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SPOTON® U TECHNOLOGY – AN IMPORTANT TOOL FOR CORROSION AND EROSION MONITORING IN THE OIL AND GAS INDUSTRY

1. Corrosion in the oil and gas industry is a very important issue

Corrosion monitoring is an important topic within the oil and gas industry as the cost of corrosion in this industry sector in the USA alone is estimated to be in excess of 27 billion USD (according to NACE International). Corrosion can present itself in many types of structures, can be external or internal, with different shapes and may be caused by several different chemical reactions. Therefore, one must be aware of which issue is likely to be present in a specific case well before corrosion monitoring can be implemented. A previous article by A3 Monitoring (Comparison of Corrosion Monitoring tools in the oil and gas Industry) dealt with explaining how different technologies could be used together to complement each other in order to minimize risk and costs. In this article we will focus solely on the issue of internal corrosion. Other corrosion issues will be dealt with in future articles.

2. SpotOn® U technology

SpotOn® U is a real-time corrosion monitoring solution designed to provide remote and frequent thickness data to asset owners. The system is sensitive to small changes in wall thickness, withstands very harsh environmental conditions and can be applied on above ground, insulated, buried and subsea pipes.
The spotOn® U unit is attached to the pipe using a stainless steel repair clamp with

SUMMARY

protective silicone on the inside. A sensor holder protects the sensor and its electronics while enabling letting the tip of the sensor probe to touch the outside of the pipe (see Figure 1). The silicone makes contact with the pipe and creates a seal between the clamp and the pipe (there is no metal-metal contact with the pipe). Up to 8 sensors can be mounted on a single clamp thereby enabling to monitor several clock positions. A temperature sensor is installed at each UT sensor location so that precise thickness trending is achieved using temperature compensation algorithms. The system can be installed either as a permanent or temporary installation, offering great flexibility to reposition the sensor. Figure 2 shows a typical spotOn® U setup where the UT sensor is attached to the pipe at a buried location. The UT signals are transferred to a battery powered control unit via a rugged cable and encrypted data are sent to a dedicated server via satellite, cellular networks or SCADA. An optional data logger is also available to manually retrieve the data. Data is then decrypted and displayed on shieldCube. Using a satellite link the need for client infrastructure is cut to zero: in this case there is no need for local servers, local networks or local facilities; the system is designed to be an easy to install turn-key solution. The batteries last a minimum of 5 years and the unit can be upgraded with an extra battery pack to increase to 10 years their duration. The latest version of spotOn® U is also available with solar power, therefore virtually removing the need to return to site to replace the battery pack. This is especially useful in harsh, difficult to reach environments.

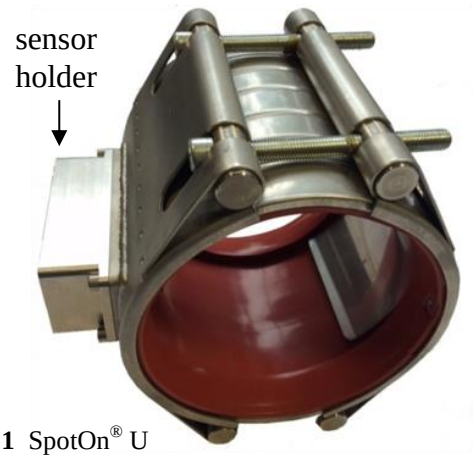

Figure 1 SpotOn® U

SpotOn® U enables the operators to:

- Quickly establish thickness trends in order to optimize inhibition strategy
- Increase profitability by flowing and processing variable fluids
- Removing access costs even for difficult to access structures, such as buried pipes
- Have great repeatability and improved sensitivity compared to other similar corrosion monitoring tools.

Just like any other UT monitoring tool, spotOn® U has limited area coverage and focuses only on internal corrosion. Other providers of UT monitoring sensors would normally propose to increase area coverage by increasing the number of sensors. A^3 Monitoring can also provide an alternative solution in the spotOn® U+ LR system. Spot On® U provides precise thickness values at certain locations, while spotOn® LR provides large coverage to establish whether there is corrosion at some distance from the position where the UT sensors are located. Below we provide more information on spotOn® LR deployment characteristics and expected performance.

