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Automatic nitrogen generator for SLS 3D printing

A CHEAP SOLUTION IS NOT A SOLUTION

Nitrogen generators that attract buyers with a low purchase price carry hidden risks in the form of manual operation, costly inspections, and unstable nitrogen purity – all of which can compromise the entire production process.

CADgen PRO, the only nitrogen generator developed specifically for the needs of SLS 3D printing, eliminates these shortcomings entirely and ensures precise SLS 3D printing in a fully controlled inert atmosphere.

Membrane and filtration	Lifetime durability thanks to lower operating pressure	Frequent replacements due to high pressure
Regulation and sensors	Electronic control maintains stable nitrogen purity precisely and continuously	Unstable purity and high risk of clogging
Nitrogen purity sensor	Optical sensors last 5 years or more without calibration	Sensors degrade and require frequent calibration
Difference in air-tank volume	No mandatory inspections thanks to the air tank staying within the 6-liter limit	Mandatory annual inspections (oversized air tank)
Elimination of human error	Automatic gradual filling, membrane protection	Risk of irreversible membrane damage
Operating costs	Long-term, more economical solution thanks to reliability and maintenance-free operation	Long-term, more expensive solution due to servicing needs and defect rate

SLS 3D print, that you will enjoy!

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What are the differences between a low-cost and a higher-end nitrogen generator solution?

1. Nitrogen generator membrane
2. Air tank – nitrogen storage reservoir
3. Nitrogen flow regulator
4. Inlet air pressure regulator for the generator
5. Nitrogen purity sensor
6. Startup, adjustment, and inspection

MEMBRANE OF THE NITROGEN GENERATOR AND FILTERS

The membrane of a nitrogen generator, together with the filtration system placed upstream of it, represents the most critical and at the same time the most sensitive part of the entire unit. The correct choice of membrane determines the generator's overall performance—both the purity of the produced nitrogen and the achievable flow rate in litres per minute. The membrane's quality directly affects operating efficiency, stability of output parameters, and the long-term reliability of the generator.

The filters installed before the membrane serve an essential protective function. Their task is to capture all impurities, water, oil aerosols, and other contaminants commonly found in compressed-air systems. By doing so, they prevent these substances from entering the membrane and causing its degradation or complete failure. Properly selected and regularly maintained filtration significantly extends the membrane's lifespan and ensures stable nitrogen quality.

Conversely, poorly chosen or insufficiently effective filters can lead to irreversible membrane damage. Once the membrane becomes compromised, it cannot be repaired and must be replaced entirely, which results in substantial financial cost and operational disruption. For this reason, proper filtration is absolutely crucial for safe, economical, and long-term reliable operation of a nitrogen generator.

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The CADgen PRO is equipped with a Parker membrane which, when combined with high-quality filters, ensures trouble-free operation for at least 10 years without the need for replacement.

A high-quality membrane does not require high inlet-air pressures to achieve the desired purity (a lower pressure is sufficient, which reduces costs for the compressor and the air-supply system).

In such a setup, the filters are recommended to be replaced once every 1–2 years, depending on the cleanliness of the inlet air.

Low-cost solution

The amount and quality of the nitrogen produced depend on the surface area of the separation material. Low-cost membranes typically have a significantly smaller active area. As a result, it is necessary to use more membranes or apply much higher air pressure to achieve the desired output.

The parameters stated by manufacturers of cheap membranes often do not reflect real performance. **For SLS printing, the difference between using nitrogen with 99% purity and 99.5% purity is substantial. Nitrogen purity below 99% has no positive effect on the printing process and is not worth using.**

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AIR TANK – NITROGEN STORAGE VESSEL

Another essential component of a nitrogen generator is the air tank, which equalizes nitrogen pressure throughout the entire system.

Its role is to ensure a stable and continuous nitrogen supply even during fluctuations in consumption or short-term changes in generator output. This prevents pressure drops that could otherwise stop the printer or compromise print quality.

The air tank acts as a reservoir that stores nitrogen and releases it according to the device's current demand.

This significantly increases overall system stability, protects the membrane from excessive load, and ensures that even during sudden consumption spikes, the pressure remains within a safe and operationally reliable range. A properly sized air tank is therefore crucial for smooth, uninterrupted operation of both the printer and the entire nitrogen system.

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The 4 L air tank is integrated directly into the body of the nitrogen generator, so it requires no additional space and forms a compact part of the entire system.

Thanks to the high efficiency of the membrane used, this volume is fully sufficient to absorb pressure fluctuations in the system and ensures a stable nitrogen supply even during sudden consumption peaks. This minimizes the risk of pressure drops that could negatively affect the operation of devices connected to the generator.

Another advantage is that an air tank of this small volume is not subject to mandatory periodic pressure inspections.

