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Practical Guide to Diagnosis & Mitigation of Microbiologically Influenced Corrosion (MIC) in Fire Protection Systems

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MIC is a serious problem affecting FPS

MIC is easy to diagnose & mitigate

BTI has simple, effective, economical methods & tools for dealing with MIC

Purpose of This Guide

This guide has been prepared by Bioindustrial Technologies, Inc. (BTI) to:

1. Demonstrate that microbiologically influenced corrosion (MIC) is a serious problem affecting fire protection sprinkler systems (FPS).
2. Take the mystery out of dealing with MIC—if you understand a few basics, MIC is easy to diagnose and mitigate (prevent and treat).
3. Provide you with information about simple, effective, and economical methods and tools for dealing with MIC in FPS.

The methods and tools described in this guide are based on BTI's investigations of hundreds of FPS throughout the United States. These investigations led to the conclusions that severe MIC affected only certain *portions* of most FPS and that there were simple, but different, explanations for how MIC occurred in wet and dry/preaction FPS. Because severe MIC is usually limited to certain areas, targeted mitigation can be done on *only* those areas with real problems and can be successful *without* total pipe replacement or chemically cleaning the entire FPS with harsh cleaning chemicals. ***The bottom line:*** successful diagnosis and mitigation of MIC has been achieved in all cases where BTI's simple and inexpensive methods and tools have been used.

In order to keep this guide simple and to-the-point, we have only covered the basics. If you would like more in-depth, detailed information on MIC in FPS, please refer to BTI's "Handbook of Microbiologically Influenced Corrosion (MIC) in Fire Protection Systems." Additional information on our products and services can be found on our website: www.bti-labs.com.

MIC in FPS is a Real Problem

MIC is defined as corrosion influenced by the presence and activities of microbes. MIC has been recognized in other industries as a problem for many years (see the References section at the end of this guide for more information). In the last several years, many agencies—such as the National Fire Protection Association (NFPA), National Fire Sprinkler Association (NFSA), American Fire Sprinkler Association (AFSA), National Association of Corrosion Engineers (NACE), FM Global, and some state fire marshals—have recognized that MIC is a very serious problem affecting many FPS throughout the United States and even in other countries. For a list of documents specifically addressing the issue of MIC in FPS, please see the References section at the end of this guide.

Agencies, such as NFPA, have recently recognized MIC is a very serious problem affecting many FPS throughout the US

MIC in FPS

Microbes which cause MIC in FPS are mostly bacteria and fungi. These are present in most water used in FPS, even water treated by water suppliers to kill pathogens. The most important groups of bacteria involved in MIC of FPS are:

- Low nutrient bacteria (LNB)
- Anaerobic bacteria (ANA)
- Iron-related bacteria (IRB)
- Acid-producing bacteria (APB)
- Sulfate-reducing bacteria (SRB)

It is important to realize that the simple presence of microbes does NOT result in MIC. MIC results from having the following "MIC factors" present in an FPS on a frequent or constant basis:

1. Susceptible metal (including steels, galvanized steel, copper, stainless steels).
2. Water – essential for microbes to grow and corrosion to occur.
3. MIC-related bacteria
4. Nutrients which are present in water and sediments– very important in controlling microbial growth and MIC.
5. Oxygen which is present in water and air – very important in controlling microbial growth rate and the rate at which corrosion, including MIC, can occur.

When all five MIC factors exist in an FPS, MIC occurs in the following stages.

- MIC-related bacteria grow quickly on metal surfaces and produce slimes (see Figure 1).

MIC results from having 5 MIC Factors present on a frequent or constant basis

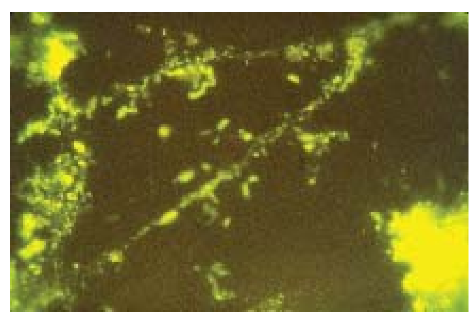

Figure 1. Microbes and microbial slimes on surface of steel exposed to city water for 12 hours as viewed using a high-powered microscope. Several million microbes are present per inch.