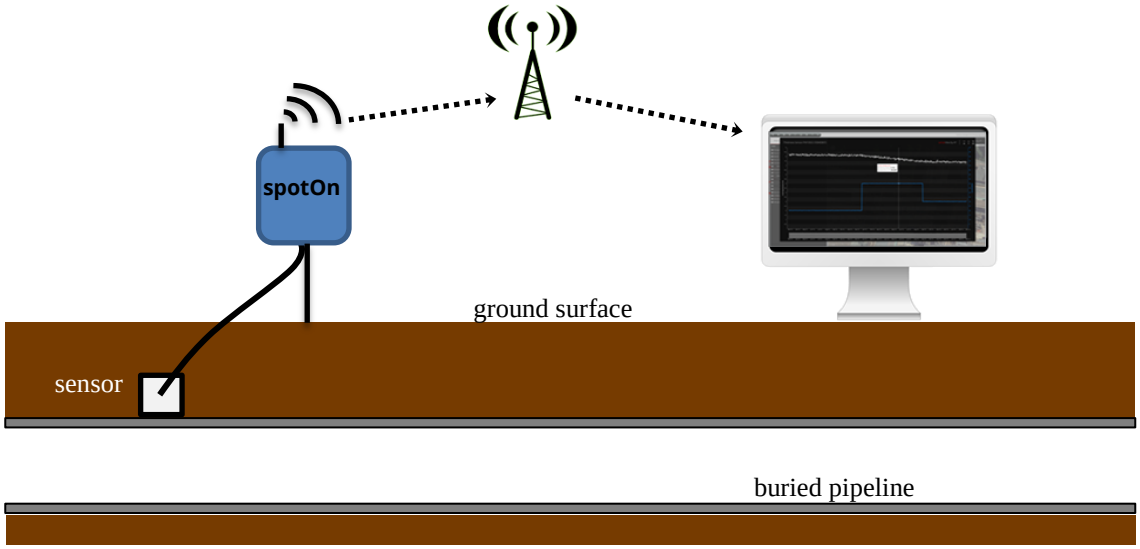

Figure 2 SpotOn U installation and communication example

3. Corrosion in refineries

The "Petroleum Refinery Gap Analysis" in 2008 estimated that corrosion costs refineries $3.7 billion annually in USA alone. Of this amount, plant turnarounds, or outages for maintenance, cost $1.4 billion.

The cost of corrosion also impacts the production capacity and profitability of a refinery. The "Petroleum Refinery Gap Analysis" report estimates that maintenance shutdowns resulted in a combined loss of earnings between $2 billion and $12 billion.
The same report informed that corrosion monitoring can play a very important role in reducing downtime and increase profitability.

The numbers reported above refer to both **internal and external corrosion** issues. External corrosion in refineries will be discussed in a future article.

3.1 Internal Corrosion

There are four main kinds of internal corrosion that can affect refineries:

- **Water-related corrosion.** Crude oil desalting and distillation generate considerable amount of wastewater which contains H2S, CO2, chlorides and dissolved solids. Also cooling water used in refining operations has various levels of corrosivity depending on its content of chlorides, oxygen, dissolved gases and microbes.
- **Processing related corrosion.** Crude units are highly affected by corrosion. Hydrochloric acid and carbon dioxide are the two most common corrosive agents. However hydrogen sulphide, low molecular fatty acids and sulfuric acids are also possible causes of corrosion in crude units depending on the type of crude that is processed.
- **Naphtenic acid corrosion**. Organic acids present in crudes can cause high temperature corrosion called Napthtenic acid corrosion. Corrosion rates can be very high and locations of these corrosion areas are difficult to identify.
- **Sulfur.** Sulfur is present in crudes in several forms. If its concentration is greater than 0.2% corrosion will

ensue on carbon steel at temperatures above 230C.

A European commission study released in 2013 reports on corrosion related accidents in petroleum refineries, analyzing their cause and providing guidance for the future. Quite interestingly, while accidents were common in distillation units before 1999, more recently the largest percentage of incidents was recorded on transfer lines at relatively low temperatures, as you can see in Figure 3.
Moreover 13% of accidents were at locations below ground which are less the focus of corrosion monitoring campaigns but clearly should be kept under control.

