On-Site Nitrogen Generation: Cheaper, Easier, More Reliable

The advantages of bringing nitrogen generation in-house

Are you currently renting nitrogen tanks that may or may not arrive when you need them? Who keeps track of inventory in your lab, and what would you do if you ran short of supply? Could a delivery delay cause you to defer a critical process or – worse – jeopardize the integrity of samples stored in a nitrogen environment?

By removing your reliance on a third-party distributor, you take control of the quantity (and quality) of nitrogen produced, and eliminate worries about vendor price increases. Maybe in the past, you've overbought cylinders due to a predicted interruption in the supply chain: where do you store the additional tanks? In-house generation lets you make nitrogen as needed.

Because this technology requires no moving parts and consumes relatively little energy, it is surprisingly economical to operate and maintain—the main recurring expense is the energy required to provide a stream of compressed feed air. The only attention a system typically needs is a watchful eye on the inlet gas flow and an occasional filter change.

What expenses should I expect for on-site nitrogen generation?

Nitrogen (N_2) is relatively easy to isolate, and the supply is plentiful. Since it comprises 78% of ambient air, we're unlikely to run out any time soon.

After the initial capital equipment expense for your system, you pay only minimal electricity expenses to provide the compressed air feed: your gas costs remain completely predictable. Installation simply requires piping compressed air to the system and piping the nitrogen to its destination.

Each nitrogen generator consists of a membrane module, controls, and coalescing filters and traps to remove oil, liquids, organic contaminants, and other sub-micron particulates from the feed air. Pre-filters eventually become saturated and need replacing, but as long as you perform this minimal maintenance, the system's primary component is protected: the nitrogen membrane.

What is nitrogen?

Nitrogen gas is utilized to provide an oxygen- and moisture-free environment. Oxygen can damage materials and parts through a process called oxidation, as in rusting metal or an apple that turns brown. Water also damages electronic parts and supports the growth of micro-organisms.

Nitrogen is used in enclosed environments such as desiccator cabinets and sealed pouches to replace the moisture-laden air and protect the materials within. As a relatively inert gas, nitrogen does not react chemically with most materials and is colorless and odorless. This makes it ideal to use for purging, drying, cooling, and to create protective barriers between sensitive parts and the damaging environment. Air contains approximately 78% N_2, 21% O_2, 1% Argon, plus traces of carbon dioxide, carbon monoxide and rare gases.

What are some uses for nitrogen?

In pharmaceutical or life science laboratories, nitrogen works within desiccators and glove boxes to protect moisture-sensitive parts and samples. It is also used with chromatography and mass spectrometry instruments for sample analysis. Other industries that rely on the drying properties of nitrogen are semi-conductor and electronics.

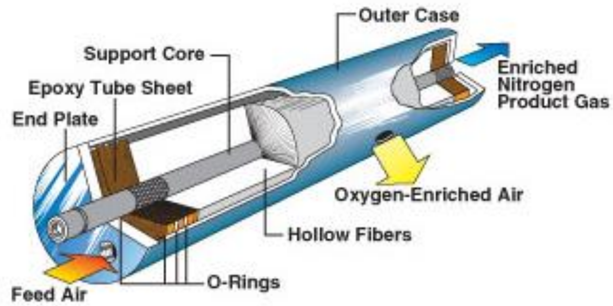
Food packaging lines are a good example of where high volumes of nitrogen are used to protect consumables from spoiling by contact with oxygen. The N_2 purges and head-space fillers in packaging create a protective barrier. The same idea can be applied to flammable raw materials: contact with oxygen would be harmful, so nitrogen is used instead.

Nitrogen is incorporated into heat-treating, welding and laser-cutting processes in the steel and aerospace industries. For chemicals production, pressurized gas can propel liquids through pipelines and help remove volatile organic chemicals (VOCs) from manufacturing environments.

How does a nitrogen generator work?

To isolate nitrogen from the air, you need two things: compressed air and a generator, containing the nitrogen filter module. The feed air typically comes from an air compressor. This pressurized air is fed into the generator and journeys through the filtration module. Purified nitrogen is routed to a storage tank, while the residual components such as oxygen and carbon dioxide are channeled out. Trace amounts of oil, water vapor, and particulates are removed by pre-filters.

How is nitrogen separated from oxygen, water and other components?



Compressed (pressurized) air is forced through a bundle of hollow, semi-permeable membrane fibers. Each membrane fiber is only about the diameter of a human hair, so a large number of them will create significant surface area capable of filtering a high volume of air.

The separation of gases and compounds occurs because nitrogen is a "slower" gas than oxygen (and carbon dioxide and water), therefore will not diffuse through the membrane in the time of exposure; oxygen's greater solubility makes it more likely to permeate the membrane. This separation involves no chemicals; it is based on physical characteristics of the compounds to be separated.

If I need to generate higher-purity nitrogen, how does that work?

To increase the purity of the nitrogen, maintain pressure, but decrease the velocity of compressed air being fed into the filter. This allows more time for oxygen, and other air constituents, to permeate the filter and be discarded. This table gives some examples of purity vs. flow rate (outlet flow rate as standard cubic feet per hour (SCFH)).

Flow Volume Decrease	
Outlet / Inlet flow, By Percentage	
At N^2 Purity	Oulet Flow
95%	53% of inlet flow
96%	49% of inlet flow
97%	45% of inlet flow
98%	40% of inlet flow
99%	34% of inlet flow
99.5%	28% of inlet flow

For nitrogen-purged storage and process systems with automatic humidity controls (like Terra desiccators, glove boxes and automate stockers), the highest purity level may not even be necessary. Terra systems automatically control the nitrogen purge to maintain the most critical humidity levels commonly required, which can generally be achieved with purity levels below 99% (typical of distributor-supplied nitrogen cylinders).

Nitrogen purity can be regulated (up to a maximum of 99%) by adjusting the input air pressure and temperature. In most cases, the greatest system efficiency is achieved at purities of 95-99%, levels adequate for most cleanroom applications.

Air-feed temperature, as mentioned above, also affects the performance of the nitrogen generator. The higher the temperature, the higher the air flow rate required, assuming constant air pressure and nitrogen purity. As air temperature rises, the membrane permeability increases, requiring an increased air-feed flow rate to maintain flow levels. However, higher temperatures eventually affect the membrane material by shortening its life. An air conditioner can be used to control the air temperature.

Things to consider when buying a nitrogen generator

Labs should evaluate their current and future needs to decide on the best equipment. Is your lab operating a single desiccator chamber, or do you have multiple desiccators, plus gloveboxes and vacuum sealers that feature nitrogen-purge functionality? The main distinguishing factor is size, with larger units having higher SCFH for greater capacity.

Efficient systems will also be equipped with a low-pressure alarm that alerts users of decreased inlet pressure resulting from gas line kinks or a compressor malfunction. To avoid interruptions in work flow, also look at generators that feature filter saturation indicators so you can proactively plan for replacements. See Terra's Nitrogen Generators for more information.