Predictive Maintenance for Fire Sprinkler Systems

Jeffrey D. Gentry
Sonic Inspection Corporation

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Introduction

Overview of Problem

Corrosion of Fire Sprinkler piping can lead to potentially hazardous system malfunctions, as well as costly water damage and repair costs. Microbiologically Influenced Corrosion (MIC) can rapidly accelerate corrosive growth leading to these problems even in buildings less than five years old [1]. Unfortunately, inspections for MIC and Corrosion are often overlooked until expensive problems such as damaging leaks occur or the corrosion is so prevalent that large areas of the entire Fire Sprinkler system have to be replaced. This corrective maintenance approach is a retro-active strategy. The task of the maintenance team in this scenario is usually to effect repairs as soon as possible. Costs associated with corrective maintenance include repair costs (replacement components, labor, and consumables), lost production and lost sales.

Solution

A new, proactive approach to fire sprinkler maintenance is available using completely non-invasive, ultrasonic technologies that form the basis of a predictive maintenance approach. This approach provides a cost-effective means of detecting the presence and monitoring progression of corrosion and creating a digital record of the system state that can be used to schedule replacement of localized sections of the system before leaks or operation failures occur.

Figure 1. Typical Sections of Fire Sprinkler System

Fire Sprinkler Problems with Corrosion and MIC

The most common Fire Sprinkler Pipes are constructed using steel pipes sized according to hydraulic requirements but typically ranging from 1.0 inch diameter to 8.0 inch diameter pipes in Schedule 5, 10 or 40 (with Schedule 40 having a significantly thicker wall than Schedule 5 or 10).

There are numerous types of corrosive reactions that can occur with steel and various methods for combating or trying to slow the corrosive activity. Corrosion in Wet fire sprinkler systems is not usually a problem IF all of the air is removed from the system after filling the system with water unless MIC is present (see below). Even a small amount trapped air can cause the onset of corrosive activity.

Figure 2. Corrosion Scaling in Fire Sprinkler Pipe

Microbiologically Influenced Corrosion (MIC)

MIC is the term used for corrosion influenced by microbes in the water. The primary concern is that the influence of these microbes is often an extremely accelerated rate of corrosion. MIC is not caused by a single microbe, but is attributed to many different microbes. These are often categorized by common characteristics such as by-products (i.e., sludge producing) or compounds they effect (i.e. sulfur oxidizing). In a general sense, they all fall into one of two groups based upon their oxygen requirements; one being aerobic (requires oxygen) such as sulfur oxidizing bacteria, and the other being anaerobic, (requires little or no oxygen), such as sulfate reducing bacteria [2].

Although there have been regions of the United States, such as the Phoenix, Arizona area, where a large number of MIC cases have been reported and documented, there is presently no indication that MIC is confined to any specific geographical area. Reports of MIC have been received from throughout the United States and also from abroad [1].

Figure 3. Large MIC Nodules in a Wet Fire Sprinkler System

MIC almost always occurs concurrently with other corrosion mechanisms, and it is virtually impossible to separate them. This is in part due to the fact that microbes help create conditions under which other corrosion mechanisms can occur, such as crevice corrosion, pitting, and under-deposit corrosion [1].

In a Dry system, water often collects in low spots in the piping after the pipe is periodically flushed (per NFPA requirements for Dry systems). As the water sits in the bottom of the pipe, MIC can begin to rapidly eat through the wall thickness, as most Dry systems incorporate thinner Schedule 5 or 10 pipes.

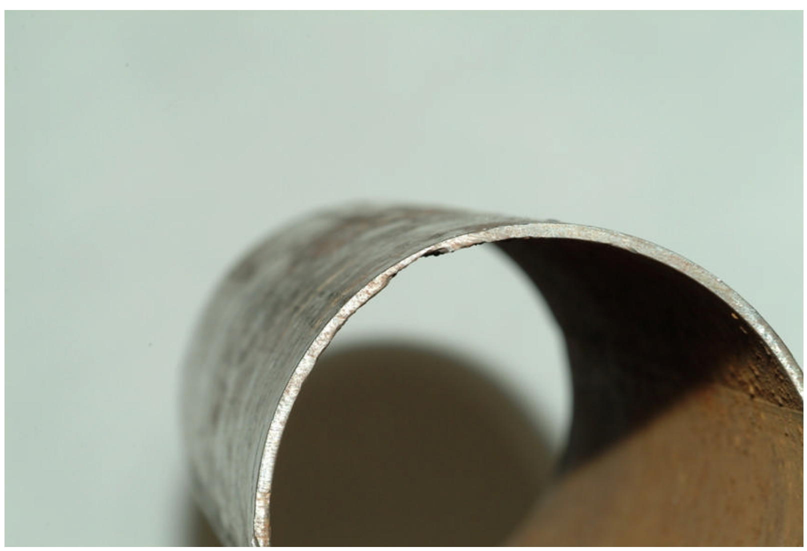

Figure 4. Wall Thinning & Pitting in a Dry Fire Sprinkler System

Solution: Sonic Predictive Maintenance Program

Sonic Inspection has developed a comprehensive inspection service and predictive maintenance program for facility managers and building owners. The basis of this program is a completely non-invasive, ultrasonic inspection technique that provides a quick and accurate measurement of internal pipe corrosion and MIC. Sonic's proprietary software permanently stores the analyzed results and ties the measurements to copies of the facilities blueprints.