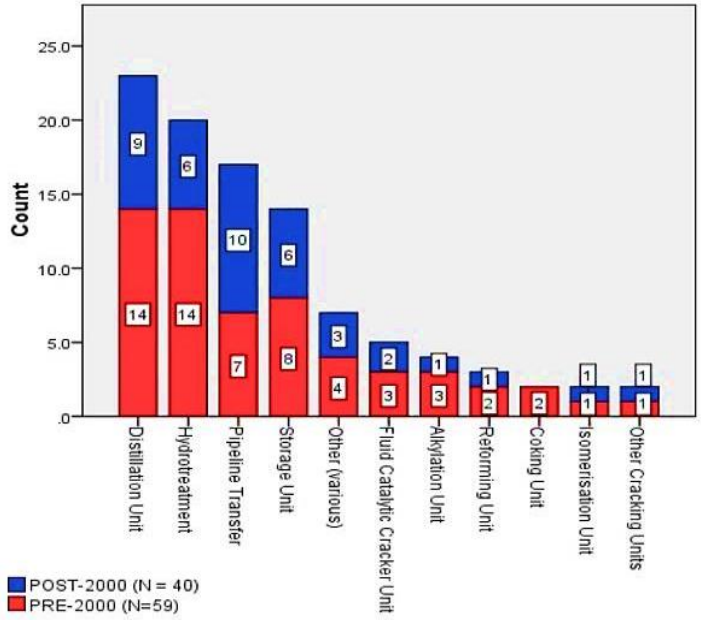

Figure 3 Corrosion related accidents in the refining sector before year 2000 (in red) and after year 2000 (in Blue). Source @Corrosion related accidents in Petroleum refineries. JRC Scientific and Policy Report. European Commission

4. SpotOn® U applications in refineries

Some of the applications of spotOn® U in the refining sector are:

- Transfer lines (above ground or buried)
- Crude distillation unit
- Vacuum distillation unit
- Fractionators
- Amine
- Sour water stripper
- Alylation
- Jetty lines

Figure 4 shows an example of spotOn® U used on the outlet of an aromatic separation unit. Figure 5 shows how the thickness value is displayed on the shieldCube software platform (www.shieldcube.com).

In this case the thickness value is very stable, confirming the low corrosion rate expected at this position under normal operating conditions.

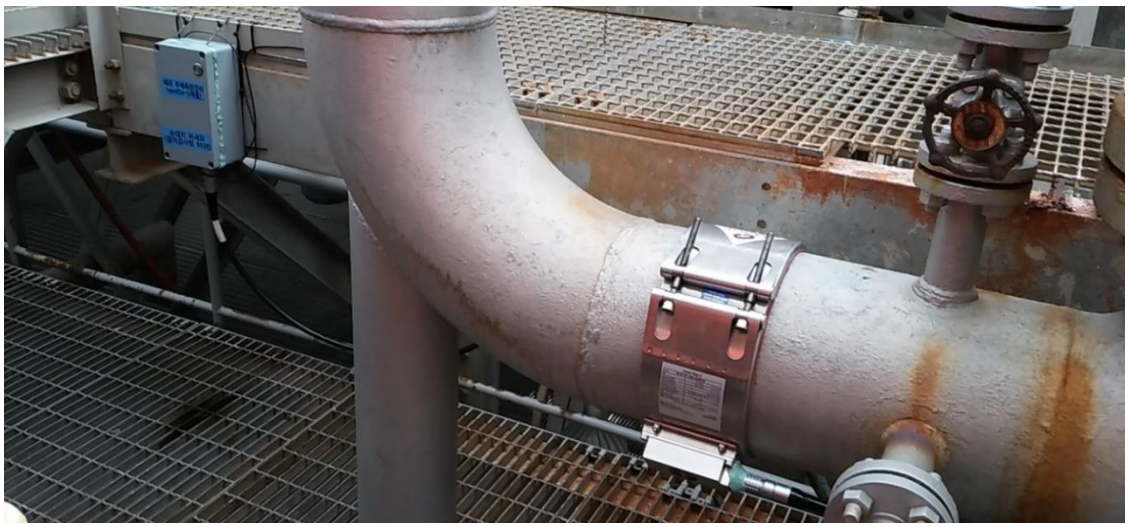

Figure 4 Example of SpotOn® U installed at pipe in Aromatic unit

Figure 5 Shieldcube thickness report window at SpotOn U installed at Aromatic unit in Figure 4

