TECHNICAL ARTICLE

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Understanding and avoiding corrosion in challenging offshore applications

Corrosion is a major problem in offshore environments due to extreme operating environments and the presence of aggressive corrosive elements

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In a wide range of offshore applications resistance to corrosion can represent the difference between trouble-free long-term operation and costly downtime. With the presence of extreme corrosive elements such as hydrogen sulphide, carbon dioxide, brine and a whole range of hazardous chemicals compounded by extreme temperatures and pressures, there are few more arduous environments than offshore. Business and consumer demands for ever higher production rates needing more complex processes while ensuring compliance with stringent regulations related to climate change and the environment only serve to add to the challenges.

The wrong choice of material for an application can, as a minimum, lead to increased downtime, unscheduled maintenance and lost production, and at worst to catastrophic failure and potential human, environmental and economic loss. There are a wide range of potential direct, and sometimes overlooked, indirect costs associated with corrosion. Aside from the obvious issues such as the need to shutdown plant or equipment to repair, replace or carry out preventative maintenance on corroded items, there are also issues that include expensive overdesign to compensate for anticipated corrosion, decreases in system efficiency and related failures of adjacent equipment to consider and contend with.

In most cases properly analysing the specific operating parameters and defining the correct material for use through the collaborative efforts of the customer and the supplier of the components or systems can ensure these situations are avoided. Leading industrial engineering companies such as Parker are continually committing heavy investment into materials research and development to deliver offshore products that meet the increasingly demanding application challenges in the sector.

As an example of the potential impact of poor material selection leading to corrosion, In the USA, it was reported that the cost of corrosion accounted for an astonishing $276 billion per year. This total loss included the values from a number of sectors, including utilities, transportation, production and manufacturing and infrastructure.

Corrosion due to the presence of extreme corrosive elements can be classified under several headings:

Uniform corrosion – Sometimes also known as general corrosion sees a decrease in metal thickness per unit of time or uniform deposit of corrosion products on the surface of the metal.

Galvanic corrosion – results from contact between two different materials in a conducting, corrosive environment. Galvanic corrosion may result in the very rapid deterioration of the least resistant of the two materials leading to a fatal failure. Avoiding the mixing of different materials, for example on tubes and fittings or valves is the most common method of minimising the problem.

Crevice corrosion – is an electromechanical oxidation reduction process. It occurs within localised volumes of stagnant trapped solution trapped in pockets, corners or beneath a shield of some description. The corrosive process is greatly accelerated if chlorine, sulphide or bromide ions are present in the electrolyte solution. Crevice corrosion is considered far more dangerous than uniform corrosion as the rate at which it acts can be up to 100 times higher.

Pitting corrosion – is characterised by deep, narrow holes that can penetrate inwards extremely rapidly while the remainder of the surface stays intact. Perforation of a component can occur in a few days with no appreciable reduction in weight of the overall structure. Stainless steels are particularly sensitive to pitting corrosion in seawater environments.

Intergranular corrosion – progresses along the grain boundaries of an alloy and can result in the catastrophic failure of equipment, especially if tensile stress loads are present. Localised attack can occur while the rest of the material is completely unaffected. The presence of impurities in the boundaries or local enrichment or depletion of one or more alloying elements can be the catalyst for this type of corrosion.

Stress corrosion cracking – sees a combination of tensile loading and a corrosive medium causing the initiation of cracks and then their growth. Time to failure depends on specific application factors and can vary from just a few minutes to several years. Stress corrosion cracking is a very serious and permanent risk in many industrial applications where materials are often under mechanical loading for sustained periods or indeed permanently. In addition to selecting the correct materials, the risk of this type of corrosion can be avoided by stress relieving or annealing after fabrication of the assembly, avoiding surface machining stresses and controlling the corrosive environment.

The types of materials used in components for offshore use by companies such as Parker include 6Mo, Super Duplex, Monel, Hastelloy, Titanium & Alloys 825 and 625. These are utilised within items such as fittings, valves, manifolds and flanged products. Whilst these materials can be more expensive than less corrosion resistance alternatives, it is important for offshore equipment specifiers to factor in the massive potential cost savings associated with medium and long-term trouble-free operation.

As an example, in a comparison of low initial material cost stainless steel 316 tubing and fittings versus highly corrosion resistant Superaustenitic 6Mo equivalents, it was found that after factoring labour and maintenance costs needed over a 10-year period, using the corrosion resistant parts gave a total cost of ownership saving in the region of 40%.

In addition to finished parts and expertise about environmental conditions that affect material selection, it is also important for suppliers of components for offshore applications to give advice about other factors. These include compliance with legislation and internal regulations that have increasing importance in the field of offshore exploration and production.

About Parker Hannifin Corporation

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