Predictive Maintenance

Predictive maintenance refers to maintenance based on the actual condition of a component. Maintenance is not performed according to fixed preventive schedules but rather when a certain change in characteristics is noted. Periodically inspecting fire sprinkler systems for the presence of MIC or Corrosion allows the facility manager to accurately monitor the condition of the system, schedule localized replacement and significantly reduce the risk and costs associated with corrective maintenance.

Using the non-invasive, ultrasonic inspection techniques described in the next section, a cost-effective predictive maintenance program can be implemented to detect the presence and the progression of corrosion or MIC in the sprinkler piping. The density of inspection locations and the frequency of inspections should be chosen based on the risk associated with a leak or operational failure, history of the system, and condition of the sprinkler system water supply.

Risk Mitigation

The risk of MIC or Corrosion in fire sprinkler piping can be broken into two general categories: (1) loss of life or property damage caused by fire that spreads due to an operational failure; and (2) significant property damage caused by a leak from corrosive pitting.

Almost any facility that is required to have a fire sprinkler system is subject to the first risk, but several types of facilities rely on the sprinkler system to extinguish or slow the spread of fire more so than other structures. These include military and commercial ships at sea, correctional facilities, petroleum refineries, chemical plants, power plants (oil, coal, and especially nuclear).

Figure 5. Fire sprinkler operation is critical for both military and commercial ships

The potential of fire sprinkler leaks may not seem especially risky, but for facilities that house sensitive electronics and equipment such as clean rooms and computer data centers a single small leak can produce potentially catastrophic financial losses.

Figure 6. Leaks above Data Centers like these could be disastrous

Return on Investment

Calculating the Return on Investment in a predictive maintenance program for MIC and corrosion in the fire sprinkler piping requires assessing the risk of either type of system failure, estimating the potential cost of such a failure, estimating the cost of a corrective maintenance approach once a problem is discovered. Once these costs are estimated they need to be weighed against the cost of inspecting the system using a non-invasive, ultrasonic technique and monitoring the level of corrosion at suitable intervals for the associated level of risk.

SONIC INSPECTION

Non-invasive, Ultrasonic Inspection Technologies

Sonic uses two separate ultrasonic inspection technologies can be used to quickly detect and monitor the level of corrosion and MIC in a fire sprinkler system.

Patented Guided Wave Pipe Corrosion Detection

Sonic Inspection uses a patented Guided Wave Ultrasonic technique to rapidly identify areas of pipe that show indications of internal corrosion. The technique uses a specialized ultrasonic scanning head placed on the exterior of the pipe to excite guided waves that propagate around the circumference of the pipe.

Figure 7. Guided Wave Scan Head

Guided Wave signatures for brand new, pristine pipe have been stored in software for all of the possible pipe diameters and schedules, for both Wet and Dry systems. The measured signature is compared to a pristine pipe. The more corrosion (presence of nodules attached to the interior of the pipe and amount of wall thinning) the more the received signal is affected.

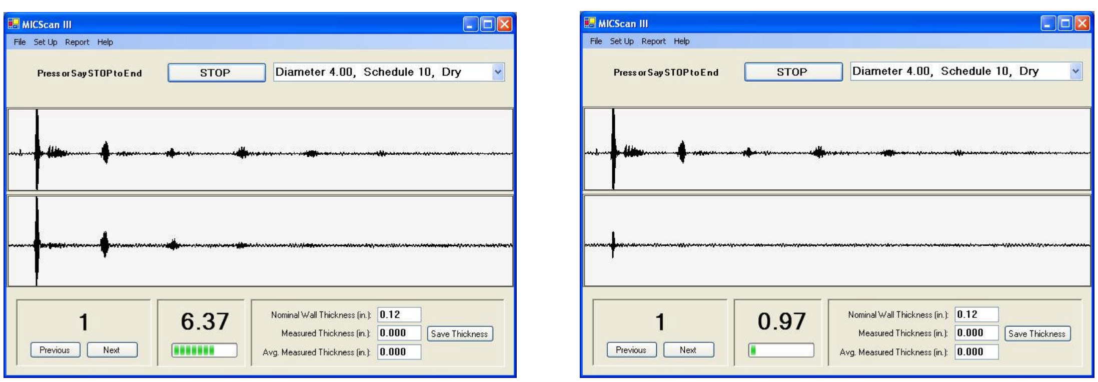

Figure 8. No Corrosion (left) versus Corrosion Indication (right)

Conventional Ultrasonic Thickness Measurements

Any areas of pipe that show indications of corrosion are investigated further with highly accurate wall thickness measurements made around the circumference of the pipe.