Figure 2. Discrete deposits on interior of steel pipe. These deposits are formed by microbes depositing materials from water and by the accumulation of corrosion products.

Figure 3. Under-deposit pitting corrosion showing distinct pits-within-pits, which are characteristic of MIC. This type pitting can occur at 0.200” per year and can penetrate FPS pipes within a few months after installation.

Figure 4. Pinhole leak in dry galvanized FPS pipe. This pitting occurred under discrete deposits located where water puddles had been.

- The growth of bacteria ultimately results in the formation of discrete deposits (a.k.a. tubercules or carbuncles; see Figure 2).
- MIC-related bacteria create conditions (principally by producing acids and consuming oxygen) that promote very rapid under-deposit pitting (localized) corrosion (see Figure 3).
- This under-deposit pitting often results in pinhole leaks, which sometimes occur within months of new FPS installation (MIC has been documented to penetrate FPS metals at rates up to 0.200” per year; see Figure 4).

Slimes, discrete deposits, under-deposit pitting, and pinhole leaks are all telltale signs of MIC.

More frequent exposure to MIC factors increases the likelihood of ***severe*** MIC. Therefore, only those *usually small* portions of the FPS where MIC factors are present frequently—due to the way the FPS is constructed and operated—suffer ***severe*** MIC. In wet FPS, these areas are typically in: a) larger diameter, horizontal pipes which see frequent water flow and accumulate sediments, and b) in pipes containing air pockets (usually at high points in the FPS—see Figure 5). In dry/preaction FPS, severe MIC is most often seen in horizontal pipes which are likely to accumulate moisture and/or water puddles and sediments (usually at low points and areas adjacent to grooves and fittings—see Figure 6). It is now recognized that frequent flow of untreated water into an FPS—due to retrofits, flow tests, and inspectors’ tests performed at remote locations—can contribute to rapid MIC in some portions of an FPS. Reducing the frequency of flow tests and performing flow tests at the riser help prevent MIC. Treatment of waters entering the FPS with agents to prevent microbial growth and reduce oxygen levels in the water is ESSENTIAL to controlling severe MIC.

How to Diagnose & Mitigate MIC in 5 Simple Steps (for Existing FPS)

(Information on commissioning new FPS is provided beginning on page 7).

BTI has developed the methods and tools necessary for the accurate and economical diagnosis and mitigation of MIC in FPS. These have been successfully used by facilities engineering, maintenance, and fire protection company personnel with no prior training in microbiology, chemistry, or water testing.

All BTI products come with everything required to perform the task, including very detailed instructions on how to use the product and properly interpret the results and free technical support. Clients can return completed test kits to BTI for a written report, including recommendations for the next step of action, if any is required.

BTI's on-site services include MIC testing, inspection and assessment, and mitigation oversight. Detailed reports are provided at the conclusion of each service.

Usually, only small portions of the FPS where MIC factors are present frequently—due to the way the FPS is constructed and operated—suffer severe MIC.

Step 1: Test Make-Up Water & Samples from FPS

- Test supply waters and samples from the FPS itself for MIC-related bacteria and chemical indicators of MIC problems.
  - o This information is critical to the diagnosis of MIC in FPS and to determining a proper treatment method.
  - o Testing different locations in the FPS provides data about where MIC is occurring and its severity. With this information, further assessment can be focused on the areas with MIC problems, thereby saving time and money and avoiding interference with operations in the facility.
- Test locations for *wet* FPS should include: make-up water, "hot spots" (areas which have had leaks), riser, and inspector's test valve. Test locations for *dry/ preaction* FPS should include: make-up water, "hot spots" (areas which have had leaks), and low point and drum drips.
- Use BTI's MICkit FPS and MIPkit FPS test kits to perform tests.
  - o Completed test kits may be sent to BTI, along with the completed FPS System Information Form, for a written report, including recommendations for the next step of action.
- BTI can perform on-site testing for you and provide a detailed report, including recommendations.

