Corrosion protection under insulation

Metco has left the Sulzer Group and is now part of the Oerlikon Group.

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To ensure controllable processes with little energy loss, columns, equipment, and pipes in refineries are insulated. Breaches in the insulation permit corrosive media to destroy the base material under the insulation. When an abandoned oil field in the Netherlands was reopened, the whole piping system was coated using *Anti-corrosion Solutions* from Sulzer Metco that guarantees protection for over 25 years and thereby reduces life cycle costs.

All around the world, oil refineries face enormous problems with severe corrosion as well as high maintenance costs to keep corrosion under control. Oil refineries are of crucial importance to our society 1. In oil refineries, crude oil is converted into products essential to our daily activities—goods such as petroleum, plastic, and medical products.

The demand for refinery products has increased tremendously as a result of continuous global industrialization. The pressure to increase production has negative side effects because inspections and maintenance are delayed to avoid downtime. A refinery consists of multiple processing units with interconnecting pipe works. Refining processes take place at elevated temperature levels. For a controllable process with little energy loss, the majority of the processing units and pipes are insulated.

The insulation is designed to be watertight to prevent infiltration of liquid from the outside environment onto the component surface. Unfortunately, breaches in the insulation from mechanical and

1 Section of a refinery—the piping can be exposed to aggressive fluids under the insulation.

environmental damage create entry points for corrosive media. This corrosive media is most often water contaminated with chlorides and sulfates, which gives rise to corrosion under insulation (CUI) 2.

Elevated temperatures increase rate of corrosion

The elevated operating temperature of the equipment and pipes increases the rate of corrosion. CUI is costly in terms of reduced production efficiency and unscheduled downtime, and it can lead to serious health and safety issues. The increasing number of problems resulting from CUI has led to the formation of several investigative groups. Two workgroups within the European Federation of Corrosion (EFC), WP 13 (Corrosion in Oil and Gas Production) and WP 15 (Corrosion in the Refinery Industry), have produced guidelines that address the management of CUI.

NACE (National Association of Corrosion Engineers) formed a task group in the 1990s to develop recommended practice to prevent CUI. In 1998, this task group published "The Control of Corrosion Under Thermal Insulation and Fireproofing Material—A Systems Approach." This document is a standard specifically directed at combating CUI.

The key parameter that controls the life expectancy of an insulated system is the protective coating. One of the original design assumptions was that the traditional organic protective coatings employed would last up to 25 years. It is now known that these coating systems consistently fall short of all expectations because they provide an average life expectancy that is often less than 10 years.

Corrosion under insulation guidelines

The CUI guideline from EFC WP 13 and WP 15 clearly states, "the coating that is most likely to provide effective corrosion protection for over 25 years is thermal-sprayed aluminum (TSA). It is therefore recommended that, where a minimum design life of 25 years is required, TSA be considered as the protective coating of all new equipment and always be considered as the protective coating of equipment subject to maintenance and rehabilitation work."

Anti-corrosion Solutions

With the *Anti-corrosion Solutions* surface solution package from Sulzer Metco, applicators have at their disposal a comprehensive tool to help them switch from organic coatings to TSA coatings. The *Anti-corrosion Solutions* package consists of three modules. In combination, these modules provide the applicator with everything necessary to apply high-quality TSA coatings. Sulzer Metco helps the applicator to understand thermal-spray technology as well as to master the required disciplines to apply TSA coatings using the combustion wire spray process.

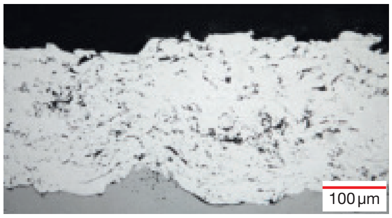
At the same time, the modules offer flexible choices that will help minimize costs with a "right-the-first-time" approach. The choices help the applicator administer the TSA coatings as efficiently and economically as possible on site. Sulzer Metco is the worldwide leader in thermal-spray technologies, and it brings more than 75 years of anti-corrosion coating technology and application experience to its *Anti-corrosion Solutions* package.

Advantages of thermal-sprayed aluminum

TSA coatings have several advantages over organic coatings (conventional paint). The piping is protected against CUI for a service life of 25 to 30 years instead of 5 to 13, which is usual the limit of an organic coating. The TSA coating can also be applied on hot equipment and pipes—therefore no shutdown is needed for maintenance reasons—and the refining process can be continuously operated with temperatures up to 480 °C (900 °F). For conventional paint, the operating conditions should not be higher than 230 °C (445 °F), and the application temperature limit is about 60 °C (140 °F). Furthermore, after application, conventional paint needs 24 hours to dry, whereas the TSA-coated equipment can be insulated immediately after the treatment.

The investment costs are about 1.05 to 1.20 times the costs of conventional painting. Figure 3 shows a photomicrograph cross section of a typical, high-quality TSA coating produced using Sulzer Metco equipment and TSA wire.

2 Many refineries have extensive corrosion under insulation (CUI) issues that result in very costly maintenance. Inset: A typical example of advanced CUI at a tower stiffener ring.



3 Photomicrograph cross section of a typical, high-quality TSA coating produced using Sulzer Metco equipment and TSA wire.

Reopening of an oil field in the Netherlands

High production costs and low oil prices in the 1990s resulted in the closure of many oil fields. One such field was the Schoonebeek oil field, which was discovered in 1943 in the eastern Netherlands, close to the German border, about 12 km south of the city of Emmen. The field extends across the border into Germany. The initial estimate of oil was in excess of one billion barrels, making it one of Europe's largest oilfields. Production started in 1947 and, during its operation, nearly 600 boreholes were drilled in 300 locations.

