Part One of Two [For the complete article, contact the authors or visit: fpcmag.com.]

Fundamentals of MIC

in Water-Based Fire Protection Sprinkler Systems

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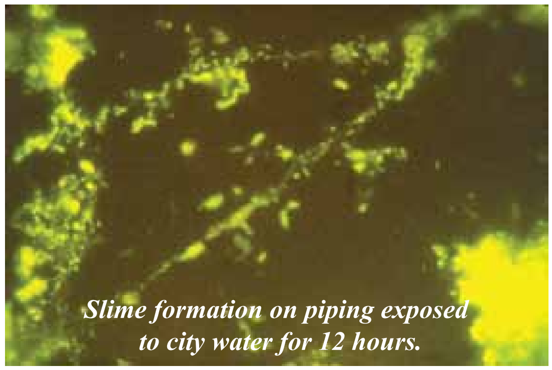
Abstract — Mechanisms for the occurrence of microbiologically influenced corrosion (MIC) in water-based fire protection sprinkler systems (FPS) are presented. Various methods proposed for the prevention and treatment of MIC in FPS are also discussed.

The **purpose of this article** is to explain how and why microbiologically influenced corrosion (MIC) occurs in water-based fire protection systems (FPS). The information in the article is based on Pope's research over 35 years, his preparation of *Guides* to MIC in many industries, and hundreds of on-site investigations by both authors to determine how MIC occurs in FPS and how it can be prevented and treated.



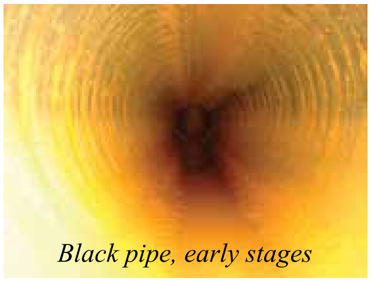
Slime formation on piping exposed to city water for 12 hours.

In 1984, Pope coined the term **Microbiologically Influenced Corrosion (MIC)** as *"Those forms of corrosion which are influenced by the presence and activities of microorganisms"*[1]. MIC means "influenced" and NOT "induced" corrosion, because microbes do not always induce corrosion but do influence when and where corrosion occurs and the forms and rates of corrosion that result. It should be noted that the authors and their colleagues in the FPS industry have successfully treated ALL cases that proved to involve MIC, including many FPS in which facility owners have chosen NOT to replace any pipe and have had NO subsequent failures.

MIC in FPS takes several **forms** (e.g., crevice corrosion, oxygen concentration cell corrosion, under-deposit acid attack, and under-deposit pitting) depending on the stage in the development of the MIC site. Pitting under discrete deposits formed as a result of microbial activities is the "hallmark" of MIC. The type of metal or alloy, chemical characteristics of water and gases at or near the corrosion site, numbers and types of microbes involved, operational factors (e.g., frequency and rates of water flows in contact with the potential or actual MIC site and location in the FPS (i.e., riser, main, or branch lines)), and the type of FPS (i.e., wet, dry, or preaction) also influence when and where MIC occurs, the forms of corrosion seen, and rates at which corrosion occurs.

In contrast to MIC, **"generalized" (uniform) corrosion** is most often formed in FPS equipment due to the reaction of metal components, especially iron, with water and oxygen. This is most often seen as rust or other iron oxides on the metal surface. Generalized corrosion, in the absence of forms of localized corrosion such as MIC, is relatively harmless as the rate of penetration of metals is slow and does not result in rapid pitting corrosion. Also, in wet FPS, oxygen is quickly exhausted by reaction with metal(s) in the pipe and, in untreated water, oxygen consumption by microbes, greatly slowing generalized corrosion until more water and oxygen enters the FPS. Even when air pockets are present in wet FPS, generalized corrosion of metal in the air pockets is limited by the absence of water. Pitting corrosion only occurs when discrete deposits (a.k.a. nodules or tubercles) are formed on the metal surface creating an environment in which pitting corrosion can occur. Some authors have suggested that such deposits are formed on

