The True Threat Of A High Corrosion Problem To A Fire Sprinkler Line

The most critical piping for any building property or plant operation is unquestionably at the fire sprinkler system.

Corrosion problems at tower water, chill water, steam, or other HVAC and plumbing piping may produce a loss of service, inconvenience, property damage, shutdown, and even millions of dollars in monetary losses, but the failure of a fire sprinkler line always threatens the loss of human life.

Often considered trouble free, corrosion related failures at fire sprinkler lines have greatly increased over the past decade - raising not only operating and repair costs, but the threat to building inhabitants as well.

No Protection Provided

Unlike most HVAC and industrial cooling applications, no chemical corrosion protection is provided to the steel pipe which carries nearly all fire service water. This is because traditionally, corrosion problems have not been a significant concern. It is also due to the virtual impossibility of providing effective chemical protection.

Up until 10-15 years ago, it was almost unheard of for fire sprinkler pipe to fail, or to learn of sprinkler pipe in need of replacement due to corrosion effects.

This prior lack of concern has changed in recent years due to the combined use of thinner gauge pipe, seemingly more corrosion susceptible steel, to a higher frequency of drain downs, testing, and modifications to fire protection systems, and to greater overall microbiological activity.

Corrosion rates which once could be expected to range below 0.5 mils per year (MPY) for fire sprinkler lines two decades ago, are now often measured at 5 mils per year and above.

Numerous Initiating Causes

Many different factors can lead to a corrosion problem at a fire sprinkler line. Absent or improper chemical clean-out prior to beginning service may leave rust, metal filings, mill scale, varnishes, iron oxide particulates, and foreign matter behind to produce severe problems years later.

The failure to disinfect the pipe of micro organisms, combined with nutrients from any remaining organic and particulate debris, can easily lead to an MIC condition.

A fire sprinkler system bringing in new, fresh and oxygenated water on a regular basis is virtually guaranteed to initiate severe corrosion problems. A frequently running jockey pump or make-up water meter, or pipe which is cold and sweating, are two sure signs of a leak or other flow problem.

Wall Loss Equals Rust

It is a correlation often unrecognized, but the presence of rust deposits at a pipe surface define that a wall loss has occurred. Likewise, an identified wall loss from an ultrasonic examination, defines that iron oxide deposits have been produced. One condition cannot exist without the other.

Exactly how much particulate debris remains within the system is generally dependant upon the piping application and any corrective measures applied.

An open tower or condenser water line, for example, will produce the same volume of deposits for the same MPY corrosion rate as a closed chill pipe of the same size. However, a substantial volume is washed out of the system during blowdown, filtration, and through regular maintenance. For open systems, the presence of rust in the tower pans, strainers, and chillers, etc. is often the first sign of a corrosion problem.

Closed circulating systems typically hold their deposits unless regularly flushed, or unless side stream filtration is provided. Rarely opened for visual inspection, a loss of heat transfer efficiency is often the first clue that an internal deposit problem exists.

But fire sprinkler systems provide a flow of water in only one direction to multiple dead end branch lines, and lack the benefit of circulation to move either cleaners or debris laden water to a drain or into a filter for disposal. All iron oxide deposits, therefore, are usually held captive within the piping.

While flushing a fire sprinkler system might show a limited benefit in removing some loose rust material over a limited range of piping, it will not likely remove those heavier deposits under which the highest corrosion and pitting activity always exists.

The True Meaning Of MPY

Minimizing the actual threat of many corrosion problems is the misconception of exactly what mils per year (MPY) means in terms of wall loss. Different authorities may provide recommended acceptable wall loss estimates in MPY, but the true impact of that pipe loss is rarely understood or appreciated in real world terms. A corrosion rate of 5 MPY is obviously worse that a 2 MPY rate, but to what degree in terms of pipe service life and volume of deposits produced?

A low corrosion rate of 1 MPY at a 10 in. fire sprinkler main, for example, while it would be viewed as acceptable by most authorities, actually translates to an annual physical loss of 11 lbs. of steel for every 100 linear feet of pipe. At 10 MPY, approximately 107 lbs. of metal is lost.

