Understanding Nitrogen Generation Technology

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Since the 1950s, Nitrogen generation technology has been adopted by a wide range of industries. The technology mechanically separates Nitrogen from the air we breathe, which is comprised of 20.9% Oxygen, 1.1% Argon/Helium/other and 78% Nitrogen. Since Nitrogen is a safe non-flammable (inert) and non-corrosive gas its utilized in applications at facilities such as food packaging plants, restaurants, oil and gas platforms, laboratories and various industrial factories. Similarly, Nitrogen technology is now increasingly used in fire protection for inhibiting corrosion and freezing within dry and preaction sprinkler systems. Specific to the application of Nitrogen in fire protection is the design of the Nitrogen generator and overall configuration of the system which ensures that 98% pure Nitrogen is equally distributed and constantly maintained throughout a sprinkler system.

Configuring the Nitrogen Generation System for Fire Protection

If designed and maintained properly, a Nitrogen generation system will maximize the service life of black or galvanized steel pipe. To follow is a discussion of the key components, which include an air compressor, air dryer package, Nitrogen generator, Nitrogen receiver tank, gas purging device and Nitrogen purity sensor.

Air Compressor and Air Dryer Package

The air compressor package serves two main purposes. The first is the ability to restore normal air pressure within the fire protection system in thirty minutes per NFPA 13. Second, it must provide ultra clean and dry air to the Nitrogen generator. To ensure proper air filtration, the air compressor should include an after-cooler to reduce moisture and lower the temperature of the air, as well as a particulate and coalescing filtration package to separate residual particulate, moisture and oil. In addition, an air receiver tank is recommended to prevent the air compressor from short cycling. The tank should include a timer drain to collect and release any residual oil and water build-up, and should be routed to a floor drain. In general, oil-bathed air compressors are preferred over oil-less because they have greater longevity, longer warranties and lower maintenance costs.

Following the air compressor, an air dryer package should be installed to squeeze out any remaining moisture, which lowers the dew point of the air prior to it feeding the Nitrogen generator. The air dryer not only maximizes the longevity of the Nitrogen generator, but assists in lowering the dew point of the Nitrogen entering the fire protection system. The two most common technologies are the regenerative and refrigerated air dryers. Regenerative dryers yield a lower dew point than refrigerated dryers because they contain desiccant material, which absorbs a greater amount of moisture. However,

regenerative dryers require more extensive maintenance, since the desiccant material and solenoids need to be frequently replaced. Also, if not properly maintained, these dryers can cause the air compressor to work harder, placing more strain on the pump and motor. For those reasons, many prefer to utilize a refrigerated air dryer. Refrigerated dryers are virtually maintenance free and, depending on the installation environment, they usually last between five and fifteen years. Also, unlike regenerative dryers, refrigerated dryers do not restrict air flow and therefore do not place any additional demand on the air compressor.

