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

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## Contact Info

To receive more information about our products or services, please contact us at:

BTI Products, LLC  
652 Silver Hills Road  
Bayfield, CO 81122  
(970) 884-4629  
e-mail: [products@bti-labs.com](mailto:products@bti-labs.com)  
website: [www.bti-labs.com](http://www.bti-labs.com)

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BTI Products, LLC  
Bayfield, Colorado 81122

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MIC is a serious  
problem affecting FPS

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## Purpose of This Guide

- This guide has been prepared by BTI Products, LLC (BTI-P) 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, accurate diagnosis and mitigation (prevention and treatment) of MIC can be easy
  3. Provide you with information about simple, effective, and economical methods and tools for dealing with MIC in FPS

2  
MIC is easy to  
diagnose & mitigate

The methods and tools described in this guide are based on BTI-P's investigations of FPS throughout the United States, and the investigations of FPS performed by Bioindustrial Technologies, Inc.

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-P's simple and inexpensive methods and tools have been used.

3  
BTI-P has simple,  
effective, economical  
methods & tools for  
dealing with MIC

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 contact us. Additional information on our products and services can be found on our website: [www.bti-labs.com](http://www.bti-labs.com).

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## MIC in FPS is a Real Problem

MIC is defined as “any form of corrosion influenced by the presence and activities of microbes”. MIC has been recognized in other industries as a problem for over 30 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 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 & NACE, have recognized MIC is a very serious problem affecting many FPS throughout the US

## MIC Factors

Microbes which cause MIC in FPS are mostly bacteria and sometimes include fungi. Microbes 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)

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

It is important to realize that MIC results from having the following “MIC factors” present in an FPS on a frequent or constant basis:

1. Susceptible metal (including black steels, carbon steels, galvanized steel, copper, and stainless steels)
2. Water – essential for microbes to grow and corrosion to occur
3. MIC-related bacteria – commonly present in supply water
4. Nutrients & Chloride – provides a food source for microbes
5. Oxygen – present in water and air, aids microbes in the corrosion process

(Note: Even when oxygen is no longer present, MIC-related microbes can continue to function by also using ferric iron, nitrates, and/or sulfates, if present)

When ALL FIVE of these MIC factors exist in an FPS, MIC can occur in the following stages:

- MIC-related bacteria grow quickly on metal surfaces and produce slimes (see Figure 1)
- The growth of bacteria ultimately results in the

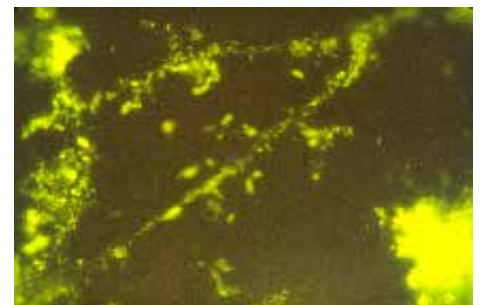


Figure 1. Microbes and microbial slimes on surface of steel exposed to city water for 12 hours as viewed using a high-powered microscope. Several million microbes are present per inch.



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.

formation of discrete deposits (a.k.a. tubercles 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 corrosion, including MIC. Treatment of ALL 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 begins on page 7)

**B**TI-P provides 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-P’s products come with everything required to perform

the task, including very detailed instructions on how to use the product and properly interpret the results. Additionally, BTI-P provides free technical support. Clients can also return completed test kits to BTI-P for a written report, including recommendations for the next step of action, if any is required.

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

## 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.
  - This information is critical to the diagnosis of MIC in FPS and to determining a proper treatment method.
  - 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-P’s MICKit® FPS and MIPkit® FPS test kits to perform tests immediately after collection. (Note: Sending samples to a laboratory for analysis can compromise the accuracy of the results, since critical factors change during transit.)
  - Completed test kits may be sent to BTI-P, along with the completed FPS System Information Form, for a written report, including recommendations for the next step of action.
- BTI-P can perform on-site testing for you and provide a detailed report, including recommendations, if necessary.