Multiplied by the number of years in service and its overall length, and the true magnitude of pipe corrosion takes on much greater significance than when reported as simply 1, 2, or 5 mils per year.

The below table illustrates just how much steel is lost at various corrosion rates and for various pipe sizes, and is applicable for any piping system.

Deposits The Real Threat

But while even a 5 MPY loss of metal can be tolerated by many piping systems for an extended period of time before resulting in a leak, it is the deposits created, and their eventual deposition and effect, that will inevitably produce far more serious and long term secondary problems.

Steel, when corroded back into iron oxide, produces a significantly greater volume of less dense material by a factor of approximately 18-20 times. Such deposits, in turn, ultimately create a substantial loss of heat transfer efficiency, constricted flow, and under deposit pitting and wall loss.

At a low corrosion rate of 1 MPY for an office building having 40 floors of 24 in. chill water piping, 242 lbs. of steel will be lost for each year of service at just the risers alone. In its less dense form of iron oxide, however, this same amount of steel is converted into a volume of 10 cubic feet. (*See back table*)

After 20 years, and where no chemical cleaning or filtration had been provided, it would be easily possible to accumulate 200 cubic feet of rust deposits at points within the system - often at heat transfer surfaces.

Pounds of Steel Lost at Various Corrosion Rates

Calculated Per Year, Per 100 Linear Feet of Schedule 40 Pipe

	Corrosion Rate in Mils Per Year (MPY)				
Pipe Size	1 MPY	5 MPY	10 MPY	15 MPY	20 MPY
2	2.2	11.1	22.2	33.4	44.6
4	4.3	21.5	43.1	64.7	86.4
6	6.5	32.4	64.9	97.4	129.9
8	8.5	42.6	85.3	128.1	170.9
10	10.7	53.5	107.1	160.7	214.4
12	12.8	63.8	127.6	191.5	255.4
24	24.2	120.9	241.9	363.0	484.1

Cubic Feet of Iron Oxide Deposits Produced

Calculated Per Year, Per 100 Linear Feet of Schedule 40 Pipe

	Corrosion Rate in Mils Per Year (MPY)				
Pipe Size	1 MPY	5 MPY	10 MPY	15 MPY	20 MPY
2	0.1	0.5	0.9	1.4	1.8
4	0.2	0.9	1.8	2.6	3.5
6	0.3	1.3	2.7	4.0	5.3
8	0.3	1.7	3.5	5.2	7.0
10	0.4	2.2	4.4	6.6	8.8
12	0.5	2.6	5.2	7.8	10.4
24	1.0	4.9	9.9	14.8	19.8

Key Factors For Failure

It is important to recognize that all carbon steel pipe will corrode to some degree. Even when chemically protected, pipe corrosion can only be minimized, never stopped.

With the application of chemical corrosion inhibitors generally not feasible for fire sprinkler service, the rate of its inevitable deterioration becomes generally dependent upon certain fixed parameters.

Of first importance is the amount of fresh water entering the pipe - with highest corrosion rates consistently found where water flow is the greatest, such as at the inlet.

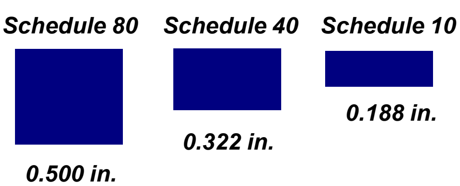
A second critical factor is pipe schedule. At any given corrosion rate, the service life of a pipe before failure is directly dependant upon its initial wall thickness.

For this reason alone, far more sprinkler failures occur today due to the common use of thin wall schedule 10 pipe. Schedule 10 offers savings on material, time, and installation costs, but at the trade-off of severely reduced service life.

Whereas extra strong schedule 80 would have been typically installed 50-75 years ago for fire service, lighter schedule 40 has been used since around the mid 1960's.

Over the past 20 years, this thin wall schedule 40 fire pipe has been frequently replaced with even thinner schedule 10 - leaving very little available pipe wall to corrode before reaching minimum acceptable thickness limits and inevitable failure.