This results in lower operating costs, less administrative burden, and simpler long-term maintenance. The entire solution is therefore economically efficient, reliable, and very low-maintenance.

Low-cost solution

If the membrane is not capable of supplying a sufficient amount of nitrogen (at the required purity), a very large air tank must be added to the system.

For example: the printer requires 9 nl/min of nitrogen (with a minimum purity of 99.5% and a minimum pressure of 5 bar). A cheap membrane is able to produce 6 nl/min at 8 bar ⇒ the remaining 3 nl/min must be supplied from the storage tank (air tank).

If the print job lasts 24 hours, the total nitrogen demand is 24*60*9 = 12,960 nl.

The membrane can supply 24*60*6 = 8,640 nl.

The difference that must be supplied from the air tank is 12,960 – 8,640 = 4,320 nl.

The printer requires at least 5 bar and at most 8 bar (a difference of 3 bar) ⇒ the minimum air-tank volume is: 4,320 / 3 = 1,440 liters!!!

It must also be taken into account that a tank of this size takes around 12 hours to fill.

This example shows that compensating for insufficient membrane performance with an air tank is not a viable solution. If such a large tank is replaced with a smaller one, a pressure multiplier must be added to the system to increase the pressure inside the tank, which introduces additional costs as well as further servicing requirements.

In every EU country, air tanks of this type are subject to mandatory annual inspections starting from a volume of 6 liters.

Annual air-tank inspections = increased operating costs.

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NITROGEN FLOW REGULATOR

This component of the nitrogen generator is just as important as the membrane itself and the filtration system. The nitrogen flow regulator plays a crucial role in ensuring that the membrane can operate correctly and efficiently separate nitrogen from the other components of compressed air. If the regulator is not properly adjusted, or if a low-quality type is used, even the best membrane cannot produce nitrogen at the required purity or volume.

The regulator's task is to create the necessary backpressure for the membrane, enabling optimal nitrogen separation inside the membrane fibers.

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A more advanced and technically superior option is the use of an electronically controlled flow regulator integrated directly into the nitrogen generator. This regulator actively controls the back-pressure required for proper and highly efficient nitrogen separation inside the membrane. Thanks to electronic control, the membrane is continuously supplied with optimal operating conditions, which has a positive effect on performance stability and the long-term lifespan of the entire system.

If the regulator were to move into a position where it stops responding, the control unit immediately identifies the situation as an error. It then automatically increases the system pressure, forcing the regulator to move again. The electronics therefore act not only as a control element but also as a preventive safeguard against mechanical blockage, significantly reducing the risk of failures and downtime. A major advantage of the electronic regulator is its speed and precision. It can set the required flow rate—and thus the resulting nitrogen purity—within a few hundred milliseconds. This ensures that no lower-quality nitrogen enters the system, which is crucial especially for sensitive applications. By comparison, a mechanical regulator may take several seconds to achieve the same adjustment.

The electronic regulator also handles uneven or pulsed nitrogen demand far more effectively. It can adapt quickly, stabilize the pressure, and maintain constant output-gas parameters even during dynamic changes in operation. This makes it an ideal solution for demanding applications where stability, precision, and reliability are essential.

A correctly set flow rate is therefore essential for stable generator performance, long membrane lifespan, and consistent nitrogen output quality.

Flow regulators can be designed either as mechanical or electronically controlled units.

Mechanical regulators are simple, reliable, and low-maintenance, while electronic versions offer more precise control, automatic adaptation to operating conditions, and often remote diagnostics. The choice of regulator depends on the required precision, operating environment, and the overall configuration of the nitrogen system.

Low-cost solution

A more affordable option is the use of a mechanically controlled flow regulator built directly into the nitrogen generator.

This type of regulator operates on the principle of backpressure, and its adjustment is purely mechanical, without any electronic control. Under normal operating conditions, it can reliably maintain the required flow rate and create the necessary resistance for proper nitrogen separation inside the membrane.

Problems arise when the generator is not used for extended periods or operates only at minimal load.

In such cases, the regulator may become "stuck" in one position. The internal springs and mechanical components can seize if they do not move regularly, and the system pressure may not be sufficient to release them. Once the regulator stops responding correctly, it can no longer create the required backpressure for the membrane, and the membrane itself becomes unable to produce enough nitrogen.

Replacing this regulator is relatively expensive—manufacturers typically list the price of a replacement part in the range of 350–450 EUR (excluding VAT).

From a long-term perspective, it is therefore important to consider whether a mechanical regulator is truly the most suitable choice for the intended operating conditions.

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INLET AIR PRESSURE REGULATOR FOR THE GENERATOR

This component regulates the inlet air supplied to the nitrogen generator, from which nitrogen is subsequently separated inside the membrane.