## Step 2: Gather & Record System Information

- Fill in as much of the FPS System Information Form as possible (forms are provided with each test kit).

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



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.



- o Information about FPS construction, materials, modes of operation, and history are critical to diagnosis and mitigation of MIC.
- The completed System Information Form should be returned to BTI-P, 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

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

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

### 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.
  - o 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-P's MICKit® Pipe Inspection Kit to perform inspections. BTI-P can assist you in identifying locations where inspections should be done.
- BTI-P can perform on-site inspections and provide a detailed report, including recommendations and options for mitigation, if necessary.

### 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.
  - o 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.

#### 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. (Note: 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 a sufficient velocity of water.
- In a few cases, targeted chemical cleaning is used.
  - 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.

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

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## 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**, after cleaning, treatment should involve the following:
  - Treat ALL water entering the FPS to prevent the growth of MIC-related bacteria in the FPS **and** to reduce oxygen in the water.
  - Minimize water flow through the FPS.
  - Eliminate air pockets.
- For **dry/preaction FPS**, after cleaning, treatment should involve the following:
  - Fill the FPS with water treated to prevent the growth of MIC-related bacteria **and** to reduce oxygen in the water. Leave treated water in the FPS overnight, then drain FPS.
  - Eliminate moisture and/or water accumulation and retention.
  - Eliminate oxygen. (Note: Nitrogen may be used instead of air to purge and pressurize the FPS.)\*
  - 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.
- BTI-P can provide specific protocols for cleaning and treatment using BTI-P's MICtreat® FPS System and MICtreat® FPS Chemicals.
- BTI-P can provide on-site assistance and oversight of mitigation.

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

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## 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-P's MICtreat® FPS Monitor Kit to monitor the FPS, this kit is included with the MICtreat® FPS System.
- BTI-P can review monitoring data and provide free technical support, if required.

## Commissioning New FPS

During commissioning of new FPS, the goal is to reduce, as much as possible, all factors involved in MIC so that corrosion 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 a 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.
- Eliminate oxygen. (Note: Nitrogen may be used instead

of air to purge & 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.

## Other Mitigation Options

We recognize that, in the industry, there are *other* approaches recommended for corrosion control & mitigation, such as Nitrogen Inerting, Corrosion Inhibitors, etc. But, in BTI-P's experience none of these approaches completely prevent & control corrosion in FPS caused by MIC (see the articles in the References Section for more detailed information).

\*Please note: While we have referenced the use of Nitrogen Gas for purging & pressurizing an FPS, it should be noted that, the use of Nitrogen *alone* to control corrosion, including MIC, does not eliminate all MIC-related bacteria (see specifically the article "Nitrogen Inerting is Good- but Cannot Prevent all Forms of Corrosion in Dry and Pre-action Fire Protection Systems" in our References Section).

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

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## About BTI Products, LLC.

BTI Products, LLC. (BTI-P) has been providing industrial clients with testing, consulting, and treatment solutions to microbiologically influenced corrosion (MIC) since 2009 (and as a department of Bioindustrial Technologies, Inc. since 1984). BTI-P has been involved in the diagnosis and mitigation of *hundreds* of cases of MIC in fire protection systems (FPS) throughout the United States.

Our commitment to the unique needs of the FPS industry is exhibited by our active membership and participation in the National Fire Protection Association (NFPA), American Fire Sprinkler Association (AFSA) and National Association of Corrosion Engineers (NACE). BTI-P's employees have authored articles on the subject of MIC which have appeared in industry journals and have given presentations, focused on MIC corrosion, at various conferences.

BTI-P 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-P recognizes that FPS are complex and have unique characteristics. Because traditional methods do not work well in FPS, BTI-P has developed simple, accurate, and inexpensive methods specifically for the diagnosis, prevention, and mitigation of MIC in FPS.

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