Production peaked at 24 000 barrels of oil per day in 1954 and slowly declined over the years, until the field was finally shut in in 1996. By then about 250 million barrels of oil had been produced from the Schoonebeek Field, only about 25% of the estimated oil in place.

The oil is heavy, with an API in the region of 25°, and over the years many different oil recovery techniques, including cold and hot water injection, borehole heating, steam injection and in-situ combustion, have been used and tested in the field.

Abandonment of Schoonebeek

The decision to close down Schoonebeek in 1996 was not an easy one, especially since operations continued—and still continue—across the border in Germany. The abandonment of the field was justified on economic grounds based on the techniques and infrastructure available at the time.

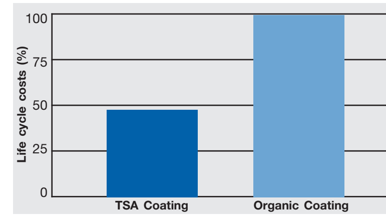
Essentially, work on the field was discontinued because operating costs were high and oil prices in the early 1990s were very low—between $11 and $18 a barrel. In addition, there were some significant economic factors relevant to the field itself. Charges for recycling the water were adding between $1 to $3 per barrel to the production costs. In the new project, all the water produced will be injected into exhausted gas fields.

Redevelopment now

Today, new recovery techniques are available so that production costs are lower, and a completely different oil price scenario is used. One of the largest Dutch national gas and oil producers plans to redevelop the field. Using advanced recovery procedures, engineers plan to extract additional at least 100 million barrels of oil in the next 25 years of operation.

Although it is only 14 years since the field was shut down, both technological and economic factors have changed and advanced a great deal. The idea of reopening the Schoonebeek field has always been attractive due to the large amount of remaining resources—theoretically, 750 million barrels of oil, but not the whole amount is extractable from an economical point of view.

New technologies that are important for enhanced recovery include the combination of horizontal drilling and innovative high oil recovery techniques. New methods of particular use exist in the production of heavy oils, such as those found in Schoonebeek. A typical scenario is that steam is injected into a borehole. As steam enters the reservoir, it heats the reservoir fluids and surrounding rock. Hot oil and condensed water drain to a production hole at the bottom of the formation through the force of gravity. Similar techniques are used when producing oil from the Canadian oil sands.



4 Cost of applying TSA coatings is estimated to be 120% that of organic coatings. However, with an estimated TSA service life expectancy of 25 years compared to 10 years for organic coatings, TSA saves in the long-term, with better protection.

Transportation of the oil

The extracted crude oil is first treated on site in a preparation plant and then transported more than 25 km to the refinery, which is located in Germany. In the past, the transportation was done via freight train; however, today the transportation is done using pipelines.

The refinery in Germany is adequate because it elaborates similar heavy oil from the German fields. The oil export pipeline is subterranean. During on-site oil preparation plant, the extracted production water contains numerous salts and cannot be reused or exported as wastewater. This water is pumped to abandoned gas fields.

According to today's projections, the oil will be extracted profitably during the next 25 years. After that period, all subterranean and aboveground establishments will be removed.

Environmental protection

The establishments and piping system had to take a comprehensive test concerning environmental protection. The planning of the location of the wells had to take into consideration the sensitivity of the environment—in particular, the water cycle.

In addition, external security is crucial. The piping system (steam, oil-water mixture, and gas) from the production site to the processing plant are aboveground. They need to meet the safety regulations. To increase security, a subterranean export pipeline has been planned. In the event of a leakage, due to the high viscosity of the oil when it cools down, the area of contamination would be restricted. Emergency plans have been prepared.

The piping system

The most obvious catastrophe in a piping system is a breakage or a leakage. If an aboveground pipe is damaged it is usually visible. If the pipe is subterranean, then it is more difficult because the leakage can only be detected later. Nevertheless, the environmental risk can be controlled because the oil cools down outside the piping system and then coagulates. There is practically no dispersion of the coagulated oil.

An incident in wastewater piping is worse. The wastewater can easily disperse underground. Additionally, the wastewater piping in Schoonebeek crosses an ecologically valuable zone. If a leakage were to occur, the saltwater could damage the soil and the groundwater. To prevent incidents and catastrophes, there is a plan in place to check and maintain the pipes on a regular basis.

Corrosion protection for over 25 years

Due to the high environmental sensitivity of the piping system and the project life cycle of 25 years, it was decided that thermal-sprayed aluminum would be used since it is the coating that is most likely to provide effective corrosion protection for that length of time. A large part of the piping system is insulated to reduce energy losses. This insulation is particularly important for the steam pipes—the steam is produced centrally in the plant and then transported to the borehole—and for the oil pipes—the oil has to be heated up and kept hot to be able to pump it easily.

Reducing maintenance costs

In the initial project calculation for the piping system, a standard organic coating (painting) was planned. The application costs of TSA can be between 1.05 to 1.2 times the costs of an organic coating. However, in calculating the entire life cycle costs, the TSA saves money [4], and the extra costs for the application could, in the case of Schoonebeck, be allocated from the budget for the maintenance costs.

The whole piping system with a length of 25 km was treated with the *Anti-corrosion Solutions* from Sulzer Metco [5].

When the organic protective-coating life is reached—after 7 to 10 years—the "out-of-site" nature of CUI makes it difficult and expensive to detect. For piping systems that are safety, health, environment or reliability sensitive, high confidence level is required, and inspection costs can exceed the cost of field repainting.

The maintenance costs of the system are so expensive that the system has to be optimized more cost effectively by fundamental prevention. TSA is inspection and maintenance free for 25 years. The first inspection incurs higher costs than the difference in price between paint and TSA. Therefore, the additional costs from TSA are already covered after first inspection.

[5] A typical pipe coating system as used with the *Anti-corrosion Solutions* of Sulzer Metco. On-site application of TSA.

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