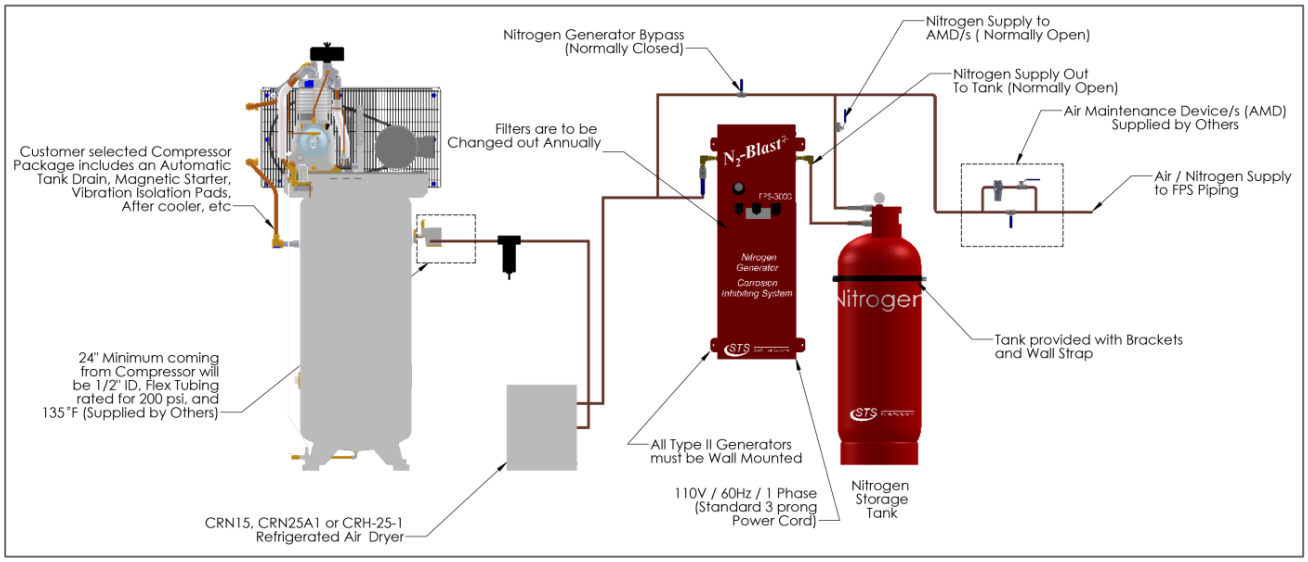
Nitrogen Generation System

As with the air compressor and air dryer package, it is also imperative that the proper engineering has been invested into the design of the Nitrogen generator. The separation of Nitrogen from the air is an intricate process since Nitrogen molecules are very minute, having a diameter of approximately 3.6 angstroms or *0.00000001417* of an inch. Thus, an experienced manufacturer places a great amount of emphasis on such design considerations as air flow patterns, air temperature, filtration, operating and delivery pressures and purity versus volume in order to ensure the Nitrogen generator is capable of reaching its full potential lifecycle. Features such as an air bypass alarm, leak detection system, Nitrogen receiver tank and auto purge system are key indicators of a Nitrogen generator carefully designed to avoid unnecessary runtime and maximize the life of components such as solenoid valves and pressure switches. Moreover, those features dually benefit the fire protection system by ensuring 98% Nitrogen purity throughout the sprinkler piping. Before choosing a manufacturer, be sure that they can provide references attesting to significant longevity from their Nitrogen generators.

Membrane and Pressure Swing Adsorption Technologies

Although Nitrogen generators are fairly complex in design, they require very little maintenance due to the nature of the mechanical separation processes. The two main technologies available are Membrane and Pressure Swing Adsorption (PSA), which both offer a mechanical means of separating the Nitrogen from the air, at a relatively low pressure. Membrane utilizes a filtration process, while PSA employs an absorption method to abstract the Oxygen molecules, allowing the Nitrogen to be captured and sent into the fire protection system. If designed properly and serviced according to the manufacturer's recommendations, Membrane and PSA technologies can yield the recommended 98% Nitrogen purity for upwards of fifteen (Membrane) and twenty-five years (PSA), respectively.

Depending upon the Nitrogen generation technology that is utilized, the air in (i.e. the feed air coming from the air compressor) to Nitrogen out ratios are 3:1 (Membrane) and 2.25:1 (PSA). For this reason, it is standard to size the air compressor package so that it is capable of restoring normal air pressure



Typical Nitrogen Generation System Layout Drawing

within the fire protection system in thirty minutes per NFPA 13. Once the sprinkler system is brought up to supervisory pressure, an "air bypass valve" is closed and another valve is opened to allow for Nitrogen to begin supervising the fire protection system. This sequence of operation permits the use of the most cost-effective Nitrogen generator with a minimal footprint. Regarding the installation of the Nitrogen generator, equipment utilizing Membrane technology should be wall-mounted, whereas those utilizing PSA technology should be enclosed within a cabinet that is four inches or greater above floor level. This ensures that any water drainage within the riser room does not create a potential issue with the electrical within the Nitrogen generator. Furthermore, it is important to always consult the manufacturer of the equipment in order to determine which model Nitrogen generator to utilize (based on the total gallons of sprinkler pipe capacity).

