



The Expanding Role of Nitrogen in Mitigating Sprinkler Pipe Corrosion

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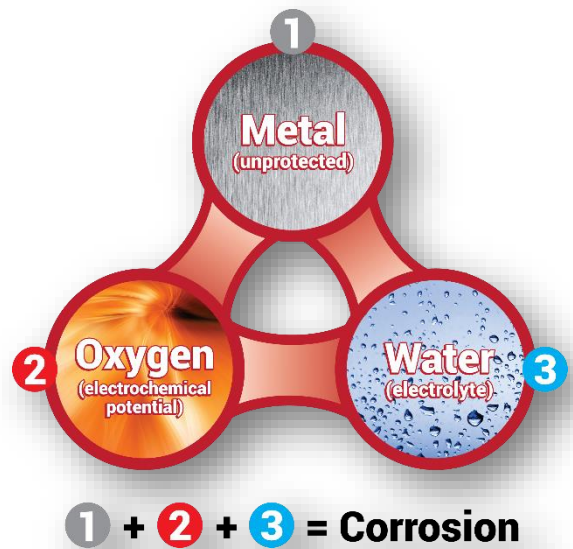
Introduction

Compressed air is out. Nitrogen is in. This is both an observation of evolving standard practices in the Fire Protection Industry, and a summary of the solution to corrosion issues in dry and pre-action sprinkler systems.

The use of high purity nitrogen as a supervisory gas is not new to fire protection. Use of high pressure cylinders can be traced as far back as the 1970's. Nitrogen generators, machines which separate high purity nitrogen from the atmosphere to create an inexhaustible source of the gas, have been utilized in the Industry for over a decade. But over the past several years, the technology has experienced exponential growth in its adoption rate. Specifying engineers and installing contractors alike have now seen the impact of replacing compressed air with high purity nitrogen in dry and pre-action systems. For those unaware or unfamiliar, the following will be an introduction to what is rapidly becoming the standard across the Industry.

Why Nitrogen?

The science behind why nitrogen is superior to compressed air for use in dry and pre-action fire protection systems is simple. Just like the fire triangle, there is a corrosion triangle (pictured to the right). Electrochemical corrosion takes place any time unprotected metal interacts with moisture (electrolyte) and oxygen (electrochemical potential). You cannot avoid the metal in this equation. Even in dry and pre-action systems, you cannot dodge the moisture aspect either. Therefore, the most effective way to inhibit the corrosion process is to replace the compressed air (Oxygen) with high purity Nitrogen.



Corrosion tests performed by various metallurgists and corrosion experts have shown just how effective this process is in terms of extending sprinkler pipe service life. The Industry's longest-running 3rd party exposure test was conducted in 2009 to compare the performance of black and galvanized steel sprinkler pipe in compressed air and nitrogen environments¹. The test environment was comprised of six schedule 10 black and galvanized steel sprinkler pipe assemblies, each half-full of water and individually subjected to either compressed air, 95% nitrogen, or 98% nitrogen supervision. At designated time intervals, one-foot sections were removed for evaluation. Based on the difference between the remaining wall thickness and nominal thickness for the diameter of pipe, the corrosion

¹ Van Der Schijff OJ, Bodemann SC. Corrosion of Piping in Dry and Preaction Fire Sprinkler Systems: Interim Results of Long Term Corrosion Testing Under Compressed Air and Nitrogen Supervision. Sprinkler Age, 2013 32 (10)

penetration rate and projected pipe service life were calculated. The results show the introduction of nitrogen at 98% purity to triple the expected service life of schedule 10 black steel; from 20 years to more than 60 (Figure 2.). Likewise, it shows nitrogen can take schedule 10 galvanized from 10 years of service life to over 170 (Figure 3.). These controlled tests mirror what contractors and fitters have experienced in the field for years; under compressed air supervision, pinhole leaks occur sooner in galvanized steel than in black steel pipe. However, the test also proves that 98% pure nitrogen not only mitigates that issue, but when used in conjunction with galvanized steel can extend the service life of the piping beyond the expected life of the building itself.



Figure 2. Schedule 10 black steel corrosion test results at 7.9 years.



Figure 3. Schedule 10 galvanized steel corrosion test results at 7.9 years.

The use of 98% nitrogen gas supervision in real world installations has demonstrated the same success achieved in clinical testing. Thousands of installations across North America are proving that the future is bright for nitrogen generators in the fire protection Industry. Property owners and facility managers are looking for viable and cost-effective measures to minimize the ongoing cost of sprinkler pipe replacement. This, in addition to 3rd party certifications such as FM Standard 1035, UL 508A ICP, and CE, are driving the Industry’s acceptance and wide-spread use.

