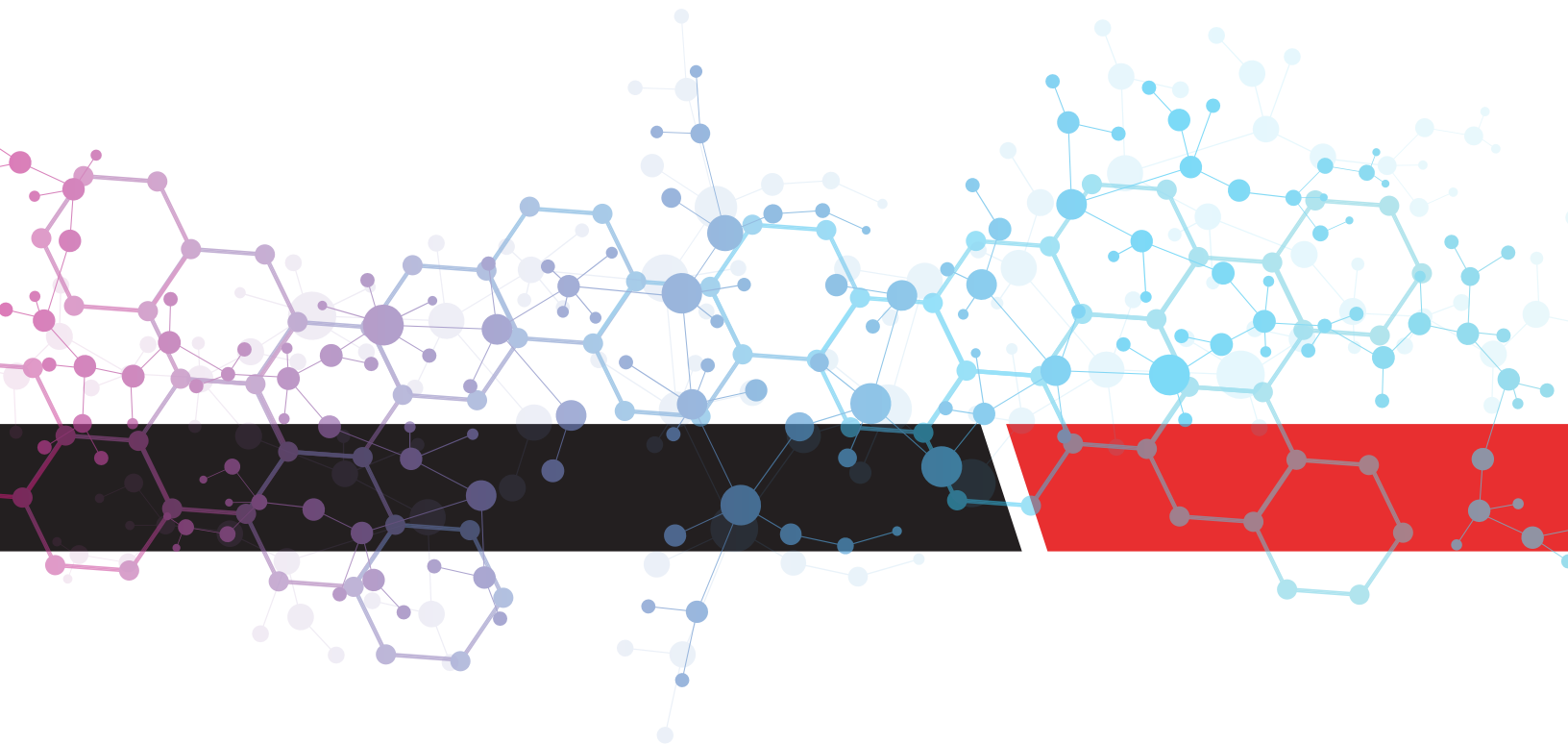


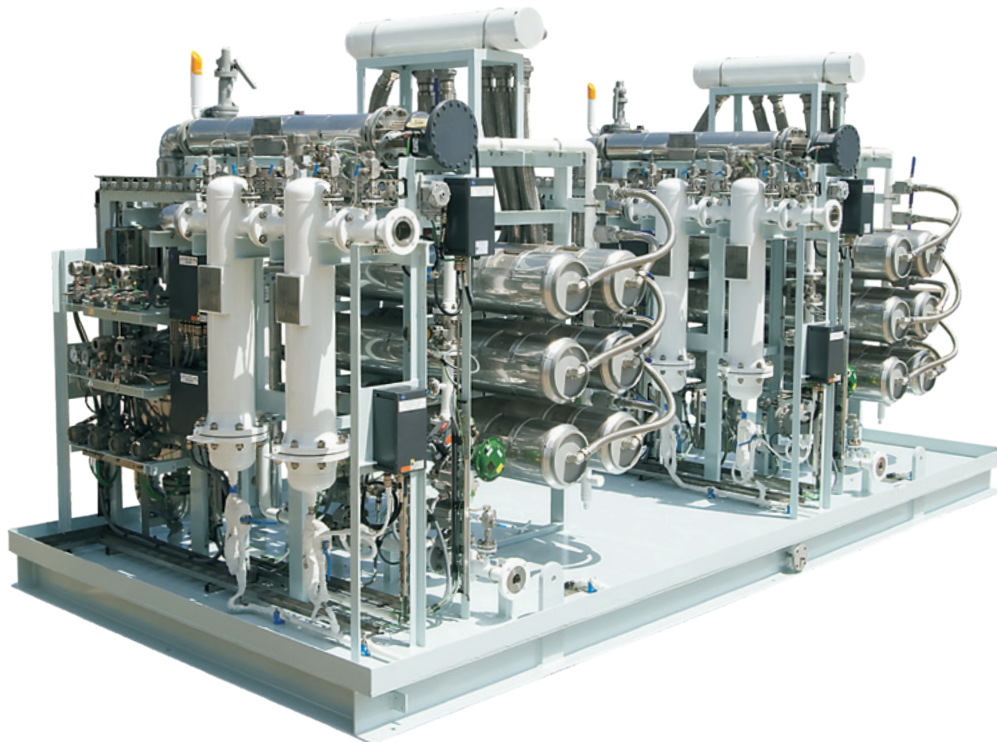
THE GUIDE TO

**MEMBRANE
NITROGEN
GENERATORS**



MEMBRANE NITROGEN GENERATORS

The membrane nitrogen generator utilizes a hollow porous fiber to separate the N² molecules from other molecules, including O². Put simply, they take the nitrogen out of the air you breathe. The air is made up of 79 percent nitrogen, and a membrane nitrogen generator utilizes green technology to filter out all the other gases and then concentrates the left-over nitrogen in a storage tank to be used.



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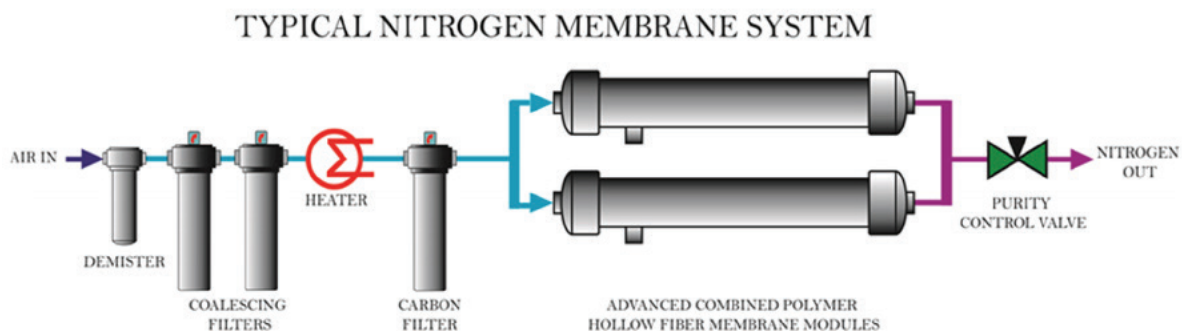
HOW MEMBRANE NITROGEN GENERATORS WORK

The membrane generators available today use porous hollow fibers that vary in length, diameter, efficiency and material. Pressure is then used to separate the molecules from the stream of compressed air that is flowing in. This pressure process is officially called selective permeation.

The fibers making up the membrane run parallel to each other to provide the required capacity. The fibers are semi-permeable, which allows the faster gases to move through the walls quicker and be released back into the atmosphere. Generally, these gases are made up of hydrogen, water vapor, oxygen and carbon dioxide.

The benefits offered by using membrane technology over other types of nitrogen generators include:

- Uses a lower operating and delivery pressure
- Simple airflow designs and high levels of reliability
- High N² purities or higher N² volumes at lower levels of purity
- It's the most affordable method for producing N²
- It's a safe, mechanical process – not a chemical process



USES FOR MEMBRANE NITROGEN GENERATORS

Today's systems are ideal for use in a number of industries, including refinery facilities, chemical manufacturing, transportation and marine industries and the oil and gas industry. The actual machines put to use can be chosen from pre-designed standard systems or custom designed to meet the specific engineering requirements of a company or organization.