Air Bypass Alarm

It is important to include an air bypass alarm when designing a system. This will notify the building operator if air is entering the fire protection system instead of Nitrogen. This could be the result of a maintenance technician that had switched over to supervisory air while servicing the Nitrogen generator, but forgot to switch the system back to Nitrogen. An air bypass alarm will notify the building monitoring panel so that the correction can be made prior to the sprinkler pipe experiencing corrosion.

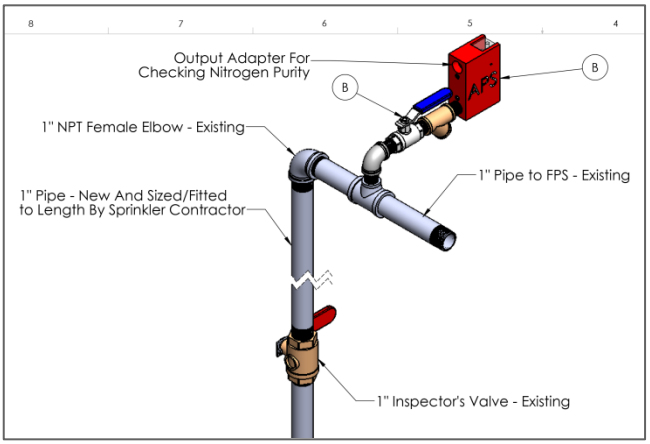
Leak Detection System

Another key feature is the leak detection system, which will monitor the runtime of the Nitrogen generator. Often times, leaks within the sprinkler piping go unnoticed and the supervisory air compressor or Nitrogen generator run constantly to keep up with the excessive demand. Consequently, more operating hours are placed on the equipment, jeopardizing its longevity. An effective leak detection system proactively monitors *runtime* and will alarm prior to the added stress being placed on the equipment. This type of system is not to be mistaken for one that only monitors pressure via a low air alarm or pressure switch, which will only react after there has been a catastrophic failure with the supervisory equipment.

Nitrogen Receiver Tank

Every Nitrogen generation system should be designed with a Nitrogen receiver tank, which is sized in proportion to the Nitrogen generator (typically ranging from 28 – 80 gallons). The tank is installed between the Nitrogen generator and Air Maintenance Device/s, creating a "buffer" (similar to an air receiver tank), which eliminates the short cycling of the Nitrogen generator. A Nitrogen receiver tank is required because there is usually not enough capacity within the piping between the Nitrogen generator and Air Maintenance Device/s to create a sufficient buffer. With the addition of the Nitrogen receiver tank, the solenoids, pressure switches and other vital system components enjoy much greater longevity. Additionally, the Nitrogen receiver tank allows supervisory pressure to be maintained for a short period of time while basic annual maintenance is being completed on the Nitrogen generator. This prevents the facility from having to go into a fire watch procedure during this time.

Auto Purge System



Typical AutoPurge System Layout Drawing

Since compressed air is utilized for the initial supervisory fill, most all manufacturers provide an air vent or auto purge system. This device displaces air from within the sprinkler piping, allowing Nitrogen to fill the system in short time (typically 2 – 4 weeks). As Fick's law of diffusion demonstrates, Nitrogen will disperse very rapidly throughout the sprinkler piping. Upon introduction to the fire protection system (near the valve), Nitrogen will immediately begin to evenly distribute and the Nitrogen purity concentration will rise throughout the system. The auto purge system contains an engineered calibrated orifice similar to the one located within an air maintenance device. In essence, an auto purge system creates a minute leak so that fresh Nitrogen can constantly cycle throughout the fire protection system. Fick's Law is verified by Computational Fluid Dynamics (CFD) modeling, which shows that only a single auto purge system is required per dry or preaction system. While the auto purge systems can be located anywhere along the sprinkler piping, most prefer to mount them as far from the valve as possible to confirm (for peace of mind) that Nitrogen is fully blanketed throughout the fire protection system. Also, because the auto purge system's leak rate is merely a few liters per minute, the Nitrogen generator and air compressor only experience a couple additional minutes of runtime per day. A properly designed auto purge system is a *tunable* device that calibrates the purge rate based on the capacity of the individual fire protection system. This ensures that the added runtime of the Nitrogen generator is minimal.

