



## Innovations in Corrosion Monitoring Product Summary

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### Corrosion History

Corrosion monitoring in the process industry has always been something left to the expert corrosion engineer—that trained specialist heavily educated and largely experienced in metal alloys and chemical reactions. The corrosion evaluation methods used by these individuals often involved the analysis of sacrificial samples (coupons) placed in the pipeline. These samples were precisely weighed prior to their exposure to the process media then analyzed for metal loss and other imperfections. This was the basis for determining the general and localized corrosion rate for the entire process. More coupons located at more locations resulted in larger amounts of data for evaluation thus a more accurate corrosion picture for the facility. Over the years, corrosion evaluation tools have been developed to help the corrosion engineer do his or her job more efficiently. In the end, these tools gave the corrosion expert a high level of data for determination of corrosion but the data was only useful to the specialist, not the facility operator or control systems engineer—until now. Finally, a corrosion monitoring system that can be easily implemented into a standard control room architecture is available.

### Corrosion Future



Figure 1

a new level with a simple, easy-to-use 2-wire transmitter operating on the industry standard 4-20 mA control basis and easily integrated HART protocol.

### Corrosion Technology

The corrosion process is based on the fact that when a metal/alloy is immersed in an electrically conducting

liquid it will corrode through an electrochemical process. The following example shows a simple reaction of a metal (iron) dissolving in an acidic solution:

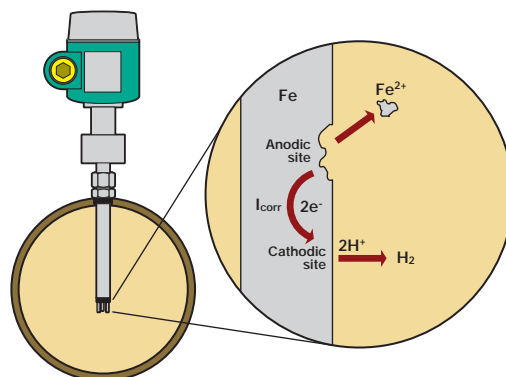
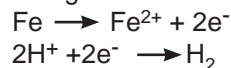


Figure 2

An anodic site is formed when metal from the surface of the corroding pipe or tank passes into the adjacent solution (the liquid causing the corrosion) by way of an ion ( $\text{Fe}^{2+}$ ). This process results in an excess of electrons at the metal surface. The excess electrons flow to a nearby cathodic point which results in the corrosion current  $I_{\text{corr}}$ . These excess electrons are then consumed by the oxidizing agents in the corrosive solution. Anodic and cathodic points continuously shift position and exist within the entire conductive surface (metal). This random configuration makes direct measurement of  $I_{\text{corr}}$  impossible. To overcome this limitation, an electrical probe consisting of three measurement electrodes of the same metal is placed into the corrosive solution. Using this probe, it is possible to apply small potentials between the electrodes and measure the resulting current. The same corrosion process responsible for  $I_{\text{corr}}$  influences this current. If the electrodes are corroding at a high rate, metal ions ( $\text{Fe}^{2+}$  in this example) are passing easily into the solution and a small potential applied to the electrodes will produce a high current proportional to  $I_{\text{corr}}$ . Similarly, if the electrodes are corroding at a low rate with ions passing slowly into the solution, a small potential applied to the electrodes will produce a small current. Using complex algorithms and data analysis, CorrTran interprets this corrosion information and makes it available for plant engineers in the form of a 4-20 mA signal.

### CorrTran Operation

At the heart of CorrTran are state-of-the-art, patented algorithms and data analysis techniques that accurately measure corrosion rate and localized corrosion (pitting). Harmonic distortion analysis (HDA) is applied to improve the performance of the industry accepted linear

polarization resistance (LPR) technique used to measure corrosion rate. To further enhance the performance, an application-specific Stern Geary value (B-value) can be stored in the transmitter. In fact, the B-value can be adjusted by the customer to more accurately represent the pipe and material used in the process. During a measurement cycle, CorrTran performs a unique electrochemical noise (ECN) measurement, which in combination with the corrosion rate data provides a measurement of pitting. At the completion of each measurement cycle, the respective corrosion rate or pitting value is calculated and made available to the plant personnel in the form of a 4-20 mA signal.

