Nitrogen Generator Standard Nears Completion

After more than two years of study, a new Approval Standard provides FM Approved corrosion mitigation solution for dry/preaction sprinkler systems, an industry first.

Organizations that rely on dry and preaction sprinkler systems to protect unheated garages, hangers, freezer warehouses, and sensitive areas such as pharmaceutical processing, computer rooms and rare book depositories will soon have FM Approved solutions to help prevent corrosion and sprinkler pipe leakage. A new standard—Approval Standard 1035, *Nitrogen Generators*—is undergoing final internal review and the first FM Approved systems are expected in 2015.

Nitrogen generators provide a cost-effective and relatively low-maintenance means to deliver a continuous supply of compressed nitrogen for use as supervisory gas in dry and preaction sprinkler systems. When inert nitrogen (N_2) replaces the oxygen in sprinkler piping, it dramatically reduces the rate of corrosion in both internally galvanized and unprotected steel pipe.

Corrosion of automatic sprinkler systems piping is a long-standing and serious problem that can lead to costly damage from leaks and catastrophic losses when impaired sprinkler systems result in uncontrolled fires. For many years, FM Approvals and FM Global have provided standards, research, engineering guidance and data

sheets intended to help organizations avoid corrosion in sprinkler piping through proper installation, maintenance and mitigation strategies.

Despite these efforts, corrosion continues to be a major issue for automatic sprinkler systems. While corrosion may be expected in a wet system where metal piping is in continuous contact with water, the corrosion problem in supposedly water-free dry and preaction systems can be surprisingly aggressive. In fact, FM Global loss data during a recent 20-year period shows that dry and preaction sprinkler systems are involved in the majority (59 percent) of fire losses where the sprinkler system was found to be obstructed.

Residual water left behind from initial testing and condensation, combined with the supervisory compressed air typically used to keep the dry pipe valve closed, can result in heavy corrosion and leaks within just a few years in many cases.

Nitrogen has long been suggested as a supervisory gas for dry and preaction sprinkler systems. In fact, since 2001 the FM Global Property Loss Prevention Data Sheet 2-1, *Prevention and Control of Internal Corrosion in Automatic Sprinkler Systems*, has recommended the use of bottled or plant-supplied nitrogen for this purpose.

Despite the fact that nitrogen can inhibit corrosion and extend the life of sprinkler piping, adoption of nitrogen as a supervisory gas has been slow. It is believed that this is due, in part, to the cost and inconvenience of bottled nitrogen systems.

The introduction of compact cost-effective nitrogen generation systems in recent years has led to new interest in using nitrogen for corrosion mitigation in dry and preaction sprinkler systems. The new systems use various forms of separation technology to extract 98 percent pure nitrogen gas from surrounding air for use as compressed supervisory gas.

Until now, there have been no standards for the evaluation of the performance of nitrogen generation systems. The new Approval Standard for nitrogen generators is an industry first and will eventually provide FM Approved systems on a global basis, as well as a means for manufacturers to certify the performance of their products.

Team effort leads to new standard

The new nitrogen generator standard is the culmination of more than two years of study by FM Global research, FM Global engineering standards and FM Approvals. "When we started seeing these systems in the field and getting inquiries from FM Global clients, we really didn't know a lot about nitrogen generators," says David Fuller, manager, protection and special hazards, for FM Global engineering standards. "We found that some manufacturers of these systems had done their own research showing that their systems would work; however, we needed to see for ourselves."

FM Global research already had an ongoing strategic program of corrosion research and welcomed the challenge of evaluating the effectiveness of nitrogen generators for corrosion mitigation (see sidebar). "Our clients have been experiencing leakage issues for a very long time and don't know how to solve it," notes Paul Su, a senior scientist and corrosion specialist for FM Global research. Su is a member of the National Association of Corrosion Engineers (NACE International) and chairs two of the organization's technical committees.

"Even though our data sheets and field engineers recommend proper sloping and drainage as well as the use of galvanized pipe, dry and preaction systems can still experience inadequate pitching or other drainage issues," Su says. "Trapped water and dissolved oxygen and carbon dioxide can lead to very high corrosion rates, even in galvanized pipe. We've seen leaks begin in sprinkler piping in as little as two to three years."

Su and his research team evaluated the effectiveness of compressed nitrogen for corrosion mitigation in dry and preaction sprinkler systems at the FM Global Center for Property Risk Solutions research facility in Norwood, Massachusetts, USA. A test apparatus was built to test full-scale sprinkler

Photograph showing tubercles and pinhole (circled) leakage of galvanized steel sprinkler pipe in dry pipe systems. On left: tubercles heavily formed inside a galvanized steel pipe (4-inch [10-cm] diameter). On right: through-wall (circled) leakage underneath a tubercle (removed) on a galvanized steel pipe. *From* Research Technical Report, *Corrosion and Corrosion Mitigation in Fire Protection Systems*, page 28.

