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 relevance of microbiologically influenced corrosion (MIC) in these systems. Proponents of chemical treatments have claimed that anaerobic MIC can still take place in nitrogen-supervised systems and therefore nitrogen supervision should only be used in conjunction with chemical treatment.

This should be evaluated carefully knowing that these chemicals invariably add another level of complexity, expense, 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 the National Fire Protection Association (NFPA), Underwriters Laboratories (UL) 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 International (formerly National Sanitation Foundation) approval (that some suppliers of treatment chemicals cite on their products), does not imply NFPA or FM approval for use in fire protection systems.

The proprietary, "designer" nature of these chemical solutions is aimed at maintaining exclusivity for the inventor. The solutions primarily consist of a mix of oxygen scavengers, inhibitors, and biocides. Their purported efficacy relies on the effective removal of oxygen, inhibition of the corrosion reaction, and eradication of any bacteria in the sprinkler water. As such, the maintenance and proper concentration of these constituents have to be carefully managed and possibly increase costs to the owners, operators, and maintainers of treated systems. Disposal of treated water generated during flow testing, and/or flushing of treated systems, and the risk of contact by humans with these solutions (such as fire fighters or sprinkler technicians) are additional factors that may incur liability for the owner.

Activity of very specific bacterial species can potentially assist 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. 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 the NFPA13 Standard[1], dry and pre-action systems are required to be substantially dry without significant amounts of residual water. The standard calls for complete drainage after hydrostatic testing and installation of adequate means to achieve this (i.e. adequate pitching, auxiliary drains at low points). Field experience has shown that destructive corrosion of these types of FPS is associated with residual water that was not or could not be drained after initial hydrotesting[2,3]. 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 likely in these areas.

Once localized pitting has damaged a system, the resulting change in surface roughness and the presence of large amounts of corrosion product deposits permanently alter the requirements of the flow calculations and specifications used to validate the systems operating flow characteristics. 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 such 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. However identifying these affected areas presents its own challenges. 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.[4] 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 possibility that they can be a factor in the initiation or acceleration of localized corrosion is unlikely 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 has been published in the open, peer reviewed literature.

The likely reasons for this are as follows:

- Anaerobic bacteria related to MIC are found in colonies where they co-exist with aerobic bacteria. One such example is sulfate-reducing bacteria (SRB) that are found underlying 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, and charged with nitrogen, electrochemical corrosion will not occur and aerobic or anaerobic bacteria cannot take hold.

- MIC is found in conjunction with, and as a consequence of electrochemical corrosion. If electrochemical corrosion is prevented, MIC cannot occur either. Even if small amounts of water originating from humidity remain 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.

- To proliferate or grow, bacteria need water AND organic nutrients that can be metabolized by them to produce the by-products that accelerate electrochemical corrosion. Potable water, which is almost without exception the source of sprinkler water, is treated to remove organics and bacteria. This further reduces the possibility of the re-introduction of MIC-related bacteria into new or rehabilitated FPS.

- Inexpensive and quick field tests used for MIC testing are unreliable and inadequate to identify and quantify MIC-related bacteria. The mere presence of heterotrophic bacteria, is by no means an indication that MIC has played an active role in corroding FPS. The specific bacteria that are known to be associated with MIC must be identifiable and present in large enough numbers to justify a diagnosis of MIC. Past experience have 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)[5]. If the root causes for localized corrosion are properly identified and addressed, MIC very often become a non-issue.

Rigorous scientific testing and practical, real-life experience with systems charged with nitrogen have proven it to be and effective and reliable method to inhibit or completely prevent internal corrosion of dry and pre-action FPS.[6] No verifiable, peer-reviewed data of nitrogen-supervised systems where corrosion resulting from the activity of anaerobic bacteria has been identified. 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 aerobic MIC has been indentified as a corrosion mechanism in nitrogen-supervised FPS.

References

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