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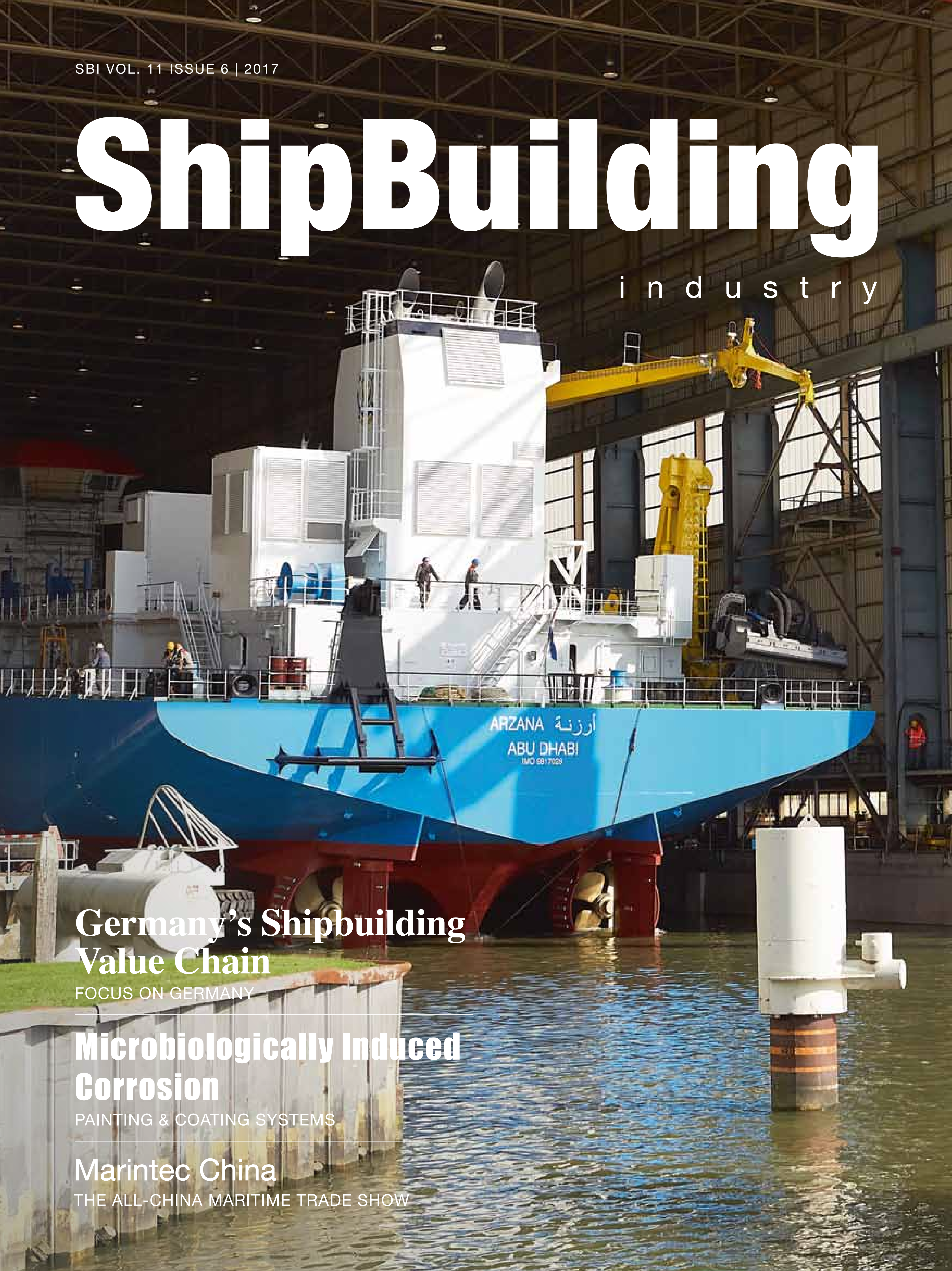

Germany's Shipbuilding Value Chain
FOCUS ON GERMANY

Microbiologically Induced Corrosion
PAINTING & COATING SYSTEMS

Marintec China
THE ALL-CHINA MARITIME TRADE SHOW

FIRE SYSTEM AND PIPELINE CORROSION DANGER

Microbiologically Induced Corrosion

CORROSION IS, UNFORTUNATELY, PART OF THE DAILY BACKDROP IN MARINE ENVIRONMENTS. BIOLOGICAL CORROSION IS OFTEN ACCEPTED AS SOMETHING inevitable. There is a form of biological degradation which can have serious consequences: microbiologically induced corrosion (MIC, also known as Microbiologically influenced corrosion).

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MIC is often caused by sulphur-reducing bacteria (SRB), which can live under both aerobic and anaerobic conditions. Anaerobic bacteria can create a corrosive biofilm on the metal surface which can lead to severe corrosion damage. Moreover, these bacteria can be concurrently present in a biofilm as both aerobic and anaerobic. The aerobic bacteria are present on the water side because they always need oxygen; the anaerobic bacteria will prosper on the metal side. In practice, this relative new form of biological corrosion is very devastating and manifests on many metals and metal alloys. Carbon steel and stainless steel are very sensitive to this form of corrosion.

