

What in the world is Microbiologically Influenced Corrosion (MIC), and why do contractors need to know anything about it? Well, it turns out that MIC can negatively affect your profits.

MIC is corrosion caused by microorganisms, such as bacteria and fungi, that attach to material surfaces. These microbes will create chemical and electrochemical interactions leading to pitting and degradation of material properties. MIC is a costly problem that affects many industries, including oil and gas, power, marine, and water systems. It can also degrade structural integrity and the operation of the components over their service life.

A typical contractor may encounter the effects of MIC on applications that require piping and vessels or components to be hydrostatically testing. Filling a component or piping system with water to prepare for the hydrostatic test can lead to MIC since corrosion can occur due to microbial activity during and after a hydrostatic test. This happens when microorganisms in the test water, which is often untreated or low-quality, forms biofilms that initiate corrosion within the piping systems or components being tested. This corrosion can attack welds and lead to premature failure or leaks months or years after the system is put into service.

You may ask, “How does any corrosion due to MIC affect me? I welded and tested everything in accordance with the project contract documents, and that project was months (or even years) ago.” If MIC occurs and it can be shown that the water you used for hydrostatic testing was not adequately treated, or that the contract documents stated that all water after the hydrostatic test should be drained (but it wasn’t), you could be held liable for any damage caused by corrosion due to MIC.

The mechanism for this is:

- A. **Microbial Growth** – Microorganisms such as sulfate-reducing bacteria (SRB) are present in untreated test water.
- B. **Formation of the Biofilm** – The microbes form biofilms on the inner surfaces of pipes and vessels while they are filled with water.
- C. **Corrosion** – The biofilm causes highly localized corrosion that attacks the metal surface through uniform corrosion or localized pitting.
- D. **Leaks** – The corrosion can lead to severe pitting, particularly in welds and heat-affected zones (HAZ), and eventually cause leaks and early failure during service.

There are several factors that can contribute to MIC during hydrotesting.

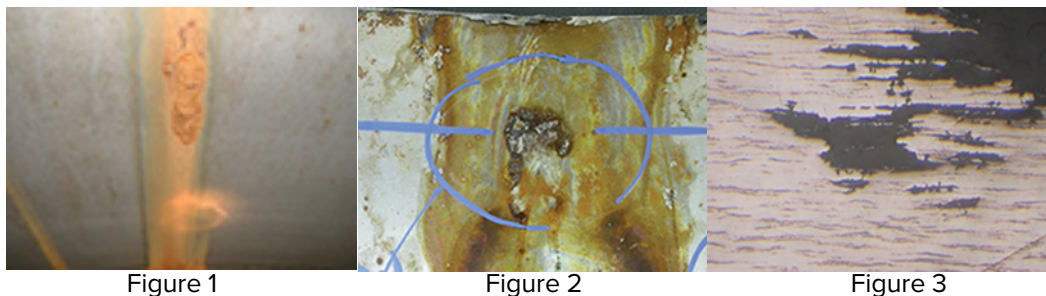
1. **Untreated Water** – Water that is not properly treated to eliminate microbes or bacteria is the principal way that contaminated water is introduced to components during the hydrotest. Insufficient biocides in the test water will fail to control microbial growth. The waters that typically cause MIC are raw (untreated) from fresh water sources such as reservoirs, rivers, streams, wells, or other inadequately treated fresh waters. Bacteria that cause MIC can also come from dirt and dust that gets into the pipe during installation.
2. **Incomplete Draining** – Water that is left in vessels or piping after the hydrotest is complete can create a good environment for microbial growth. This is particularly true when the water is left stagnant for long periods of time before components are placed in service.
3. **Material Susceptibility** – Some materials are more susceptible to MIC than others. Stainless steel, often looked on as a very corrosion-resistant material, is especially susceptible to MIC. Austenitic stainless steels get their corrosion resistance from the creation of a passive layer on the surface of the metal. Certain bacteria can aggressively break down this passive layer, leaving the underlying base metal open for aggressive attack. Carbon steels and aluminum alloys are also susceptible to MIC.