Treatment Method	*Type FPS*	*Treatment Time Required for 1,000 Gallon FPS*	*Approximate Cost for 1,000 Gallon Pre-action FPS*
Biocide/Oxygen Scavenger	Dry/preaction	Fill FPS (approximately 30 minute fill time), let sit overnight and drain, then purge and pressure using dry nitrogen bottles (approximately 30 minutes). Note that treatment agent remains in water puddles in FPS for months to years.	Approximately $2,600-$3,100. Note that treatment system remains on-line permanently to provide automatic protection of FPS for many years.
Biocide/Oxygen Scavenger	Wet	Approximately 30 minute fill time. Treatment agent remains in water for months to years.	Approximately $2,600-$3,100. Treatment system remains on-line
Nitrogen Generator	Dry/preaction	Pressurize FPS and then slowly purge thru remote valve over 2-3 weeks	Approximately $10,000-$22,000
Nitrogen Generator	Wet	FPS is filled with nitrogen and purged 3 times via high-point vent, then FPS is filled with untreated water while "gases" are purged via high-point vent. Approximately 2-3 hour process.	Approximately $10,000-$22,000
		Please Note: All data based upon information provided by suppliers of treatment systems.	


Black pipe, early stages

metal surface simply due to settling of iron and other substances present in the water onto the metal, with pitting due in most cases ONLY to oxygen cell corrosion. Our investigations of hundreds of cases of pitting corrosion in FPS do **NOT** support this as the mechanism for rapid pitting corrosion in FPS.

The **main source** of MIC bacteria to FPS is water added to an FPS, including those used to hydrotest. Almost 100% of potable water sources tested contained MIC bacteria. This is because treatment of potable water is done using disinfectants, such as chlorine, to kill pathogens. Since MIC bacteria are not classified as pathogens, they are not routinely monitored and the amount of disinfectant used is not sufficient to kill MIC bacteria in the water supplied to FPS.

The **main stages** in the development of a MIC site were described by Pope in 1988[2]. **Phase 1** is the attachment of "pioneer" MIC bacteria to metal surfaces. The authors termed these Low Nutrient Bacteria, or LNB. LNB are aerobic (need oxygen to grow), slime-forming bacteria that are adapted to growing in environments such as potable waters, which are low in nutrients. The result is a patchy slime (biofilm) on the metal. It is patchy because MIC bacteria prefer sites on the metal, which provide protection from the dislodging action of flowing water, nutrients such as organic materials concentrated on the metal surface, and that contain inorganic substances such as iron and manganese found in the metal and those sites that are prone to pitting corrosion.

Phase 2 involves growth of the MIC bacteria community and recruitment of additional types of MIC bacteria such as: anaerobes (ANA), which don't like oxygen; acid-producing bacteria (APB); sulfate-reducing bacteria (SRB), which produce corrosive hydrogen sulfide; and, iron-related bacteria (IRB), which deposit iron and manganese, thus increasing the size and hardness of what is now recognizable as a discrete deposit.

End of Part One

For the complete article contact the authors or info@fpcmag.com.

Part Two will address further characteristics of MIC; Phase 3; Preventing and Treating MIC in FPS; What **does** "prevent and treat MIC in FPS?"

References:

[1]Pope, D.H., Duquette, D.J., Wayner, D.C. and Johannes, A.J., *Microbiologically Influenced Corrosion: A State of the Art Review*, Columbus, Ohio: Materials Technology Institute of the Chemical Process Industries, 1984.

[2]Pope, D.H., Dziewulski, D.M., Zintel, T.P. and Siebert, O., *Guide to the Investigation of Microbial Corrosion in Gas Industry Facilities*, Gas Research Institute, 1988.

[3]Uhlig, H.H., and Revie, R.W., *Corrosion and Corrosion Control* 3rd Edition, John Wiley & Sons, New York & Toronto, 1985.

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