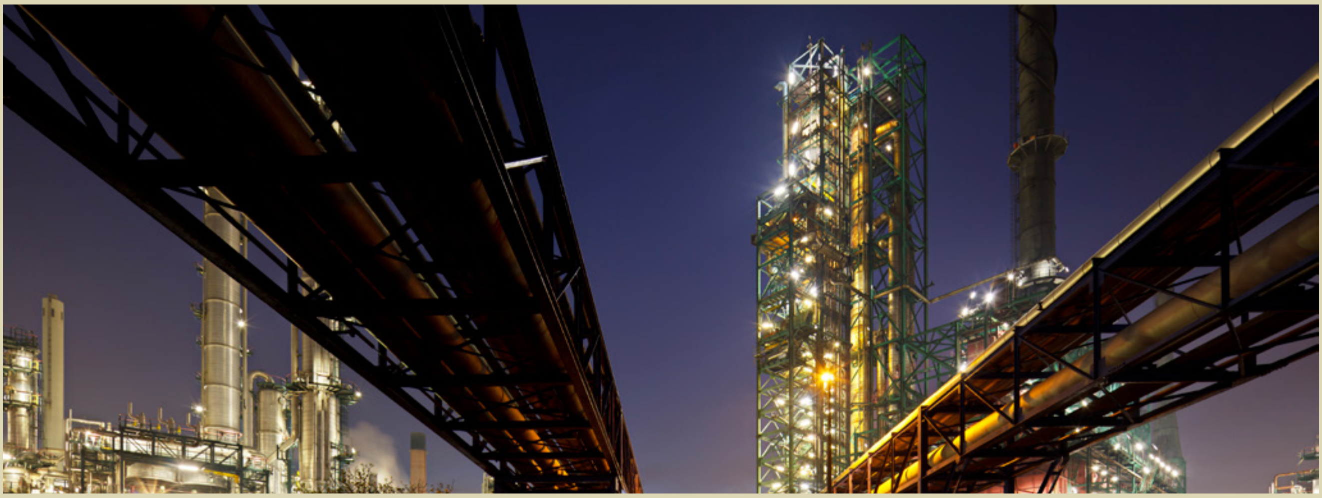
Figure 5: Proof test instruction in accordance with the Functional Safety Manual for the E+H Micropilot FMR60/62/67.

**B) Use in various systems at BASF**

About 50 HART assemblies (spread over three systems) and 40 vacant positions in two additional systems are used in a plant which manufactures an intermediate product for the cosmetics industry at the BASF site in Ludwigshafen. In this process, HIMax acts as a safe gateway to E+H's FieldCare asset management system. This is used for the acquisition, parametrization, device exchange, and for the carrying out of repeat tests. BASF regards the selective permission of the HART communication as a particular benefit. In another BASF operation, Endress+Hauser Coriolis flow meters work together with HIMax to supply relevant diagnostic values automatically once a month. These are filed in the operating data information system at the same time so that predictive maintenance can be scheduled. There is also a pilot system with which loop checks (testing of the circuits) of the sensors can be carried out. This is controlled and monitored by HIMax via an automated simulation in the device. With these measures, BASF aims to extend the test interval of the SIL repeat test to up to three years.

**C) The first "big project" where the HART solution is used**

A large-scale use of the HART solution has already proved an initial success for an oil and gas company in the Germany, Austria, and Switzerland region. The project involved explosion protection over the complete plot with a size of approx. 1.4 km² plot, using approx. 900 gas warning sensors with SIL 2 classification spread over 18 plant parts. The safety function was realized via the 4-20mA loop. The extended requirements plus the customer desire for simplified device parametrization, online calibration reporting, and documentation, and for statistical reports and predictive maintenance could not however be fulfilled via standard AMS functions, and expensive customer-specific solutions would have been necessary. The HART solution from HIMA and additional standard software (SCADA system with reporting functions) saved time and money on initial installation. The solution is flexible with regard to changes, upgrades and updates. Additional advantages for the customer included the possibility of working with familiar systems while also receiving an integral security concept.



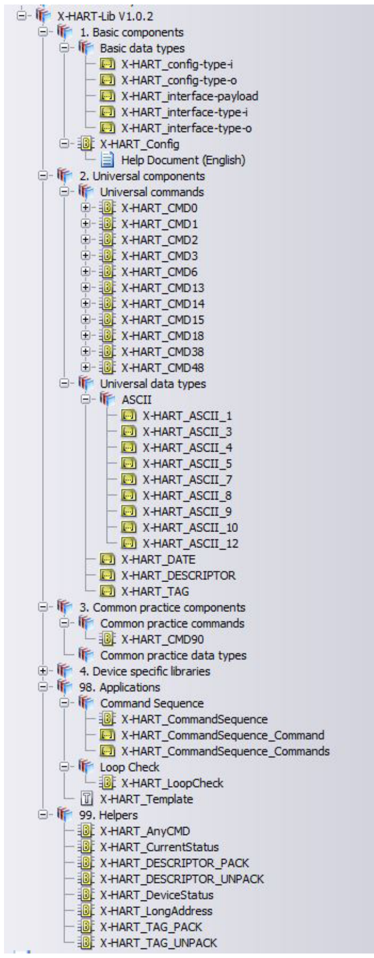
# Predictive maintenance possible for the first time

The HIMA HART solution sets new standards in the acquisition of diagnostic data from field devices in safety circuits. Plant operators can make the diagnostic data acquired with field devices easily and safely usable for the asset management system. Unauthorized changes to the device are detected or prevented immediately by write protection. This reduces the risk of cyberattacks causing damage. Extended trend information enables meaningful predictive maintenance to the safety systems in the process industry. The analysis of data from the field devices provides decisive information for the operation of the plant while supporting development toward Industry 4.0. Targeted repairs can be planned at an early stage, misuse can be prevented, and defined maintenance intervals can be extended. All these reduce the potential for plant outages.

Combined with HART devices, the HIMA HART solution also increases security. The additional possibilities for blocking and filtering in SIL 3 quality and the possibility of monitoring with reference to configuration changes for SIF field devices ensure that the plant is protected against manipulation. This applies to both unintentional configuration changes such as operating errors and to intentional attacks by hackers. The HART solution from HIMA therefore closes an important safety loophole in the process industry.

Plant operators can integrate the solution into existing infrastructure without incurring huge costs. They benefit from low engineering costs, shorter commissioning times, and reduced maintenance costs due to optimized work instructions and maintenance plans. The HART solution also offers support functions for NAMUR NE106 with more flexible test intervals; the automatic repeat test means that test intervals can be extended, thereby reducing maintenance costs and increasing availability. Plant operators can also reduce the supplier pool as it may no longer be necessary to have an asset management system if the HIMA HART solution takes on tasks which would otherwise only be solved in the AMS with a disproportionate amount of work and expense.

HIMax HART module X-HART 32 01.




Extract of HIMax HART software package.

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