The LPR technique has long been the industry standard for general corrosion monitoring and it is based on the Stern-Geary relationship. This B-value relationship correlates the potential excitations with the measured corrosion current to produce a measurement of polarization resistance. This resistance is then used to determine the general corrosion rate. Since it is critical to use the correct B-value in this method, it is generally considered unreliable by itself as a measurement technique for general corrosion rate. The HDA analysis is based on an evolution of the LPR technique. By applying a low frequency sine wave to the measurement current, the resistance of the corrosive solution can be calculated through a harmonic analysis of the resulting signals. With both the polarization resistance and the solution resistance, a more accurate general corrosion rate can be determined. Lastly, the ECN method allows the localized corrosion rate to be calculated. ECN is the measurement of spontaneous fluctuations generated at the corroding metal-solution interface. This measurement is only possible in a 3-electrode probe configuration and is used to determine the existence of localized corrosion.

### Real-Time Corrosion Monitoring

Real-time information using a 4-20 mA control signal allows the facilities operator to interpret the corrosion status. The operator can evaluate historical corrosion rates to current rates and quickly determine changes in water quality, chemical changes and inhibitor performance. As expected, all these situations can affect pipeline corrosion and each can be more efficiently monitored and controlled with the help of CorrTran. Furthermore, the plant operator using CorrTran and its real-time data can plan for replacement of suspect equipment as part of a predictive maintenance schedule. The superior performance of this instrument allows the user to monitor general corrosion or localized corrosion. It is localized corrosion that can be especially dangerous if not detected at an early stage. Corrosion of this type can perforate a pipe very quickly but with early intervention it can be neutralized. For the first time, both general and localized corrosion can be monitored on-line and in real-time rather than in a historical "after-the-fact" method that misses the possibility of a process-corrosion correlation. Rather than determining corrosion occurrence over a period of time using an outdated technique, corrosion can now be monitored

like any other process variable (i.e., pressure, flow, level, temperature, pH) by the plant operator or control systems engineer using the existing human-machine interface (HMI). CorrTran operates better than any other monitoring device since it is capable of detecting both types of corrosion. This is critical since in some situations the general corrosion rate may be low but localized pitting may result in high rates of attack and unexpected perforation in a pipe. This real-time data allows for a rapid and clear understanding of corrosion.

Why is real-time corrosion data important? Plant assets are working harder and longer than ever before so the reliability of the process (up-time) is critical to bottom-line profitability and employee safety. Corrosion has a clear and direct relationship to system reliability. Never before has an on-line tool like CorrTran been available. It is difficult to understand why any plant operator would be satisfied with off-line measurements of temperature, level or pressure. The same is now true for corrosion. A real-time corrosion measurement can be used as an evaluation tool of system integrity and asset damage just like temperature, level and pressure are used for some of the very same reasons. The process data accumulated by the DCS and PLC systems are typically displayed "real-time" on monitors in a control room. What would a process engineer do if the data were delayed by an hour or a month?

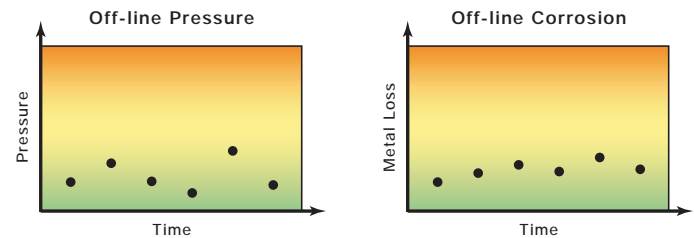


Figure 3

The actual conditions of the process could be drastically different than the off-line information displayed in Figure 3.

