

Corrosion erosion

Corrosion is the perennial enemy of oil and gas production facilities, and the threat is intensifying as the industry moves into more hazardous environments to exploit the deepwater pre-salt reserves off Brazil or drill beneath Arctic ice. Inspection, maintenance and repair are all vital, but for new facilities the emphasis is increasingly on anti-corrosion technology. **James Bridges** reports.

Tackling corrosion is vital if the oil and gas industry is to ensure that its production assets are safe, reliable and operate cost-effectively. Upstream and downstream operations are vulnerable to corrosion, which can attack any component and persist throughout the lifecycle of any asset. From the start of drilling, for instance, there is the possibility of oxygen contamination, and the threats mount

up all the way through to the refining and distribution process.

Combined with water, carbon dioxide and hydrogen sulphide are the most common causes of corrosion. However, there are many other factors to consider, from microbiological activity and the accumulation of solids to the atmospheric factors that affect offshore structures.

Rigorous inspection and maintenance processes designed to maintain asset

integrity are essential elements in ensuring the corrosion does not get the upper hand and cause serious safety issues or interfere with production. But for a long time now, the emphasis has been on preventing corrosion, or delaying its onset, often using protective coatings. Over the years, these coatings have had a huge impact on maintenance processes and have generated significant savings on repair. >>

The improvement of coatings continues to be a major area of investment in the oil and gas industry, which is also looking at changes to the processes for separating crude oil from other contaminants. The focus has intensified because of the highly corrosive nature of many offshore environments. Immersion, UV exposure, abrasion in the splash zone, and thermal and chemical factors must all be taken into account.

The coating structures in corrosion-resistant materials have generated a huge amount of R&D over the years, and work to design coatings that perform well in the hazardous offshore environment continues today. Metals, ceramics and polymers have all been used as the basis for these coatings.

One example is magnetron sputtering, which sees aluminium-cerium-cobalt deposited on aluminium alloys or carbon steel. This has proven highly

Cathodic protection is another widely used technique to protect subsea structures, using either sacrificial anodes or an impressed current. The first technique turns the surface that needs protecting into the cathode of an electrochemical cell, with the anode being more easily corroded. The impressed current method, often preferred for larger structures, uses anodes connected to a DC power source. That said, there is an argument for the use of sacrificial anodes on FPSOs, as they require less maintenance, and make it more likely that repairs to the system can be made without the need for dry-docking. The repair of an impressed current system on an FPSO may, therefore, be less favourable from a cost perspective.

While it is highly effective in many instances, cathodic protection does pose its own corrosion risks. It can, for instance, generate hydrogen, which can be absorbed by the material that is being protected. One potential danger of this is the hydrogen embrittlement of welds. Cathodic disbonding, due to the formation of hydrogen, can also affect protective coatings that have been applied to a structure.

One of the key decisions in the design phase is how to balance various anti-corrosion measures such as coatings and cathodic protection, as each can give rise to further threats. Cathodic protection, for instance, can lead to the release of hydrogen, which can play a part in the cracking of steel or nickel-based alloys. >>

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In a broad sense, however, corrosion control technology has not seen a major paradigm shift in the past four decades. But now there is a need for new approaches – deeper offshore fields, such as the pre-salt finds off of Brazil, pose problems that current technology has not yet fully solved. The approach to the design of assets to exploit these reservoirs will have to take into account all of the corrosive threats, and integrity engineers will have to make very careful decisions about materials and protective measures to ensure that new facilities in the region perform to their optimum potential.

Surface protection

Steel is one of the most widely used materials for pipelines and large offshore structures, and where there is steel there is the risk of corrosion. The typical approach to protecting steel on an offshore facility is by applying a coating, often combined with cathodic protection in the immersion zone.

Advances in these coatings have focused not only on improving their barrier properties against seawater, which is highly corrosive over time, but also on making them more resilient to the additional stresses in the offshore environment, including extreme temperatures and increased pressure. Prevention is a must, as the cost of maintaining and repairing offshore facilities can be huge.

effective, as have diamond-like carbon coatings using plasma-immersion ion deposition. This results in very hard, dense coatings that can be used on many components. Hard surfaces have also been achieved using nanocomposite coatings deposited by plasma-enhanced magnetron sputtering.

Chemical corrosion inhibitors have a crucial role in protecting pipelines and production facilities. Forming a thin-layer protecting the metal surface from fluids, these substances are widely injected into pipelines. Vapour-phase corrosion inhibitors have also become popular for the protection of components where coating is made difficult because of inaccessibility. The process enables protection without the physical contact with a chemical by forming a layer on metal surfaces at the molecular level.



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Smart solutions

One approach to solving this problem has been for material suppliers to look at the development of alloys that are specifically designed for use on offshore facilities. The results have seen new alloys used in shafts,

bolting, pumps and valves. These corrosion-resistant alloys include an ultra high-strength cupronickel alloy, which is less susceptible to hydrogen embrittlement than those that are based on iron, nickel or titanium.

Looking to the future, there is hope that advances in nanotechnology will unlock the ability to create self-repairing ‘smart’ materials that can respond to changes in external conditions, including humidity or acidity. The development of such

materials – which has been ongoing for a number of years – could revolutionise the effectiveness of coatings in extreme environments.

Advances in materials technology, either as a result of R&D by oil and gas companies or borrowed from other industries, will be crucial to the protection of new structures, especially where E&P moves to marginal and deepwater reserves. Similarly, innovative thinking about production methods, including downhole separation, is likely to have a huge impact.

Whatever technological improvements the future brings, corrosion prevention measures must take their place in a broad scope of processes and systems, including inspection and monitoring. In the design phase, the mechanisms that pose a corrosion threat must be clearly identified in order to choose the right mitigating systems and processes.

In the future, as now, the trick is not only to understand the risks, but to find the right blend of technology and understanding of materials with corrosion engineers. ■



Corrosion Protection System
Fire Protection System
Offshore Float-over System
FPSO System
Jacket - Leg Can System
Jacket – Load Transfer System

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