The majority of nitrogen generators are being installed into pre-existing facilities, of which most have experienced corrosion related failures, so a large emphasis has been placed on designing a unit that is “plug and play”. Meaning, with little modification to the existing fire protection system, a nitrogen generator can be integrated and commissioned in brief time. To follow are some key considerations to note before specifying or procuring your first nitrogen generator.

Understanding Nitrogen Generation Systems

Dual-bed Pressure Swing Adsorption (PSA) Nitrogen Separation Technology

The efficiency and longevity of nitrogen generators designed for use in fire protection applications have improved drastically over the past decade with the introduction of dual-bed PSA technology. Unlike membrane systems of the past, dual-bed PSA nitrogen generators utilize an adsorption process, by which compressed feed air passes through pressure vessels called sieve beds, which are filled with Carbon Molecular Sieve (CMS). Under pressure, the CMS material adsorbs oxygen, water vapor and other impurities from the feed air, allowing the nitrogen to pass through and into the fire protection system. This process requires less feed air to generate the same amount of nitrogen as a membrane system and allows the feed air compressor to run at lower pressures and temperatures - ultimately maximizing the life of the feed air compressor and other integral components. It is 33% more efficient as it yields a 2:1 air to nitrogen ratio versus the 3:1 ratio of a membrane system. In terms of longevity, CMS material does not break down nearly as fast as the hollow fibers do within a membrane. As a result, a dual-bed PSA nitrogen generator requires less frequent maintenance and provides 98%+ purity for 20+ years, nearly double that of a properly designed membrane system.



Another consideration regarding longevity is how the manufacturer sizes their nitrogen generator. To ensure maximum system longevity, nitrogen generators should be sized to at least NFPA 25 leak rates (36 psi [2.5 bar] loss over 24 hours). Some manufacturers size their equipment to leak rates as low as 1.5 – 6 psi (0.1 – 0.4 bar) loss over 24 hours, meaning those systems could run in upwards of 18 hours daily on sprinkler systems conforming to NFPA 25 leak rates. And if leak rates exceeded NFPA 25 standards, those nitrogen generators would be outpaced over 24 hours. Simply put, a properly sized nitrogen generator will produce more nitrogen, run less frequently, and be less susceptible to runtime failure on a fire sprinkler system with an excessive leak rate.

Web-Enabled Software/User Interface

The digital age also requires the fire protection Industry to change with the times and provide contractors and end-users alike with web and mobile app capability. Software/user interfaces allow

control, testing and troubleshooting capabilities, as well as remote access to the nitrogen generator from any mobile device. One example of this kind of software is South-Tek Systems' own SMART-Trak™ technology. Valuable data such as the trending fire protection system leak rate, equipment runtime, time in air bypass mode, current equipment operational status and nitrogen purity levels can be tracked and stored on a removable SD card. As the supervisory gas source, a nitrogen generator can tell you a lot about the state of your fire protection system. For instance, the *Advanced Leak Monitoring System* logs the average daily and monthly system leak rates to ensure progressively increasing leak rate trends do not go unnoticed. Another convenient tool is the operational status screen, which displays real-time gas flow animations and symbols to indicate if a component is working properly. It provides a quick reference point for system diagnostics and links with the Patent Pending BlastOff™ III – *Early Warning System* to both alarm and pinpoint the location of a significant leak upstream, within, or downstream of the nitrogen generator.



Figure 4. SMART-Trak™ home menu with touchscreen navigation.

