Anaerobic MIC in Nitrogen Supervised Dry and Pre-action Fire Protection Systems Fact or Fiction?

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The advent of nitrogen as a viable and cost-effective supervisory gas to inhibit or prevent internal corrosion in dry and pre-action fire protection systems (FPS) has rekindled the debate about the risk of microbiologically influenced corrosion (MIC) in these systems. Proponents of chemical treatments are claiming anaerobic MIC can still take place in nitrogen-supervised systems and therefore nitrogen should only used in conjunction with chemical treatment.

This is, at best, a half-truth and should be evaluated carefully knowing that these chemicals invariably add another level of complexity and possible liability for owners, operators, and installers of these systems. Moreover, none of these chemicals are approved for use in long-term contact with other metallic and polymeric parts of FPS (such as sprinkler heads, O-rings, valve seats, and gaskets) by authoritative bodies such as NFPA or Factory Mutual (FM). Their long-term effect and role in degradation of these components are unknown and have not been evaluated with scientific rigor. It is also noteworthy to mention that NSF or GRAS approval does not imply NFPA or FM approval.

The proprietary, "designer" nature of these chemical solutions is aimed at maintaining exclusivity for the inventor, thereby capturing the client for life. The solutions often consist of a mix of oxygen scavengers, inhibitors, and biocides. Their purported efficacy relies on the effective removal of oxygen and inhibition of corrosion reaction on affected surfaces. Small amounts of biocide, which can be very toxic and has been shown to have a negative impact on the integrity of polymeric components and CPVC pipe, supposedly prevents MIC. As such, the maintenance and proper concentration of these constituents have to be maintained religiously and at great expense to the owners and operators of treated systems. Upon activation, flow testing, and/or flushing of treated systems, disposal of treated water and/or contact with humans (such as fire fighters or sprinkler technicians) is another factor that may well incur significant liability for the owner.

The metabolic activity of some bacterial species can potentially initiate or accelerate electrochemical corrosion in FPS resulting from the presence of chemical species produced during their metabolic processes. Typically, these chemical species lower the localized pH, thereby changing the local chemistry and accelerating the rate of electrochemical corrosion by enabling the cathodic hydrogen reaction. Other species such as iron oxidizing bacteria, metabolizes the ferrous ion (Fe^{2+}) (which is one of the products of electrochemical corrosion) into the ferric ion (Fe^{3+}), thereby shifting the chemical equilibrium and accelerating the electrochemical corrosion reaction. Aerobic bacteria require the presence of oxygen, water, and organic nutrients to survive and proliferate. The same is true for anaerobic bacteria, but in the absence of oxygen.

Per the requirements of NFPA13, dry and pre-action systems are supposed to be substantially dry without significant amounts of residual water. The code calls for "complete drainage" after hydrotesting and installation of adequate means to achieve this (see NFPA13 section on "Drainage"). Field experience has shown that destructive corrosion of these types of FPS is always associated with residual water that was not or could not be drained after initial hydrotesting. Due to the presence of the other two requirements for corrosion, namely, the presence of a continuous supply of oxygen in the compressed supervisory air and the presence of vulnerable materials (mild steel or galvanized steel), initiation and propagation of localized pitting is extremely likely in these areas and many owners of such systems can attest to that fact.

Once localized pitting has damaged a system, the resulting change in surface roughness and the presence of large amounts of corrosion product deposits permanently violate the requirements of the flow calculations and specifications. Chemical cleaning may remove the deposits, but the surface characteristics in areas where localized pitting had taken place cannot be restored. Therefore, the only viable way to restore to specifications in such affected areas of the FPS is to replace the pipe with new sections that are free of deposits and conform to surface roughness requirements. It is also imperative that adequate means of drainage be installed at the same time in areas vulnerable to retention of water to ensure complete drainage.

The substitution of compressed air with high-purity nitrogen as supervisory gas has been proven to be a reliable and cost-effective way to inhibit or completely prevent the re-initiation or propagation of localized pitting. Displacement of oxygen eliminates the oxygen reduction reaction and therefore corrosion is not possible; even in the presence of the normally alkaline sprinkler water. While it is true that anaerobic bacteria can survive under these conditions, the probability that they can be a factor in the initiation or acceleration of localized corrosion is relatively low due to the absence of electrochemical corrosion and aerobic bacteria. To the best of our knowledge, no verifiable instances where this was indeed the case have been published in the peer reviewed literature.

The reasons for this are as follows:

- Anaerobic bacteria related to MIC are often found in colonies where they co-exist with aerobic bacteria. One such example is sulfate-reducing bacteria (SRB) that are often found associated with colonies of aerobic bacteria. The activity of the aerobic bacteria effectively strips the underlying substrate of oxygen and thereby creates localized anaerobic conditions. If an FPS is properly installed (new) or repaired, drained of all water, and charged with nitrogen, electrochemical corrosion will not occur and aerobic or anaerobic bacteria cannot survive.

- Even if small amounts of water originating from humidity remains in the FPS, charging with nitrogen prevents the onset of electrochemical corrosion as has been proven by examination of rehabilitated FPS with nitrogen as supervisory gas. Moreover, the low dew point of high purity nitrogen of approximately -40˚F, enables it to absorb significantly more moisture than compressed air. Over time, and with active cycling of the nitrogen, such residual moisture will completely dry out the FPS thereby eliminating a requirement for both electrochemical corrosion and bacterial activity.

- Inexpensive and quick field tests that are used for MIC testing are often unreliable and inadequate to identify and quantify MIC-related bacteria. The mere presence of heterotrophic bacteria is by no means an indication that MIC is playing an active role in corroding FPS.

> The specific bacteria that are known to be associated with MIC must be identified and present in large enough numbers to justify a diagnosis of MIC. In addition, chemical and metallurgical tests are required to confirm a diagnosis of MIC. Past experience has shown that this is the case in a very small minority of affected dry and pre-action FPS and, without exception, the direct result of installation (i.e. improper or inadequate sloping) design, (lack of drainage), and/or environmental factors (i.e. raw, untreated water). If the root causes for localized corrosion are properly identified and addressed, MIC always becomes a non-issue. Very often the results of these field tests are used to scare owners and operators into committing to unnecessary and ineffective chemical treatments with potentially huge liabilities.

Rigorous scientific testing and practical, real life experience with systems charged with nitrogen have proven it to be an effective and reliable method to inhibit or completely prevent internal corrosion of dry and pre-action FPS. No peer reviewed reports of nitrogen-supervised systems where corrosion resulting from the activity of anaerobic bacteria, have been published. We have worked with numerous owners of systems that previously had failed due to internal corrosion. They all have successfully implemented rehabilitation programs and switched to nitrogen supervision, thereby safeguarding their FPS against recurrence of internal corrosion. Not a single instance is known where the corrosion returned or MIC has been identified as a corrosion mechanism in nitrogen-supervised FPS.