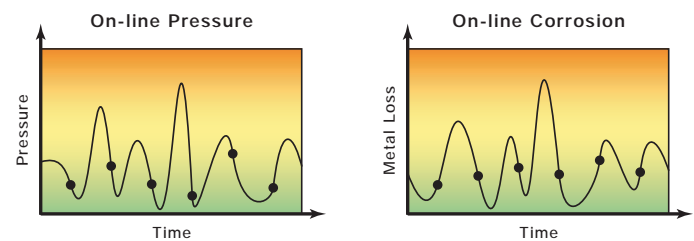


Figure 4

It is clear from these illustrations (Figures 3 & 4) that on-line variables are extremely important to any process. It is impossible to imagine a facility operating in an off-line methodology for the basic process variables of pressure, level and temperature; therefore, it is only reasonable to imagine the need for on-line corrosion information in this manner as well. Dangers related to run-away reaction, over-flow conditions or corroded pipes are too valuable to allow them to be evaluated in an off-line method. The need for CorrTran is clear.

## New Developments

Pepperl+Fuchs and InterCorr knew the process industry required a product that would give plant operators the ability to monitor corrosion rates within their existing control system and to distinguish between general and localized corrosion. The industry needed a product that would enable the use of existing asset management tools rather than sophisticated software programs operating with non-standard communication protocols. What grew from this need was a joint technology project between Pepperl+Fuchs and InterCorr. This relationship was formed to solve a growing concern for on-line corrosion monitoring in the process industry. By combining forces, Pepperl+Fuchs was able to apply its interface and transmitter expertise while InterCorr's role is clearly centered on its corrosion monitoring expertise and their SmartCET tool.

Twinsburg OH-based Pepperl+Fuchs is part of a larger, internationally recognized firm headquartered in Mannheim, Germany. This 2600-employee-strong company serves both the factory automation and process automation markets with a wide range of intrinsic safety barriers, purge/pressurization equipment, level monitoring instruments, proximity sensors and fieldbus equipment. P+F services the world's automation markets through three main facilities in the United States, Germany and Singapore. With offices in more than 70 countries, P+F is focused on offering a wide range of solutions to a wide range of industries. Corrosion monitoring is a natural evolution of P+F's core competency and blends easily into its existing product range.

## The Goal

The goal in the development of CorrTran was to create a product that would easily integrate into a standard 4-20 mA control system, easily communicate with the industry standard HART protocol and would be easily installed in either hazardous or non-hazardous atmospheres. With this goal in mind, Pepperl+Fuchs chose one of their proven, Type 4X, 7, 8 and 9 transmitter housings used on its Vibracon (vibration fork point level monitoring) and Barcon (hydrostatic pressure level measurement) line of products as the basis of the CorrTran hardware platform. It then went about the process of transforming the serial communication based SmartCET into a 4-20 mA HART-based instrument. This proved to be a relatively complex task.

First and foremost, power consumption needed to be greatly reduced. Unlike other multi-conductor corrosion monitoring instruments, the new instrument needed to operate on as little as 4 mA (actually 3.7 mA) so the entire electronic insert had to be redesigned and optimized.



Figure 5

Also, the critical measurement parameters normally available in the serial communication of the SmartCET had to be linked to a HART interface. Lastly, the overall size of the electronic insert was reduced to fit into the relatively small space of the transmitter housing. After nearly 18 months of development, the end result was a 2-wire, loop-powered instrument that can be mounted in a safe area or Division 1/2 hazardous location. The transmitter can be connected to any analog input port used on a distributed control system (DCS) or programmable logic controller (PLC). Since it is HART enabled, critical data from CorrTran can be monitored with a standard hand-held communicator by field personnel at a plant, accessed directly by a "smart" analog input I/O card in the DCS/PLC or sent directly to an asset management software (i.e., Emerson Process Management or Cornerstone Software) via a HART multiplexer (i.e., 2700 or KFD2-HMM from Pepperl+Fuchs).