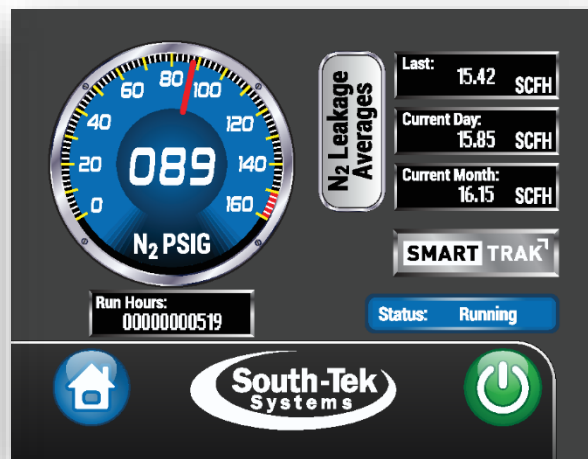


Figure 5. Dashboard displaying output pressure, runtime, and FPS leak rate

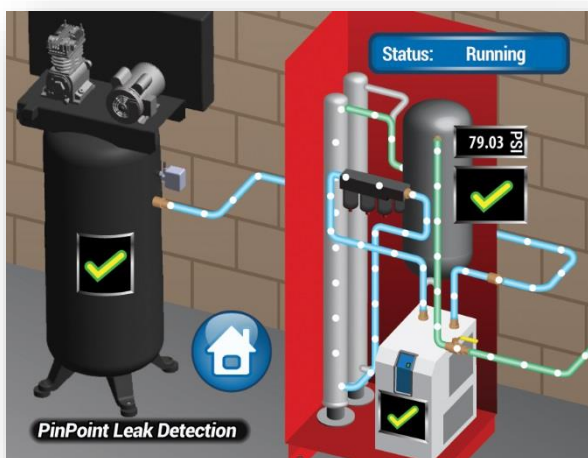


Figure 6. Normal operation showing feed air-in (blue), nitrogen-out (green).

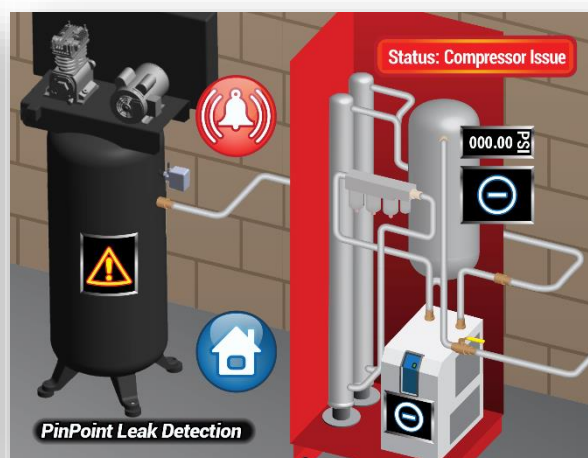


Figure 7. Alarm status pinpointing feed air (compressor) supply issue.

Sequence of Operations

While the design of the technology has improved, the way a nitrogen generator operates remains simple. Regardless of the size of nitrogen generator, the startup process remains the same. An air compressor brings the sprinkler system up to pressure within 30 minutes per NFPA code. After the fill process is complete, the nitrogen generator then takes over supervisory pressure. The nitrogen is stored in a low-pressure receiver tank, which acts as a buffer and prevents the generator from short cycling. The nitrogen flows from the receiver tank to an air maintenance device with a regulator, not a pressure switch. Every dry or pre-action system has at one point been at atmospheric pressure or initially filled with compressed air, making it imperative that the oxygen is depleted from the system to effectively inhibit corrosion. Therefore, an automatic purging device is installed at a remote section of the sprinkler piping network to displace the oxygen. This device contains an engineered calibrated orifice that creates a minute purge so that fresh nitrogen can constantly cycle throughout the fire protection system, which is the key to maintaining 98% or greater purity at all times. In general, this arrangement is very similar to that of a traditional air compressor, but you're displacing the corrosive oxygen within the piping by introducing high purity nitrogen in lieu of air.



Conclusion

While many new design/build specifications already call for nitrogen generators, about 55-65% of installations occur in pre-existing facilities. If a customer has experienced ongoing corrosion issues, selective pipe replacement with the addition of a nitrogen generator is the most cost-effective and proven means of arresting corrosion and maximizing the life of the sprinkler system. This is an excellent alternative to wholesale pipe replacement. In some cases, where the present air compressor is still operable, and the total capacity is less than 1,650 gallons (6,245 litres), a nitrogen generator can be simply installed between the existing air compressor and air maintenance device. The existing air

compressor can meet the 30-minute fill requirement of the largest zone, and the nitrogen generator can maintain supervisory pressure during normal operation. This is a plug-and-play solution for the Contractor to offer their customers in lieu of costly pipe replacements.

Having covered the ease of installation, we should mention the basic maintenance requirements of a nitrogen generator, which are little more than those of a standard air compressor. The maintenance items include changing the filters once per year or every 1,000 hours (whichever comes first), checking for 98% or greater nitrogen purity at the purge devices, and monitoring the equipment run-time, which should not exceed 3 hours per day.

With countless installations in high visibility projects around the world, there is no shortage of references when looking for proof of the success of Nitrogen generators in the Fire Protection Industry. From data center pre-action systems, to attic systems in assisted living facilities, or parking garage dry systems, Nitrogen generators can be found in every region and every market. The results are there both in science and application. As this technology moves closer to becoming the standard, the only question that remains is, are you going to be the one that brings it to your customer? Or will someone else offer it first?