Figure 6 shows an example of spotOn® U corrosion monitoring data taken at an overhead line in a Crude Distillation Unit and exported from shieldCube for further analysis.

As clearly visible from this result, the corrosion trend was changing very rapidly depending on the fluid flowing within the pipe being monitored. Precise and reliable daily measurements were sent to the client to compare the inhibitor performance depending on the fluid, and later rectify the issue of high corrosion rate by further optimizing the inhibitor injection strategy.

Although currently spotOn® U is used on relatively low temperature pipes only, it is clear from recent statistics that it is targeting the vast majority of internal corrosion issues present on refinery installations. Issues such as high temperature Naphtenic acid corrosion may need to be addressed with different type of monitoring solution.

In refineries, several corrosion issues present an additional problem. "*Where would I put the sensors?"* That is a very appropriate and very difficult question to answer. For example, an experienced refinery integrity engineer was asking how it could be possible to monitor for dew point corrosion on their lines considering that changing the crude slate was causing a change in the axial position of the corrosion. Very fair point! While most

other corrosion monitoring providers would reply that it is necessary to install many sensors along the pipe which is perhaps technically feasible but not economically viable with the current economic climate, the solution that A3 Monitoring would propose is to use a combination of movable sensors. SpotOn® U would provide precise thickness value and thickness trend at the position where dew point corrosion has already been identified or is most likely to be present, and spotOn® LR would be used to verify that the position chosen is correct and remains correct over time.

As the sensors are movable, if the position initially chosen was not the best, it would be possible to move the sensor.

This strategy is particularly useful on very long lines such, as for example jetty lines where identifying representative spots may be challenging.
Also, on long stretches of pipe, the use of independent communication at each single node without restriction on distance from a main hub may be vital to reduce costs.