Favourable Conditions

While MIC is usually caused by sulphur-reducing bacteria, iron and manganese oxidising micro-organisms can also be a cause. Rough surfaces in aqueous environments are very sensitive to MIC, because these conditions are highly favourable for the deposition of corrosive biofilms. This occurs mainly in water cooling systems, sprinkler systems, storage tanks, heat exchangers, fire mains, sand bed filters, etc. As the temperature rises, the bacteria multiply faster, and may mutate to become resistant to higher temperatures. This bacterium seems capable of surviving in an environment of up to approximately 87°C. Some bacteria produce aggressive substances when they decompose, such as sulphuric acid and hydrochloric acid. Steel and stainless steel are not resistant to these acids. Wall thicknesses of a few millimetres can be completely perforated after a couple of months. As metal corrodes in the anaerobic layer of the biofilm, tubercle reagents will form, manifesting as rust clusters in the shape of small cauliflowers. Under these clusters, sulphuric acid forms, attacking the material at the weakest spot and etching the rest. This is why an affected spot is often visible next to a hole.

Twenty years ago, these types of corrosion were very uncommon. Today, it almost seems to be the most common form. Opinions are divided on the question why. The most likely scenario is that globalisation and rising temperatures have allowed sulphur-reducing bacteria to spread around the world.
Materials are infected quickly and may succumb to MIC in a short amount of time. In addition, the biofilms created have a disadvantageous effect on heat transfer, and water-filled systems may clog up due to congestion, which creates an unacceptable problem for the sprinkler systems.
There is a good chance that MIC will start to

Steel pipe affected by MIC.

Photo courtesy of MIC Europe

crop up in still water, particularly when the temperature starts to rise. Fire system mains constructed of stainless steel AISI316, which are filled with still water, have been found to leak within a year.

There are biocides such as sodium hypochlorite that can effectively kill such bacteria, but these cannot be applied everywhere: the final product may be adversely affected, and sometimes a biocide is too corrosive for the metal used. Sodium hypochlorite is very corrosive to stainless steel, because it has an unstable chloric-compound. Encouraging results have also been achieved with UV light and ozone. A process engineer can assist in determining the right approach.

Firefighting Equipment Hazards

Since MIC is not noticeable from the outside until the material wall is pierced by corrosion, its presence in firefighting equipment can easily cause hazardous situations. >>

The stainless steel AISI 304 foot of a pump, one year after being infected with MIC. The pump was infected during pressure testing during manufacture because the test reservoir was contaminated with SRB's.

Test with PipeShield on steel wool: on the left is tap water, on the right tap water treated with PipeShield.

View of the inside of a stainless steel alloy 316Ti pipe pierced by MIC.

The cauliflower-like tubercles can clog pipes and sprinkler heads, preventing the whole system from functioning during a fire. Leakages caused by MIC are often very small at first. If the perforations enlarge, water damage occurs, causing irreversible harm. Through extensive international research, it has become clear that 73% of the installations examined that are over fifteen years old, no longer comply with the design harm.

In the world of fire prevention, there are dry and wet systems. These names can be misleading, as 'dry' systems are not dry at all. During fire drills and tests, the systems are filled with water. When drained, there is enough moisture left to initiate MIC. This became apparent during research done by the German Sprinkler Authorities (VdS) on dry and wet systems, when the 'dry' systems performed even worse than the wet ones. The Netherlands has commissioned a Corrosion of Sprinkler Authorities Workgroup and a Commission of Experts in Extinguishing Systems (CvD) to create a memorandum on how to deal with MIC.

Zinc-Coating is No Solution

Pipes with an internal zinc coating are often seen as the solution to curb or prevent MIC, but this is a misunderstanding. Zinc on steel gives a protective layer against water and carbonic acid, which is present in the atmosphere. This means there is an insoluble layer of the zinc patina, which in fact is a layer of zinc carbonate. It is important that a system alternates between wet and dry, and this is usually not the case with sprinkler systems. Because of the oxygen in the water, the zinc will dissolve due to the lack of carbonic acid so no zinc patina can be formed. That is why there will still be corrosion, and in fact the ideal structure is formed to connect a biofilm.

Protection Against MIC

One product that can help protect metals from MIC is PipeShield from MIC-Europe. PipeShield is a REACH-registered product, which is added to water to create a protective layer on the surface. This layer is only atoms thick, but still offers a high resistance against the microbiologically induced corrosion. PipeShield enables micelles (lipid molecules that arrange themselves in a spherical form in aqueous solutions) to accrete as a surfactant substance on the metal wall, protecting it from MIC. Moreover, bacteria and micro-organisms are encapsulated by this surfactant, whereby their corrosive development is limited. During a test, steel wool was immersed in normal drinking water with and without PipeShield. After a couple of weeks, the steel wool dissolved into iron hydroxide in the untreated water, while this did not occur in the water treated with PipeShield. PipeShield is pH neutral and dissolves fully in water.

Cathodic Protection

Interesting results can also be obtained with intelligent cathodic protection, which works with fluctuating currents. As a result, the acidity level fluctuates, which micro-organisms cannot easily tolerate. This fluctuation can be achieved with sacrificial anodes and with impressed current. Because the electric current fluctuates, anodes last approximately twice as long compared to anodes using conventional cathodic protection. Such smart anodes can only be applied in water reservoirs and tanks where firewater is contained.

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