## What Is A Contractor To Do?

If hydrostatic testing is part of your project scope, what can you do to prevent MIC? Since MIC can be very aggressive, and nearly impossible to eliminate once established, consider taking the following precautions:

1. **Use Adequately Treated Water** – Verify that the water being used for hydrostatic testing is free from microbes by adding corrosion inhibitors and biocides, especially if the system is 300-series stainless steel or it will be holding water for more than a few days after hydrostatic testing has been completed. The main considerations for adequately treated water are:
  - a. **Limit Total Dissolved Solids (TDS)** – TDS increase the electrical conductivity of the water, leading to increased corrosion.
  - b. **Check Chloride Content** – If chlorine is used as a biocide, it should be between 5 and 50 parts per million.
  - c. **Adjust pH** – The pH of the water should be between 8 and 10, but at least 7.4.
2. **Ensure Complete Drainage** – Unless the system will be put in service with properly treated water within a few days of completing hydrostatic testing, it should be drained of water immediately after the hydrostatic test. Hot, dry air can be used to facilitate drying of the system.
3. **Low Chloride Flushing** – If complete drainage is not possible for austenitic stainless-steel piping, flushing it with deionized water is best. Water that has a low chloride content (< 5 ppm) is an acceptable second choice.
4. **System Design** – Although it is typically beyond the contractor’s scope to contribute to the design of the system, the system should be designed and installed to ensure proper water drainage after hydrostatic testing.
5. **Fabrication Practices** – Crevices and other abrupt changes in section should either be eliminated or minimized as much as possible since they are sites where microbial colonies can attach and grow. The probability of MIC occurring can also be minimized by:
  - a. Using complete joint penetration (CJP) welds
  - b. Purging stainless steel to prevent the formation of heat tint
  - c. Removing any heat tint that does occur – either chemically or by mechanical grinding.
  - d. Removing arc strikes and weld spatter on wetted surfaces.

**Figure 1** shows MIC on the root side of a weld where heat tint was not removed. **Figure 2** shows MIC forming in a crevice from a weld made during fabrication. **Figure 3** shows how the microstructure is affected by corrosion due to MIC.



The piping codes address the use of water quality and other factors when performing a hydrostatic test. For example, ASME B31.3 paragraph F345.4.1 states:

*“Consideration should be given to susceptibility to microbiologically influenced corrosion (MIC). This condition is especially prevalent in no-flow, high-moisture environments. Internal MIC may also depend on the characteristics of the treated or untreated test fluid. Internal MIC may be lessened or possibly eliminated by properly draining and drying systems and/or by proper selection of test fluid.”*

ASME B31.1 Nonmandatory Appendix IV-3.4 says:

*“Equipment fabricated from austenitic (300 series) and ferritic (400 series) stainless steels and requiring hydrostatic testing should be tested with deionized water, high purity steam condensate, or potable water, in decreasing order of preference.*

*After testing is completed, equipment should be thoroughly drained, with all high point vents open during draining, and dried by air blowing, swabbing, or other appropriate means. If immediate draining and drying are not possible, hydrotest water should be circulated in the piping for at least one hour daily to reduce the possibility of pitting and microbiologically influenced corrosion.”*

API 510 and 570 codes have similar wording regarding the water chemistry used for hydrostatic testing.

## **Conclusion**

Microbiologically Influenced Corrosion (MIC) poses a significant risk to contractors, potentially causing costly damage and liability years after a project is completed. This happens due to the use of untreated water during hydrostatic testing and improper draining. By implementing proactive measures such as using adequately treated water with biocides and corrosion inhibitors, ensuring complete drainage after testing, and adhering to relevant industry standards like ASME B31.1, contractors can take crucial steps to mitigate this risk.