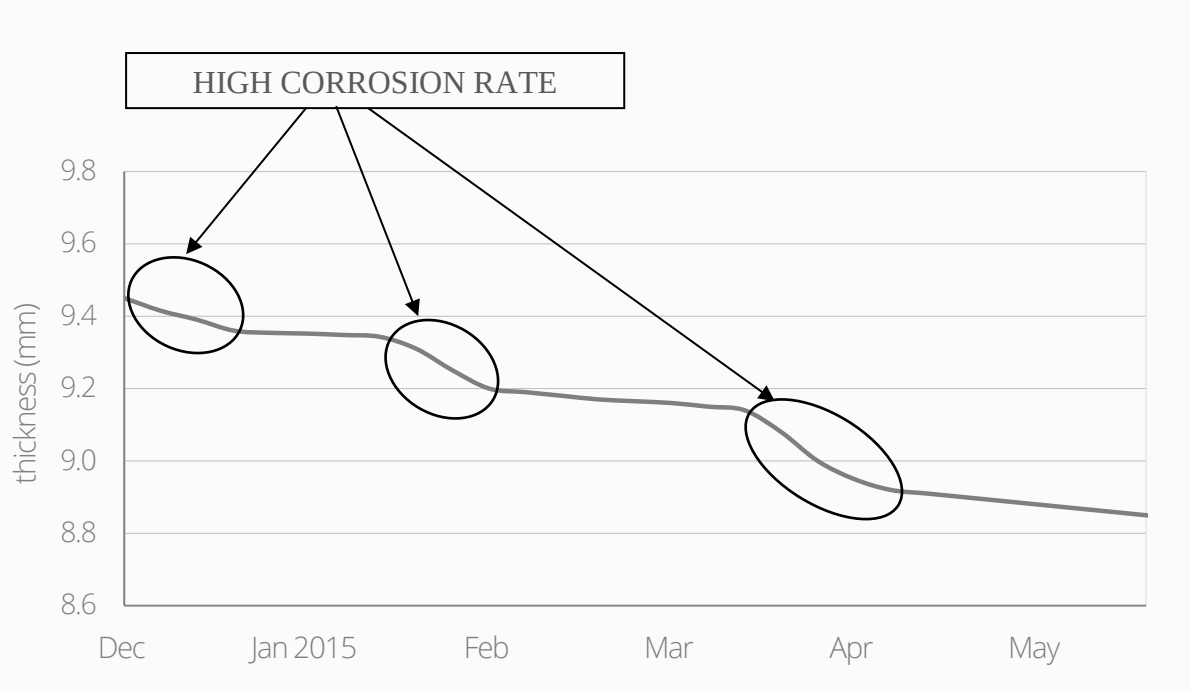

Figure 6 SpotOn® U result at crude unit. Variable corrosion rate due to crude slate. Inhibitors dosage optimization possible using spotOn® U

5. Corrosion in midstream and upstream

The cost of corrosion in pipelines is estimated to be in excess of 5 billion dollars in the USA alone (NACE International). Internal corrosion is therefore an important issue also in Midstream and Upstream Oil and gas industry.

5.1 Types of corrosion

Internal corrosion in pipelines can be divided into 2 main areas:

- **CO2 Corrosion**. Carbon dioxide corrosion is one of the most well-known form of corrosion in the oil and gas industry. CO2 present within oil reservoirs/ gas would normally contain some percentage of CO2 which then flows within the transmission pipelines. Factors such as PH and temperature affect the CO2 corrosion process. As fields develop over time, their composition and operating conditions may be leading to a change in the corrosion rate on the pipeline, and therefore corrosion engineers need to keep under control the level of corrosion on these pipes throughout their lifetime.
- **H2S corrosion.** The forms of H2S corrosion are uniform, pitting and stepwise cracking. The corrosion rate is highly dependent on the kinetics of scale formation (Iron sulphides) and as such can change with temperature and flow conditions.