Some of the applications of a membrane nitrogen generator include the recovery of hydrogen, air dehydration and the biogas upgrading and generation of oxygen enriched air. Systems offered by GENERON are able to produce consistent purities that range between 95 percent and 99.5 percent product nitrogen. Additionally, the GENERON units are about a third of the size of the competitions and use 45 percent less energy while taking up 30 percent of other system footprints, making them the preferred option for many companies.



GENERAL BENEFITS OF MEMBRANE NITROGEN GENERATORS

For quite a few analytical and industrial applications, the use of an in-house generator for the supply of nitrogen (N) offers quite a few benefits over having to wait for the gas to be delivered by a supplier, which is something many companies still rely on. While there are certain industry-specific benefits that will be discussed in more detail shortly, some of the general benefits that are true for any company or organization using the generators can be found here.

- **Uninterrupted supply of Nitrogen:** A standard system will produce N² with a purity level that is over 99.5 percent purity and that offers a flow rate of hundreds of cubic feet each minute with an outlet pressure of approximately 100 psig.
- **More affordable option:** An in-house generator will also consume much less energy to produce a kilogram of nitrogen compared to using bottled and delivered nitrogen. Additionally, you will see lower administrative costs and avoid shipping and delivery costs altogether.
- **Reduced waste:** Because the in-house system is able to generate nitrogen at a pressure and flow rate that is necessary for the application and on demand, you don't have to worry about gas being wasted.
- **Improved safety of the plant or company:** You can eliminate the danger associated with handling and moving cylinders under extreme pressure.
- **Greater supply security:** You no longer have to be dependent on outside vendors to supply the nitrogen you need for day-to-day operations. This eliminates downtime due to delivery delays, uncontrollable price hikes and long-term contracts.

Even though each situation and application will vary slightly, the majority of users can expect to receive payback for their investment in just over a year; the switch from purchasing bottled nitrogen to an in-house membrane nitrogen generator is a huge cost saver. Of course, this is under the assumption that the facility is using a flow that is equivalent or greater than 20L/min of the N² for a minimum of four hours every day. During the course of a year (250 days), a total of 1,200,000 liters of N² are going to be consumed, which is equivalent to 186 of the standard nine by 56 inch cylinders most companies use.

While there are a number of direct benefits offered by using these generators in-house, there is also an environmental benefit that has to be considered. The process of gas distillation is one that is considered very high energy. When you opt to use a hollow fiber membrane for nitrogen generation, you will be using much less energy, and as a result, the system will produce much less greenhouse gases than the fractional distillation process does. Additionally, the distillation process will also use quite a bit of energy, as well as the transporting of the cylinders from where the N² is being produced to where it is going to be used, and then transporting the cylinders back to the plant once they are empty.

THE LOWER ENERGY PROCESS OF MEMBRANE NITROGEN GENERATORS

You may wonder how this type of in-house generator is able to achieve the benefits. Instead of distilling the N² out of the air, which is a process that requires quite a bit of cooling, the hollow fiber membrane will separate the water vapor and oxygen from the nitrogen while it is still at room temperature.

The first step of this process is the compressed air flowing through a high-efficiency coalescing filter, which will remove the particulate matter and water vapor. Then it will be sent through an activated carbon scrubber in order to remove the hydrocarbons. Once through the carbon scrubber, the air is sent through the hollow fiber membranes that allow the remaining water vapor and oxygen to escape while the N² continues moving through the generator's tube. After that, the nitrogen moves through a final filter that contains activated sterile nitrogen filtration material. The last step is the purified nitrogen passing directly into the application through the system's output port.

For some applications, an in-house hollow member membrane system is a much more affordable, energy-efficient, reliable, safer and convenient way to generate an ongoing supply of pure nitrogen, which is also better for the environment.



MEMBRANE NITROGEN GENERATORS IN POWER PLANTS

There are multiple uses of nitrogen generators in power plants. For example, corrosion is a serious issue regarding the performance, longevity and safety of boiler tubes and boilers at power plants. Nitrogen protects against this type of corrosion on the inner walls of wetted parts, condensers and boiler tubes. The N_2 gas present will displace the oxygen, which is a key element in corrosion and inhibits its formation.