Landmark corrosion study leads to new standard

New research conducted by FM Global Research and FM Global Engineering Standards to verify the effectiveness of nitrogen generators for use in corrosion mitigation is included in a major update and rerelease in July of the FM Global research technical report, *Corrosion and Corrosion Mitigation in Fire Protection Systems*.

The report, coauthored by FM Global Research senior scientist Paul Su and David Fuller, manager, protection and special hazards, for FM Global engineering standards, is available for free to the public at www.fmglobal.com. The 98-page report comprehensively explains corrosion in fire protection systems (FPS), covering such factors as:

- pipe weld corrosion
- residual water in dry/preaction sprinkler systems
- trapped air in wet pipe systems
- microbiologically influenced corrosion (MIC)
- corrosive water chemistry.

Covered in the report is the status of current global standards, forms of corrosion, an examination of field leakage examples, corrosion mitigation strategies and recommendations for further study. Under mitigation strategies, the results of research into the effectiveness of nitrogen generators in providing nitrogen as a supervisory gas for dry/preaction sprinkler systems is covered. The report notes that replacing the oxygen in these systems with nitrogen significantly reduces the impact of oxygen-related electrochemical corrosion.

The decision to move ahead with the development of Approval Standard 1035, *Nitrogen Generators*, was based on the success of the FM Global research program. It was determined that nitrogen generators provided an effective new way to provide a continuous supply of nitrogen for use as supervisory gas. The first FM Approved nitrogen generators are expected to be available in 2015.

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pipe samples, including both galvanized and unprotected steel. Sample pipes were filled with a small amount of water to simulate typical residual water left over from commissioning, flow testing or condensation. The sample pipes were also filled with either compressed room air or nitrogen produced by a nitrogen generator.

In addition, test coupons of unprotected carbon steel and galvanized steel were submerged in tap water and exposed to room air or nitrogen. Coupons were evaluated using weight loss analysis at periodic intervals and the corrosion rate (CR) calculated. Based on this testing, Su and his team found that the use of a nitrogen generator to provide nitrogen as a supervisory gas for dry/preaction sprinkler systems was extremely effective in reducing corrosion rates.

For instance, the corrosion rate for unprotected carbon steel coupons (representing the most common type of sprinkler piping) was up to 50 times greater in room air than in nitrogen. Not surprisingly, galvanized steel coupons performed much better in the testing. Even so, the corrosion rate of galvanized steel in room air versus nitrogen was up to two times greater.

Based on these and other research results, FM Global requested that FM Approvals move ahead with the development of a new Approval Standard to cover nitrogen generators. "Our clients were already moving ahead with nitrogen generators and installing them in their facilities," notes Fuller. "Once we saw just how effective these systems were, we requested the new standard from FM Approvals. They had a head start based on earlier meetings, so they were able to hit the ground running."

FM Approvals senior engineer Bruce Wood, who developed an Approval Standard late last year for air drying units used to prevent condensation-based icing in dry/preaction sprinkler systems, was assigned the nitrogen generator standard as well.

"I went out and met with two manufacturers of nitrogen generators in order to educate myself and to help us determine what performance factors to include in our standard," Wood explains. "Similar to our standard for air drying units, we decided to evaluate nitrogen generators based on their capability to produce a specified volume of nitrogen over a given period and list them based on volume capacity in the Approval Guide."

Approval Standard 1035, *Nitrogen Generators*, includes performance tests to determine the amount of compressed air the system can produce in 30 minutes—a requirement under NFPA 13 in order to restore supervisory air pressure—and verification of the system's ability to produce sufficient 98 percent purity nitrogen to fill the same sprinkler system within 24 hours. These capacity figures will be listed in the *Approval Guide* to provide end users with a means to select the correct size unit to match their sprinkler system volume requirements.

Other performance requirements contained in the new standard include:

- **Maintenance assessment**—Manufacturer's guidelines will be used to perform all standard maintenance on

the unit, including replacement of membranes or adsorbent materials and filters.