Purity Monitoring

There are a few different types of technology available to confirm 98% or greater Nitrogen purity concentration has been achieved. The least expensive option is a hand held Nitrogen purity sensor, which will manually connect to an auto purge system and obtain a purity reading within seconds. For hands-free, digital monitoring and logging of historical data, a manifold with a programmable logic controller (PLC) is a better option. These devices will automatically monitor the Nitrogen purity concentration within each zone of the fire protection system every 24 hours. If the Nitrogen purity concentration has been achieved within a given zone, the manifold will close the auto purge system. These devices are provided with a dry contact and analog outputs to tie into the Building Monitoring Panel. Additionally, the manifold has Ethernet capabilities which make remote access via a laptop or even a cell phone possible.

Value Engineering

Recent studies show that utilizing 98% supervisory Nitrogen can significantly extend the pipe service lives of black and galvanized steel.[1] And as more and more facilities uncover corrosion in their dry and preaction systems, the demand for Nitrogen generators will continue to grow. It has never been as important as it is now to understand the key components and features that make up a *dependable Nitrogen generator designed specifically for fire protection*. If designed properly, a Nitrogen generator will ensure 98% Nitrogen purity throughout the fire protection system and provide years of trouble-free operation. For this reason, it is equally important to work with a manufacturer that has proven technology and will be available long into the future to support their product.

[1] Van Der Schijff, O.J. & Bodemann, S.C. NACE Paper 2846 "Corrosion of Piping in Dry and Preaction Fire Sprinkler Systems: Interim Results of Long Term Corrosion Testing Under Compressed Air and Nitrogen Supervision", NACE Corrosion 2013 International Conference – Paper, No. 2846 – 2013.

Checklist for Nitrogen Generation System

Air Compressor and Air Dryer Package*

- ☐ Capable of filling the largest sprinkler system to pressure within 30 minutes per NFPA 13
- ☐ Oil-bathed air compressor
- ☐ Operating pressure between 125 –175 PSI
- ☐ Particulate and coalescing filtration package
- ☐ Provided with an air-cooled aftercooler
- ☐ Air receiver tank with automatic tank drain

Nitrogen Generator*

- ☐ Outputs a minimum of 98% Nitrogen
- ☐ Included with a nitrogen receiver tank
- ☐ Wall mounted or located 4"+ off floor
- ☐ Fully enclosed cabinet for splash protection
- ☐ Particulate, coalescing and adsorption filter
- ☐ UL Listed Control Panel

Building Alarm Panel Connections

- ☐ Integrated Air Bypass Alarm which will notify the building monitoring panel when the Nitrogen generator is inadvertently being bypassed by compressed air
- ☐ Integrated Leak Detection System to monitor Nitrogen generator runtime and act as an onboard System diagnostic

Auto Purge System

- ☐ Provided with ball valve to isolate the device from the Fire Protection System (FPS)
- ☐ Includes ball-stop to ensure water does not evacuate from orifice
- ☐ Includes mesh filter to prevent debris from clogging orifice
- ☐ Tunable device based on FPS capacity
- ☐ Provides outlet adapter (a connection) for monitoring Nitrogen purity

Nitrogen Purity Monitoring

- ☐ At minimum, provide a portable handheld Nitrogen purity analyzer for manual FPS Monitoring (attaches to auto purge system)
- ☐ If integration to the building monitoring panel is requested, provide a manifold with PLC/digital interface

*Consult manufacturer for component sizing