The below comparison of 8 in. ASTM A53 black pipe shows the representative amount of available wall thickness that would be available to corrode at a sprinkler line installed decades ago using schedule 80, as opposed to most new installations today using schedule 10.



Under the clearly greater overall corrosion threat which exists today, only 0.088 in. exists to corrode before this schedule 10 pipe will reach minimum acceptable standards. For higher pressure applications having a higher minimum acceptable thickness limit, schedule 10 pipe will provide service only assuming that virtually no corrosion will take place - a known impossibility.

Threat Varies Per Application

The ultimate impact of internal deposits, similar to wall loss itself, is greatly dependent upon the piping system involved. Deposits produced at an open piping system will be observed quickly and be likely addressed, while a closed system will instead conceal is problem until a heat transfer loss, leak, or some other operating problem is realized.

But corrosion at a fire sprinkler system is often totally concealed from view, and may remain unrecognized for years. No external signs or indicators normally exist to suggest a corrosion problem prior to a leak occurring - at which time the major damage, often irrevocable, has already taken place.

Ultrasound, which is unquestionably the most cost-effective nondestructive technology available to detect a corrosion problem in pipe, is rarely used as a preventative tool in evaluating fire sprinkler systems.

In most cases, the concern raised due to a leak at fire sprinkler pipe is more directed to the potential for water damage or cost of replacement, rather than whether the pipe will provide the necessary water flow during a fire emergency. And yet the latter, by far, presents the greatest threat.

Potential System Failure

In fact, years of corrosion activity can easily produce thousands of pounds of debris capable of being dislodged from the shock of a fire pump kicking in, and then forced downstream into the critical actuating valves, and ultimately - the sprinkler heads.

At that point, all the fire fighting equipment, command and controls, sensing, planning, inspection, and emergency training suddenly becomes worthless if water cannot be supplied to the source of the fire.

The potential for such a catastrophe is easily demonstrated.

A 25% wall loss at an 8 in. schedule 10 sprinkler main, for example, is still not likely to produce any notice in the form of a leak or failure. Yet, that same 25% loss of steel from pipe which weighed a factory new 17 lbs. per linear foot, also means that 4.25 lbs. of steel per linear foot has now been removed from the pipe, and placed into its interior in the form of less dense iron oxide particulates.

For a 600 ft. main sprinkler feed, it is easy to estimate that 2,500 lbs. of rust would now exists in some proportion of hardened deposits or tubercles attached to the pipe's interior wall, and the rest as loose sediment and mud along the bottom.

This material accumulates with time, ultimately to the point where the pipe wall finally fails and brings attention to the problem, or to when a fire occurs.

In a very possible worse case scenario, this loose rust and mud will be dislodged by the shocking action of the fire pump starting up in response to a fire call. With perhaps thousands of pounds of loose material suddenly rushing downstream toward the fire's location, the potential to block closed any control or preaction valves, reducers, tees, small diameter distribution lines, or fire sprinkler heads is tremendous.

Such an actual event, whereby the fire sprinkler lines have been found totally clogged with rust and mud in a fire emergency, has actually occurred in previous instances - leaving those involved without the fire protection they believed existed.

MIC And Other Causes

Such severe corrosion problems have been commonly attributed to microbiologically influenced corrosion, or MIC. But while MIC may exist as the foremost cause, the end product of MIC and the source of sprinkler failures, rust deposits, can be produced by various other corrosion mechanisms.

Common to all problems, however, is the infiltration of fresh water into the system. If filled and left stagnant, a small amount of rusting occurs, the oxygen content is depleted, and corrosion almost ceases.

In contrast, the constant renovation and upgrading of newer properties itself promotes fire sprinkler problems - as every draining and refilling introduces into the pipe new oxygen, biological sources, as well as the nutrients they need to thrive.

Ironically, one of the root causes of the greater fire sprinkler problems seen today is mandated procedures to ensure their proper operation in the first place. Each required test of a fire protection system introduces new fresh water to produce further deterioration.

With so many forces acting against modern fire sprinkler systems, and few protective measures available, better corrosion monitoring becomes the only means to ensure that water will be available when a fire emergency exists.

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