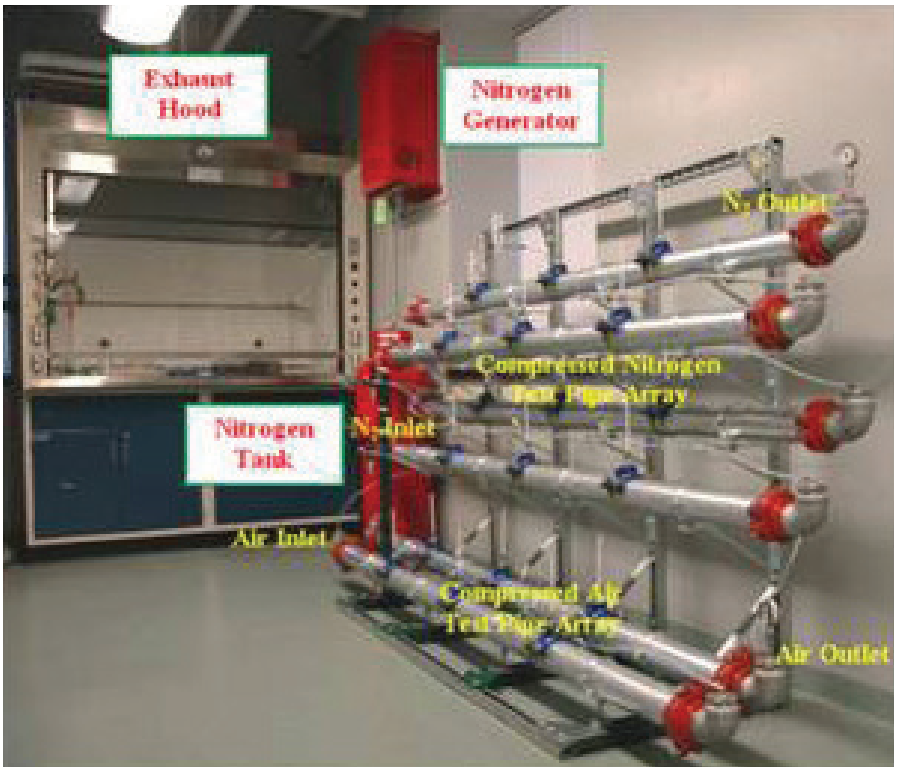
- **Pressure integrity**—Components of the nitrogen generator must be able to withstand pressure equal to or greater than two times the rated working pressure for a period of five minutes without leakage or rupture.
- **System durability**—The system must be able to produce 25 times system capacity without dropping below 98 percent nitrogen purity and without maintenance.
- **Control panel cycling (dual tower systems only)**—A sample device will be subjected to 25,000 cycles of operation without mechanical failure or change in operating characteristics.
- **Dielectric strength**—Electrical components shall withstand twice their rated voltage plus 1,000 volts between all terminals provided for external connection and ground for a duration of one minute.

"I took part in early briefings provided by FM Global to learn as much as possible about the system performance characteristics and what we were hearing from customers," Wood notes. "I think this new standard will provide a strong foundation for the industry. We're collecting industry feedback on it right now, but we're not anticipating any pushback due to the fact that we based our performance tests, in large part, on what we learned from manufacturers."

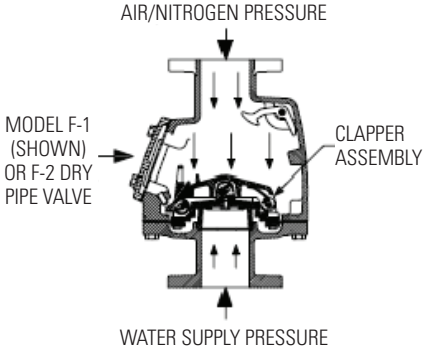
While the development of an Approval Standard for a new product category is not a unique event, the extent to which the development of the standard for nitrogen generators involved all facets of FM Approvals and FM Global made the process particularly satisfying for all involved.

"FM Global clients and any industry that makes a huge investment in fire protection systems does so to avoid business interruption and property loss," notes Rick Dunne, manager of FM Approvals fire protection group. "Protecting that system is of paramount importance. This standard and the FM Approved systems that will result from it represent a major new tool in the fight against corrosion."

He adds, "We invest significant effort on updating and revising our Approval Standards every year. Not only was this a new standard, but it was strongly supported by the field who needed it, research to verify performance and our FM Approvals standards development process. It was really a team effort and we're extremely proud of the results." ■



Compressed nitrogen test apparatus in FM Global research laboratory. Part of the two-year study of nitrogen's effectiveness in corrosion mitigation in dry and preaction sprinkler systems.



Dry pipe sprinkler valve showing supervisory air or nitrogen holding valve closed against water supply. System is triggered when the fusible link on a sprinkler head releases supervisory gas pressure thereby allowing water to flow into the sprinkler piping. *Courtesy Viking Corp.*