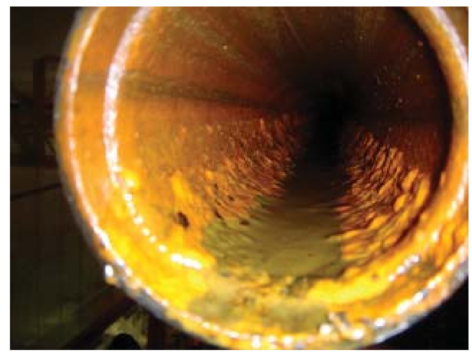

Figure 5. Larger diameter wet FPS pipe showing an air-water interface because of an air pocket. Water, oxygen, microbes, and sediments were concentrated along the bottom of the pipe. The result is MIC, as evidenced by the discrete deposits seen here and localized pitting under the deposits.

Figure 6. Pipe from dry FPS showing an air-water interface where a puddle had been. Note the discrete deposits and severe under-deposit pitting in this area.

Step 2: Gather & Record System Information

- Fill in as much of the FPS System Information Form--provided with the test kits--as possible.
  - o Information about FPS construction, materials, modes of operation, and history are critical to

diagnosis and mitigation of MIC.
- The completed System Information Form can be returned to BTI, along with the completed test kits from Step 1, for a written evaluation of the information and data and recommendations for further action, if any is required.

MIC testing helps identify where MIC is occurring & makes further assessment easier & less expensive

Step 3: Inspect & Assess Conditions in Critical Areas

- Visually inspect and document conditions in internal portions of pipe from various critical locations in the FPS.
  - This information helps to determine distribution and severity of MIC throughout the FPS and is critical to designing a simple, effective, and cost-saving mitigation plan.
- Use BTI's MICkit Pipe Inspection Kit to perform inspections. BTI can assist you in identifying locations where inspections should be done.
- BTI can perform on-site inspections and provide a detailed report, including recommendations and options for mitigation, if necessary.

Inspecting pipe from critical locations is important to designing a simple, effective, cost-saving mitigation plan

Step 4: Determine Mitigation Options & Implement Mitigation

- Determine mitigation options which take into account effectiveness, possible risks, effect on operations, and cost. The mitigation options may involve one or more of the mitigation protocols which follow.
  - This approach allows clients to choose the mitigation approach best-suited to their particular situation.
- Once a mitigation approach has been decided upon, implement mitigation.

Mitigation options should take into account effectiveness, possible risks, affect on operations, & cost

Possible Mitigation Protocols:

Pipe Replacement

- Pipe replacement should be done on pipe that is unsafe to remain in service (see FM-Global guidelines in References section) or where cleaning is *more* expensive and problematic than selective pipe replacement.
  - In most cases, very little pipe needs to be replaced.

Cleaning

- Cleaning is used to remove sediments, deposits, corrosion products, and oils from the FPS.
- Cleaning, if it is to be followed by appropriate water treatment to prevent microbial growth and reduce oxygen levels, can often be done by flushing the FPS with water.
- In a few cases, targeted chemical cleaning is used.
  - o Chemical cleaning, especially that done using harsh cleaning chemicals (such as strong acids), should *not* be used for the entire FPS. This is because severe MIC is generally limited to a few locations in the FPS, and cleaning agents may remove protective materials from some pipes.

Cleaning, if followed by water treatment, can often be done by flushing the FPS with water

Treatment

- Since the potential for MIC exists at some time in virtually all FPS, ***ALL*** FPS—wet and dry/preaction—should be treated to prevent microbial growth **and** reduce oxygen. These actions will prevent severe corrosion, including MIC, from occurring in the FPS.
- For wet FPS, treatment should involve the following:
  - o Treat all water entering the FPS to prevent the growth of MIC-type microbes in the FPS **and** to reduce oxygen in the water.
  - o Minimize water flow through the FPS.
  - o Eliminate air pockets.
- For dry/preaction FPS, treatment should involve the following:
  - o Fill the FPS with water treated to prevent the growth of MIC-type microbes **and** to reduce oxygen in the water. Leave treated water in the FPS overnight, then drain FPS.
  - o Eliminate moisture and/or water accumulation and retention.
  - o Eliminate oxygen (e.g., use nitrogen instead of air to pressurize the FPS).
  - o Any time water is introduced into the FPS, treat water as above.
- A permanently installed, automatic treatment system should be used to ensure treatment of *all waters* entering the FPS at any time.

