The danger of biological corrosion in fire systems & pipelines - Part 2

Microbiological induced corrosion (MIC) is a serious corrosive mechanism which poses a very real threat to human safety. The potential for MIC to cause catastrophic failures in fire protection systems and pipelines should not be under estimated. In Part 2 of this two-part article we examine the how MIC affects fire prevention systems, how the BART test can be used as an aid to tackle the problem, the influence of piping materials and how to effectively prevent MIC.

By Ko Buijs, Innomet, The Netherlands, www.innomet.nl

Relatively recently it was discovered that these MICs can occur in installations related to fire prevention. This is a very serious situation because this means that fire prevention may be in danger if one cannot rely on a sprinkler system. The problem very serious because it is not noticeable from the outside until the material wall is pierced by corrosion. Even more dangerous are the cauliflower-like tubercles which can clog the pipes and sprinkler heads, preventing the whole system from functioning during a fire. Leakages caused by MIC are often very small initially, whereby a spray of aerosols releases countless bacteria into the surrounding area. This could also explain why some people get a mysterious illness in a specific space. If the perforations enlarge, water damage will occur and for buildings such as museums this could mean irreversible damage to art pieces. In the USA, MIC is recognised by the National Fire Protection Association and Factory Mutual. The latter is one of the world's largest insurers related to fire damage and their datasheet 2-1 describes this corrosion mechanism and gives preventive advice. The National Association of Corrosion Engineers (NACE) has also done extensive research related to MIC in sprinkler systems, and came to the conclusion that this is one of the biggest threats for the installations, and that the industry needs to take the proper measures to eliminate the problems in this area. Through extensive international research, it became clear that 73% of the installations examined that were older than 15 years no longer comply with the design parameters, because of perforations and/or the clogging. In the Netherlands, there is increasing support for measures related to firefighting systems to make them more reliable. In the world of fire prevention, there are two main systems: dry and wet systems, and the first one could be confusing for some, as these systems are not at all dry. During checks, the systems are filled with water, and when drained, there is enough moisture left to initiate MIC. This was apparent during the research done by the German Sprinkler Authorities (VdS) on dry and wet systems where the 'dry' systems performed even worse than the wet ones. The Netherlands has commissioned a Workgroup Corrosion of Sprinkler Authorities and Commission of Experts in Extinguishing Systems (CvD) to create a memorandum on how to deal with MIC. This goes to show, that there are enough signs to wake us up internationally and take drastic measures.

The BART test

In addition to sulphur-reducing bacteria (SRB), there are 4 main groups of bacteria which can cause corrosive biofilm by acidifying the water so metal is affected. The main groups are:

- APB (acid producing bacteria)
- SLYM (mucous membrane and forming bacteria)
- HAB (heterotrophic)
- IRB (iron related bacteria)
- SRBs (sulphur-reducing bacteria).

With IRB, the ferrous ions oxidize into ferric ions whereby energy is released, making the bacteria grow. Ferric ions are highly corrosive.

Figure 3: Steel pipe totally clogged by corrosion products (photo: MIC Europe private company)

The Biological Activity Reaction Test (BART) has been designed to determine what type of bacteria you are dealing with. This test was designed by Droycon Bio concepts in Canada, and is usually employed by labs and companies who work with corrosion control in the oil and gas sector. Determining which bacteria are involved enables a more targeted treatment. In practice, they are usually dealing with the SRBs. Sprinkler systems are filled with water which usually comes from tanks or a reservoir. The water often remains still for a long periods of time, allowing aerobic bacteria to develop optimally. The corrosion products are blackish and smelly because of the H_2S formation (rotten egg smell). The resulting reaction products clog the sprinklers (Figure 3).

Zinc-coating not a solution

Pipes with an internal zinc coating are often seen as a solution to curb or to prevent the MIC, but this is a misunderstanding. Zinc on steel gives a protective layer to

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 varies 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.

Stainless steel piping

Fire pipes made out of stainless steel are also very susceptible to MIC, because the fire-fighting water is often in the pipes in an untreated condition for a long period of time. Because of this, the biofilm has time to develop optimally. In this way stainless steel AISI 316L pipes can be perforated in a short period of time. Figure 4 shows a specimen collected from a 6" S10s pipe with the quality 316Ti, which has holes after just six months. Around the hole, one can clearly see a bright spot which is caused by the etching of the sulphuric acid, which could be found under the (now removed) tubercles. The water in the pipes was taken from the IJ River in Amsterdam without being treated.
Fire mains in road tunnels are particularly sensitive to this, particularly if the temperature is higher, as in pump rooms and taps; and in pipes to which antifreeze has been added. In other words, the use of stainless steel does not guarantee that MIC will not occur, and this also applies for higher alloyed grades. When applying stainless steel, one needs to take conclusive measures, and the most optimal ones are discussed below.

Figure 4: View of the inside of the MIC pierced 6"S10s size 316Ti pipe which had been filled with IJ river water. (photo: Innomet private company)

Protection against MIC

A good protection against MIC is offered by PipeShield from MIC-Europe. This is a product where micelles (lipid molecules that arrange themselves in a spherical form in aqueous solutions) accrete as a surfactant substance on the metal wall. This leads to an adequate protection against MIC. Moreover, bacteria and micro-organisms are encapsulated by this surfactant, whereby their corrosive development is limited.

Figure 5: Test with PipeShield on steel wool: on the left is tap water, on the right tap water treated with PipeShield (photo: Innomet private company)

"Zinc coated pipes will not prevent MIC"

Figure 5 shows steel wool which 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 is not the case with water treated with PipeShield.
PipeShield is a Reach registered product which is added to water to create a protective layer on the surface. This layer only has atomic layers in thickness, but still offers a high resistance against the microbial induced corrosion. PipeShield is pH neutral and dissolves fully in water, with a normal dosage being 1250 ppm.
Further characteristics include:

- Very long lifetime and can be discharged into the sewer.
- Tested according to DIN 51360 and also ASTM D-665.
- Active up to 130°C.
- Releases the biofilms already created.
- Encapsulates bacteria and other micro-organisms, so that they can do almost no damage i.e. inhibits the formation of a corrosive biofilm.
- Highly effective in stationary systems such as fire extinguishing systems.
- Should not be used in process streams which are related to nutrition, as it is a chemical product.

Cathodic protection

If PipeShield cannot be applied interesting results can be reached with intelligent cathodic protection, which works with fluctuating currents. As a result, the acidity level fluctuates which micro-organisms do not like. This can be achieved with sacrificial anodes and also with impressed current. The latter is most relevant for the food and pharmaceutical industry. Because the electric current fluctuates, for the purpose of conventional cathodic protection, 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.

Sources: Microbiological Influenced Corrosion (MIC) in Sprinkler systems; by Jos Braes Kluwer Yearbook.
For more information: www.innomet.nl

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