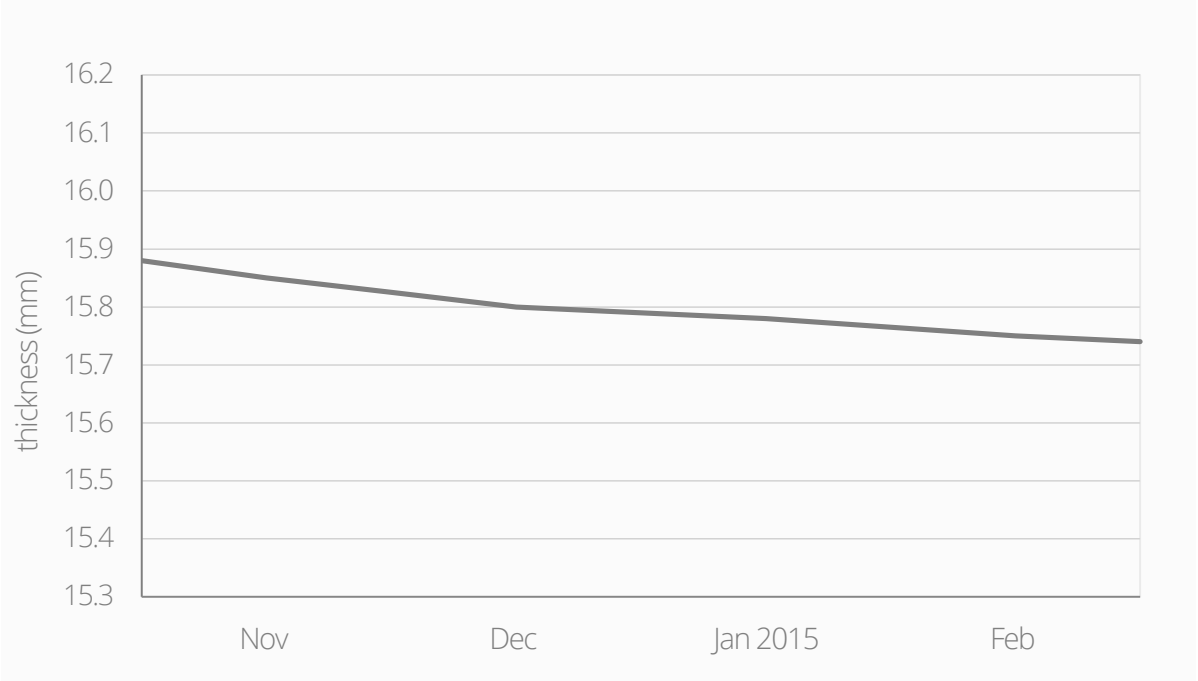

Figure 7 SpotOn® U result at E&P facility. Inhibitor dosage optimization using output thickness data from spotOn® U

6. SpotOn® U applications in midstream and upstream

Some of the applications in midstream and upstream pipeline are:

- Process piping within offshore platforms
- Riser bends in offshore platforms
- Underwater pipelines
- Pipeline High Consequence Areas (HCA)
- Pipeline carrying highly corrosive fluids
- Internal corrosion points identified by other means (e.g. pigging)
- Pipeline at slopes
- Direct assessment locations

Figure 7 shows an example of spotOn® U corrosion monitoring data taken on a buried pipeline at an upstream facility, and exported from shieldCube for further analysis. The configuration was as per Figure 8 where the pipe enters the soil at an angle. The client was already aware that a critical corrosion area for the pipe network within his installation was the 6 o'clock position at the entry point into the ground due to the slope of the pipe. Any other strategy for checking corrosion such as coupons or manual UT on this unpiggable section of pipe, would require very high costs due to the regular excavations needed to take any measurement. In this case spotOn® U was permanently buried and a communication unit was placed above ground.

The corrosion rate recorded during the first 2 months was about 20mpy. After discussion with the client and optimization of the inhibitors dosage the corrosion rate was halved to about 11mpy. This is a clear example of how spotOn® U can be used to reduce costs and increase profitability by extending the lifetime of the assets.

Another example application is the usage of spotOn® U at offshore platforms. The cost of inspection on offshore platforms is much higher than a similar application for example at a refinery location. Sending a crew of 4 people of which 2 for inspection and 2 for building scaffolding for a single inspection campaign of few weeks could be far more expensive than placing some permanent sensors that can give continuous data remotely for several years. This approach reduces risks of failure (due to frequent data gathering), risk of accidents (due to less personnel being involved) and drastically reduces the inspection costs.

Figure 8 SpotOn® U example installation at E&P facility. The sensor was buried and the comms unit was placed above ground

Figure 9 shows a typical thickness monitoring result displayed on shieldCube software.

In this case the thickness readings were confirming a very low corrosion rate.

Figure 9 Typical spotOn® U thickness output

7. Conclusions

- Internal Corrosion in the Oil and Gas industry is a very important issue due to the costs involved with maintenance and inspection. In the current economic climate it is necessary to optimize expenditures to maximize the life of the assets as there is no sufficient cash to build new infrastructure or to bear business loss due to unexpected downtime. Material corrosion engineers would argue that better material choice would lead to savings. Although this maybe correct for new projects the current challenge is to deal with existing infrastructure and get every last penny out of it. This is possible using spotOn® U monitoring and utilizing the information coming from such precise monitoring system to optimize corrosion management strategies.
- SpotOn® U can be used in a variety of downstream, midstream and upstream installations given the flexibility to be used both above ground and below ground. Considering that each single unit can communicate data independently spotOn® U is the cheapest UT monitoring solution when the targets that need to be monitored are spread over a fairly large area.
- SpotOn® U plug-and-go solution immensely reduces the implementation effort compared to any other monitoring solution available in the market. It is possible to implement spotOn® literally within 24 hours since deciding to implement corrosion monitoring at a specific location.
- SpotOn® U can also be integrated with other solutions such as for example spotOn® LR. Using technology integration detection range is optimized, target issues are safely and timely identified and cost is greatly reduced.

For more information on the capabilities of the **spotOn® U Corrosion and Erosion Monitoring System** please **contact A3 Monitoring** at:

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