## Specifications

The standard probes used for corrosion detection on CorrTran consist of 3 electrodes-2 for measurement and 1 for reference. In order to get an accurate measurement, the electrodes must be made of the same material as the pipe or tank being monitored. The sacrificial electrodes are induced with a small signal and are placed directly in the flow of corrosive media. These signals are monitored and analyzed by the transmitter over a period of 7 minutes in order to get an accurate representation of corrosion. The following is a small sampling of electrode materials available for pipeline detection:

- 1018 carbon steel
- 304 stainless steel
- 316 stainless steel
- Hastelloy
- 400 monel
- 1100 aluminum
- 2024 aluminum
- GR2 titanium

Also available are various types of mechanical probes for direct or remote mounting in fixed or adjustable lengths. The basic probe comes with a standard 3/4" NPT fitting with pressure ratings up to 1500 psi (102 bar). The process media temperature can be as high as 250°F (125°C) while the transmitter can operate in an ambient temperature range of -20°F to +158°F (-28°C to +70°C). The only requirement necessary to get an accurate corrosion reading is that the material inside the tank or pipe must be at least 1% water.

Given its rugged design and industrialized housing, CorrTran is ready to be installed in any industrial application from wastewater management to chemical processing to oil refining. If the area is considered nonhazardous (nonexplosive), this transmitter can simply be connected to an analog input on a DCS or PLC and installed according to local, state and national regulations. For Division 2 applications, its low-power design allows it to be mounted

directly within a Division 2 hazardous location as long as the corrosive material inside the pipe is nonflammable. In this configuration, the control signal (4-20 mA circuit) must be connected in accordance with the National Electrical Code according to Division 2 wiring methods. For clarification, a Division 2 location is considered to be hazardous only under abnormal conditions (i.e., faulty valve, unexpected release, aging seal, etc). As a matter of fact, significant portions of a process facility can be designated Division 2; therefore, CorrTran can be easily installed in these areas. Division 1 applications require the use of our specially designed CorrTran. Our intrinsically safe (IS) unit requires the use of an isolation barrier mounted between the I/O card and the transmitter. This IS barrier (i.e., KFD2-STC4-Ex1 from Pepperl+Fuchs) limits the energy into the Division 1 area and works in concert with CorrTran to eliminate the potential of high energy causing ignition of the hazardous location.

## Configuration

For configuration purposes, CorrTran can be connected to any HART enabled tool once the specific Device Driver (DD) has been loaded into the tool's library. This allows quick modification of a wide range of application specific values such as range, alarm points, B-value and damping. Large portions of today's HART transmitters are actually programmed with a hand-held communicator. If HART communication is either impossible or unwarranted, our transmitter can also be configured using P+F's own PACTware tool. This configuration and diagnostic program can be loaded easily onto any PC and is presently used as P+F's universal configuration tool for all of its programmable products. Some of today's DCS systems use a configuration module based on the PACTware architecture shell. This Field Device Tool (FDT) shell uses Device Type Manager (DTM) files to allow configuration of the transmitter specific parameters (i.e., CorrTran values). The only item necessary to communicate with the transmitter in this set-up is a simple HART converter that plugs directly into an available COM or USB port on a PC.

## Conclusion

CorrTran takes corrosion monitoring to a new level-one that makes corrosion data readily available to the process engineer so decisions can be made in real-time and according to current process conditions. CorrTran-Innovations in Corrosion Monitoring by Pepperl+Fuchs.

## Advantages of CorrTran

- Takes corrosion out of the laboratory and into the control room
- Lowers the risk of equipment failures
- Minimizes unplanned downtime
- Reduces ownership cost
- Easy to integrate into existing system
- Optimize equipment utilization
- Simple to connect, install and operate
- Suitable for new or existing installations
- Suitable for aqueous solutions as low as 1% water and vapor applications
- CSA certified for the United States and Canada
- Available in standard, nonincendive (Div2) and intrinsically safe versions
- Easily configured via HART or PACTware

Suitable for a Wide Range of Industries Including:

- Gas & oil refining
- Oil exploration & transportation
- Chemical & petrochemical
- Pharmaceutical
- Water and wastewater
- Power generation
- Pulp & paper



The **GreenTeam** is P+F's network of experts dedicated to providing customized process solutions.



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