Other uses in power plants include:

- **An ammonia purge:** Nitrogen can be connected to the storage tank full of ammonia and provide a blanket over the system. This prevents the ingress of air in the tank.
- **Natural gas purge:** If a leak of natural gas occurs, the site will be evacuated and nitrogen pumped into the system before repairs are made to reduce the potential for explosions.

The fact is, membrane nitrogen generators are becoming more popular in power plants because of the ability they have to produce an unending supply of on-demand nitrogen.



THE USE OF A MEMBRANE NITROGEN GENERATOR IN THE WINE AND FOOD INDUSTRY

When packing and preserving food, nitrogen has an important role. It is also crucial to the winemaking and bottling process.

Nitrogen is a dry, clean inert gas that can eliminate oxygen in a container, pipe or vessel. When it stays in prolonged contact with wine or food, oxygen will begin the oxidation process, resulting in stale food or food that goes bad. With nitrogen, all the oxygen is displaced, preventing the oxidation process and preserving the freshness of the food or wine inside.

Also, having a supply of nitrogen in-house that is mechanically produced by a membrane nitrogen generator makes it possible to use it for blanketing purposes. This will internally pad the package and help to prevent broken or crushed food products, such as crackers and chips.

There are several ways the nitrogen produced by a nitrogen generator can be used for wine production.

- **Sparging:** Introducing fine gas bubbles to remove dissolved CO² and oxygen.
- **Blanketing:** Maintains the nitrogen gas layer over the surface of the wine to prevent it coming in contact with oxygen.
- **Displacement:** Prior to bottling the wine, all air has to be flushed out of the filter housing pumps, hoses and then displaced with nitrogen.

Nitrogen is the preferred gas for the process of winemaking and packaging because it has an extremely low solubility in wine. It is also affordable when you have a nitrogen generator in-house.



USES OF A MEMBRANE NITROGEN GENERATOR BY THE U.S. MILITARY

In addition to nitrogen being used in a number of industrial and commercial locations, it is also used by the U.S. military. For aircraft this gas can be used for:

- Inerting aircraft fuel tanks
- Filling aircraft tires with nitrogen

It can also be used for waterproofing and de-fogging important military (as well as civilian) optics. It can be used for binoculars, cameras, telescopes and night vision goggles in several ways.

- **Purging:** This is when N^2 gas is used to eliminate air from the goggles that may affect how clear they are.
- **Preventing internal fogging:** When optical instruments are filled with nitrogen, it will replace the oxygen that occurs naturally and reduce moisture that can cause fogging.
- **Creation of a waterproof environment:** When an optical instrument is purged with nitrogen, it is also sealed to prevent the loss of N^2 gas that can be the result of changes in temperature or pressure. This results in the nitrogen purged instruments being completely waterproof.
- **Prevention of mold and fungus growth:** Because nitrogen is a dry gas, it can eliminate and absorb moisture when used for displacing oxygen in an environment. This will also prevent mold and fungus that may develop in a moist, enclosed area.



BENEFITS OF NITROGEN MEMBRANE GENERATORS IN THE LAB SETTING

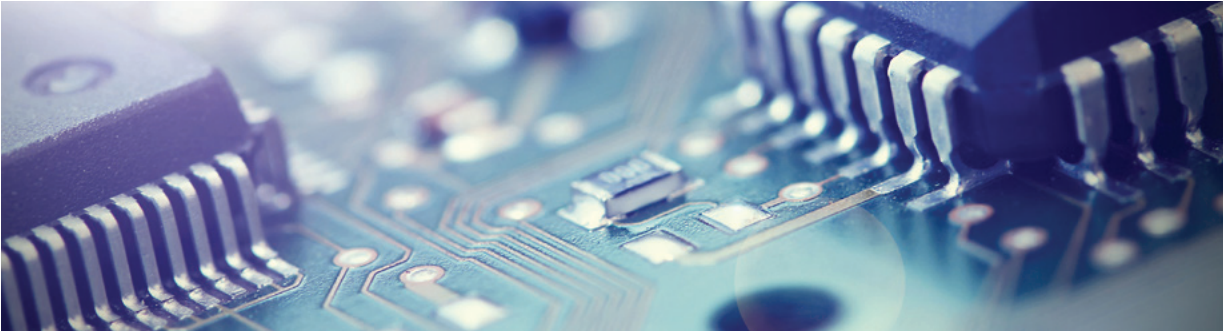
Nitrogen gas is used often in laboratories, from university research labs to clean rooms. The high purity N² is necessary for atmosphere blanketing, humidity control, management of lab equipment and more. Some of the benefits of nitrogen in the lab setting include:

- **Improvement of laboratory efficiency:** Due to the high gas volumes necessary by lab instruments, having a constant and uninterrupted nitrogen gas supply will help to eliminate any interruptions of analysis processes that are being done.
- **Improvement of the performance of analytical instruments:** With a constant flow of gas, it can improve the consistency of the analysis results, and as a result, the reproducibility.
- **Improvement in the economy:** There is a quick return of investment on the use of nitrogen membrane generator in less than a year in most cases, and there are no gas cylinder bottles or price inflation to deal with.
- **Improvement of safety:** When nitrogen is produced at a low pressure and at an ambient temperature, it eliminates the hazards that are associated with liquid Dewar's and high-pressure cylinders.
- **Simple installation process:** These generators can be installed in a lab setting in any location, which eliminates the need to have long gas lines from cylinders that have to be secured in other locations. Also, they don't require a power supply.



THE USE OF NITROGEN GENERATORS IN ELECTRONICS MANUFACTURING

The use of nitrogen is prevalent when electronics are being manufactured because it helps to maintain a dry and clean atmosphere. The gas is often used in nanolabs, for reflow soldering, in the creation of circuit boards, for selective soldering and in the reflow oven.



THE USE OF NITROGEN GENERATORS IN FIRE SAFETY TRAINING

An important part of the training experience for fire rescue organization and employees is smoke simulation. In many situations, nitrogen gas is used to produce a dense vapor that helps to safely simulate smoke. As a result, a realistic training environment can be created while ensuring trainees remain safe from actual smoke that would be produced during a fire.

Since nitrogen is one of the safest gases around because it is non-combustible, it let's fire rescue groups hold training sessions without any risk to those participating. With a nitrogen membrane generator in place, fire training sessions can have an unlimited supply of the "fake smoke" to provide adequate training and preparation for when fire workers are in the real situation.



THE ROI OF IMPLEMENTING AN IN-HOUSE NITROGEN MEMBRANE GENERATOR

If you own a business, are a supervisor at a facility or even a plant manager, you know the value of keeping the workplace both efficient and safe. You also understand the importance of keeping your bottom line healthy. This is why you need to consider the ROI of any investment you want to make. If you are still signed into an expensive contract for your N² supply from a third-party supplier, or if you are ordering liquid nitrogen in bulk, then you know that this can be unreliable, inefficient and quite expensive. However, you may still wonder if it is really worth the expense to install a nitrogen membrane generator at your facility.

The answer is yes, yes it is, but a few reasons that may help persuade you include:

- Studies have found that the average ROI seen when making the change from purchasing liquid nitrogen in bulk to having a generator that produces your own nitrogen on-site is about 12 to 14 months.
- As a result, you could see payback for your initial investment in as little as a year. Also, the savings don't stop once your initial investment is repaid. When you continue to use the nitrogen membrane generator, you will save money on delivery costs, operational costs, energy and more.
- Consider all the costs – in terms of time and finances – that are associated with having to handle liquid nitrogen or be obligated to a contract with a gas supplier. No longer do you have to deal with delivery, storage or handling, and efficiency, safety and administrative tasks are simplified, as well.



TYPES OF GENERON NITROGEN MEMBRANE GENERATORS

There are several types of GENERON nitrogen membrane generators to meet the needs of your specific business or company. These include:

- **The Cabinet Series:** If you have a need for low to medium nitrogen flow rates and require a small footprint, this is ideal.
- **Skid Mounted Systems:** These are most commonly used for ammonia plants, refineries, chemical manufacturing facilities and in the oil and gas industry.
- **Containerized Mobile Systems:** Found in refineries, chemical manufacturing facilities, ammonia plants and the oil and gas industry. These are designed to operate both off- and onshore.
- **Marine and Offshore Systems**
- **Custom Solutions and Packages:** You can customize the packages to include a nitrogen generation system, instrument air or a dry air system, primary air compression, high pressure booster compressor, bottle back up system and nitrogen bottle fill.



THE BOTTOM LINE

The modern nitrogen membrane generator is an important piece of equipment for use in a wide array of applications and industries. Those business owners unsure whether or not it is worth the investment can see why this machine can be beneficial for their particular needs and their bottom line. Make sure to consider the type of generator needed to get the highest level of efficiency from the installation.