Sonic Inspection Corporation
2070 Kahala Circle
Castle Rock, CO 80104

Phone (303) 308-3000
Fax (720) 733-9975
www.SonicInspection.com

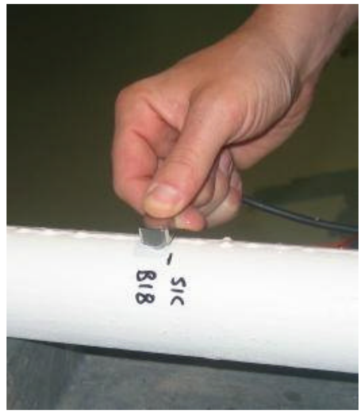

Figure 9. Conventional Ultrasonic Thickness Measurements

Alternative Inspection Techniques

Some areas of pipe may be inaccessible and therefore cannot be measured using the ultrasonic techniques described above. One alternative method for inspecting hard to reach pipe includes feeding a digital video boroscope into the pipe and recording the visual condition of the pipe interior. This method may be appropriate for limited use in high risk areas but is too intrusive and expensive for a general recurring inspection of an entire facility.

Analysis and Reporting

The measurements are permanently stored for each location and a report showing the current level of corrosion can be produced using the sprinkler system blueprints.

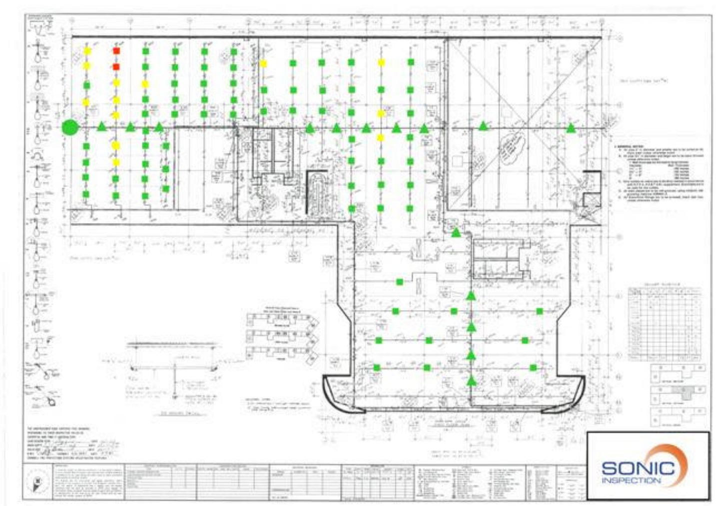

Figure 10. Corrosion measurements are tracked for each location

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Castle Rock, CO 80104

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Summary Remarks

There are four general approaches to maintaining any system: (1) Corrective Maintenance; (2) Preventative Maintenance; (3) Reliability Centered Maintenance (RCM); and (4) Predictive Maintenance. Because of the nature of MIC and corrosion and expense of Fire Sprinkler Systems, neither Preventative Maintenance (i.e. simply replacing the pipes on a scheduled basis before corrosion can occur) nor RCM are good choices. Corrective maintenance refers to the practice that is common today of waiting until the corrosion causes a leak or operational problem and then reacting to the problem with some sort of corrective action.

Until recently, facility managers and building owners had little choice but to wait for corrosive problems to arise before implementing costly corrective maintenance in a totally reactionary mode. Under these circumstances, a lot of pipe is either replaced unnecessarily (at a very high cost), or corroded pipe is left in place to cause a future problem (which is also costly).

Now, with Sonic's Predictive Maintenance Program, the presence of MIC and corrosion can be quickly identified, and tracked to provide cost-effective risk mitigation for both pin-hole leaks and operational failure of the system. Facility managers and building owners now have the means to create a database (see Figure 10) with the current level of corrosion and MIC in their fire sprinkler system piping and use this information to proactively schedule replacement of only the pipe deemed unacceptable.

References

1. FM Global Property Loss Prevention Data Sheet for Internal Corrosion in Automatic Sprinkler Systems. May 2001.

2. Huggins, Roland. "Microbiologically Influenced Corrosion: What It Is and How It Works", Article on American Fire Sprinkler Association Web Site.