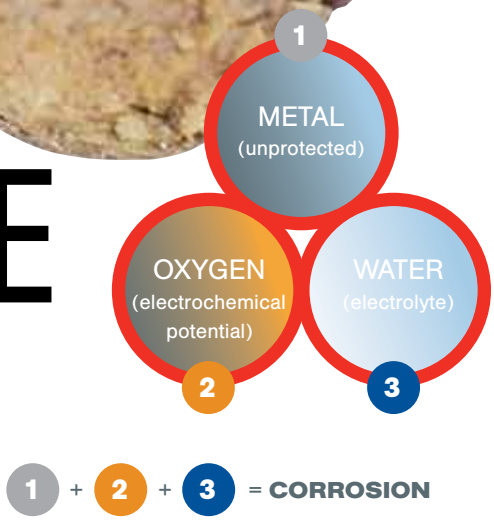
THE EXPANDING ROLE OF NITROGEN IN MITIGATING SPRINKLER PIPE CORROSION

Compressed air is out. Nitrogen is in.



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The use of high-purity nitrogen as a supervisory gas is not new to fire protection. The use of high-pressure cylinders can be traced as far back as the 1970s, while the industry has used nitrogen generators—machines that separate high-purity nitrogen from the atmosphere to create an inexhaustible source of the gas—for more than a decade. But in the past few 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 with the technology, the following provides 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 also a corrosion triangle. Electrochemical corrosion takes place whenever 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. Therefore, the most effective way to inhibit corrosion is to replace the compressed air (oxygen) with high-purity nitrogen.

Corrosion tests performed by 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 third-party exposure test[1], conducted in 2009, compared the performance of black and galvanised steel sprinkler pipe in compressed air and nitrogen environments. The test environment comprised six schedule 10 black and galvanised steel sprinkler pipe assemblies. Each pipe was 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 penetration rate and projected pipe service life were calculated. The results showed that the use of nitrogen at 98% purity tripled the expected service life of schedule 10 black steel—from 20 years to more than 60. Likewise, it showed that nitrogen can take schedule 10 galvanised steel from 10 years of service life to more than 170.

These controlled tests mirrored what contractors and fitters have experienced in the field for years; under compressed air supervision, pinhole leaks occur sooner in galvanised steel than in black steel pipe. However, the test also proved that 98% pure nitrogen not only mitigates that issue, but when used in conjunction with galvanised steel, can extend the service life of the piping beyond the expected life of the building itself.

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, cost-effective measures to minimise the ongoing cost of sprinkler pipe replacement. In addition to third-party certifications, such as FM Standard 1035, UL 508A ICP and CE, this is driving the industry's acceptance and widespread use of nitrogen.

The majority of nitrogen generators are being installed into pre-existing facilities. As most of these have experienced corrosion-related failures, a large emphasis has been placed on designing a unit that is 'plug and play'. Following are some key considerations to note before specifying or procuring a 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 dramatically over the past decade with the introduction of dual-bed PSA technology. Unlike membrane systems of the past, dual-bed PSA nitrogen generators use an adsorption process in which compressed feed air passes through pressure vessels called sieve beds, which are filled with carbon molecular sieves (CMS). Under pressure, the CMS material adsorbs oxygen, water vapour and other impurities from the feed air. This allows the nitrogen to pass through and into the fire protection system.

The PSA 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 maximising the life of the feed-air compressor and other integral components. It is 33% more efficient than a membrane system, as it yields a 2:1 air to nitrogen ratio (vs a 3:1 ratio for a membrane system). In terms of longevity, CMS material does not break down nearly as fast as the hollow fibres do within a membrane. As a result, the nitrogen generator requires less frequent maintenance and provides 98%+ purity for more than 20 years—nearly double that of a properly designed and maintained membrane system.

Another consideration regarding longevity is how the manufacturer sizes a 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 upwards of 18 hours daily on sprinkler systems conforming to NFPA 25 leak rates. 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 than a compressed air system and be less susceptible to runtime failure on a fire sprinkler system with an excessive leak rate.

Web-enabled software and user interface

The digital age also requires the fire protection industry to change with the times. Software and user interfaces allow control, testing and troubleshooting capabilities, as well as remote access. 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 a fire protection system. For instance, logs of average daily and monthly system leak rates ensure progressively increasing leak-rate trends do not go unnoticed. Another convenient tool is the operational status screen. This 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.

Sequence of operations

While the design of the technology has improved, the way a nitrogen generator operates remains simple. Regardless of the size of the generator, the start-up 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 a calibrated orifice that creates a minute purge, allowing fresh nitrogen to constantly cycle throughout the fire protection system. This 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 the corrosive oxygen is being displaced within the piping by introducing high-purity nitrogen in lieu of air.

Conclusion

While many new design and build specifications already call for nitrogen generators, in our experience, 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 maximising 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

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FIGURE 1. SCHEDULE 10 GALVANIZED STEEL (7.9 YEARS)

AS RECEIVED CLEANED

COMPRESSED AIR SUPERVISION

9.9 YEARS SERVICE LIFE

95% NITROGEN SUPERVISION

12.6 YEARS SERVICE LIFE

98% NITROGEN SUPERVISION

176 YEARS SERVICE LIFE

FIGURE 2. SCHEDULE 10 BLACK STEEL (7.9 YEARS)

AS RECEIVED CLEANED

COMPRESSED AIR SUPERVISION

20.7 YEARS SERVICE LIFE

95% NITROGEN SUPERVISION

25.2 YEARS SERVICE LIFE

98% NITROGEN SUPERVISION

63.2 YEARS SERVICE LIFE

the total capacity is less than 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.

Having covered the ease of installation, we should mention the basic maintenance requirements of a nitrogen generator. These 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
- monitoring the equipment runtime, which should not exceed three 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 centre 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. ■

1. Van Der Schijff OJ, Bodemann SC, 2013, '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, 32(10)