- BTI can provide specific protocols for cleaning and treatment using BTI's MICtreat FPS System and MICtreat FPS Chemicals.
- BTI can provide on-site assistance and oversight of mitigation.

ALL FPS should be treated to prevent microbial growth & reduce oxygen

Step 5: Monitor

Monitor routinely after treatment to ensure MIC is under control

- Once the FPS has been treated, monitor routinely to ensure microbial growth and corrosion, including MIC, is under control.
- Use BTI's MICtreat FPS Monitor Kit, provided at no extra cost with the MICtreat FPS System, to monitor the FPS.
- BTI can review monitoring data for you, if required.

Commissioning New FPS

During commissioning of new FPS, the goal is to reduce, as much as possible, the factors involved in MIC so that MIC will not occur.

Wet FPS

- Design and construct wet FPS to minimize areas which trap sediments and which allow the formation of air pockets. Where necessary (e.g., high points), install mechanisms to eliminate air pockets. Construct wet FPS with the least amounts of oil and dirt possible.
- Once installed, flush or clean FPS, if necessary. Avoid leaving untreated water in the FPS.
- Install automatic treatment system, and fill FPS with water treated to prevent the growth of MIC-related bacteria **and** reduce oxygen.
- Remove all air pockets.
- Leave automatic treatment system in place so that *all water* entering the FPS is treated to prevent MIC.
- Minimize water flow through FPS.
- Monitor to ensure microbial growth and corrosion, including MIC, is under control.

MIC in new FPS can be prevented by proper design/construction, operation, & treatment

Dry/Preaction FPS

- Design and construct dry/preaction FPS with proper pitch, drains at low points, and with provision to use nitrogen instead of air to maintain pressure in the FPS. Construct dry/preaction FPS with the least amounts of oil and dirt possible.
- Once installed, flush or clean FPS, if necessary. Avoid leaving untreated water in the FPS.
- Install automatic treatment system and fill FPS with water treated to prevent the growth of MIC-related bacteria **and** reduce oxygen. Leave treated water in the FPS overnight. Then, drain the FPS, making sure to eliminate as many water puddles as possible.
- Use nitrogen instead of air to pressurize the FPS.

- Leave automatic treatment system in place so that *all water* entering the FPS is treated to prevent MIC.
- Monitor to ensure microbial growth and corrosion, including MIC, is under control.

About BTI

Bioindustrial Technologies, Inc. (BTI) has been providing industrial clients with testing, consulting, and treatment solutions to microbiologically influenced corrosion (MIC) for over 25 years. BTI has been involved in the diagnosis and mitigation of *hundreds* of cases of MIC in fire protection systems (FPS) throughout the United States and in other countries. BTI's president and founder, Daniel H. Pope, Ph.D., coined the term "microbiologically influenced corrosion (MIC)" and has written the Guides to MIC for the natural gas, nuclear, electric generating, chemical, and fire protection industries.

Our commitment to the unique needs of the FPS industry is exhibited by our active membership and participation in National Fire Protection Association (NFPA) and National Association of Corrosion Engineers (NACE) task groups which deal specifically with MIC in FPS. BTI employees have also authored many articles on the subject which have appeared in several industry journals and have given numerous presentations at NFPA conferences and SFPE chapter meetings .

BTI approaches diagnosis and mitigation of MIC and other microbial problems based on scientific investigations and analysis of data from real-world facilities and situations. As a result, BTI recognizes that FPS are complex and have unique characteristics. Because traditional methods do not work well in FPS, BTI has developed simple, accurate, and inexpensive methods specifically for the diagnosis, prevention, and mitigation of MIC in FPS.

BTI's methods & tools for diagnosis & prevention of MIC in FPS are: simple, accurate, & inexpensive

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