Its primary task is to ensure that neither too high nor too low pressure enters the membrane. A correctly adjusted inlet pressure is essential for a stable and efficient separation process and directly affects both the purity and the volume of nitrogen produced.

The regulator's behavior during generator start-up is absolutely critical. At this stage, the system must not experience a sudden pressure spike, as an abrupt pressure surge could irreversibly damage the membrane and significantly reduce its efficiency. The membrane is a sensitive element, and sudden overload can cause permanent degradation.

For this reason, the regulator must open gradually, allowing the entire system to fill slowly and in a controlled manner.

A smooth pressure increase protects the membrane, ensures long service life, and allows the generator to reach optimal operating parameters without the risk of damage.

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After the generator is started, the control unit begins to fill the entire system with air gradually and very slowly to prevent any sudden pressure increase. This controlled pressure ramp-up is essential for protecting the membrane, which is sensitive to pressure shocks and could be irreversibly damaged by rapid pressurization.

Once a stable pressure level is reached, the valve automatically switches to full flow, allowing the generator to operate in its normal mode. This entire process serves as an effective safeguard against human error and significantly reduces the risk of membrane damage.

The electronically controlled regulator also keeps the inlet pressure consistently within the optimal range to ensure maximum nitrogen-separation efficiency. As a result, the generator maintains stable nitrogen-output quality, responds quickly to changes in demand, and operates with higher reliability than mechanical alternatives. The pressure regulator, together with the slow-start valve, is integrated inside the CADgen PRO nitrogen generator.

Low-cost solution

The commonly used type of pressure regulator is a cost-effective option, but its use comes with certain operational risks.

The inlet air pressure for the generator must be adjusted manually, which requires experience and careful handling by the operator. Any incorrect adjustment—especially increasing the pressure too quickly or too high—can damage the nitrogen membrane, which is highly sensitive to pressure shocks and sudden changes in operating conditions.

For this reason, the pressure regulator must be installed outside the generator housing to ensure easy access for the operator.

While manual regulation reduces initial investment costs, it also increases the demands on proper handling and regular monitoring, as any mistake can lead to reduced efficiency or even irreversible membrane damage.

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NITROGEN PURITY SENSOR

This component is added to nitrogen generators to enable continuous monitoring of the quality of the nitrogen being produced. There is a wide range of purity sensors on the market, differing significantly in price, accuracy, and long-term measurement stability. Cheaper and lower-quality sensors typically show a larger spread in measured values, and their reliability is limited.

They often operate on an electrochemical principle—in essence, they are small voltage cells that generate a signal proportional to the amount of oxygen in the mixture. Just like ordinary batteries, these cells gradually discharge, which leads to a progressive loss of accuracy. To provide meaningful results, such a sensor must be calibrated regularly, usually twice a year. Without regular calibration, the readings can become highly distorted and unusable for operational decision-making.

For all types of sensors—regardless of their quality or measurement principle—it applies that in order to display any meaningful value, the nitrogen generator must be properly calibrated after every startup. Only after this calibration is it possible to measure the actual nitrogen purity and determine whether the generator is operating in its optimal regime.

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A higher-quality purity sensor is installed in the CADgen PRO nitrogen generator, operating on the principle of modern optical measurement. This type of sensor offers minimal measurement deviation, high stability, and a long service life—typically at least 5 years—without the need for regular calibration. Because optical technology does not rely on electrochemical cells, there is no gradual discharge or loss of accuracy over time.

Thanks to this high-quality sensor, the operator always has precise and immediate information about the purity of the nitrogen being produced. This significantly increases the overall reliability of the system and eliminates the risk of lower-purity nitrogen entering the supply line.

Low-cost solution

In practice, nitrogen-purity sensors are often not installed in nitrogen generators at all. The purity of the output nitrogen is then set only according to the assumed efficiency of the membrane and the operating parameters of the system. Another option is to use cheaper sensors, which, however, typically degrade quickly and gradually lose their measuring accuracy. These sensors usually need to be replaced after roughly two years of operation because their precision decreases significantly as the electrochemical elements age.

A key factor for the proper functioning of all sensors—regardless of their quality—is regular calibration. For a sensor to display an accurate nitrogen-purity value, the nitrogen generator must be manually calibrated after every startup. This process is essential for setting the reference value against which the sensor subsequently measures.

If calibration is not performed correctly, or is skipped entirely, the sensor's readings will not reflect reality. In such cases, the nitrogen-purity value is only approximate and cannot be relied upon for process control or quality assurance. Proper and regular calibration is therefore crucial for the measurement to have any meaningful value.

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START-UP, ADJUSTMENT AND INSPECTION

At every startup of the nitrogen generator, it is essential to correctly set the inlet air pressure and perform system calibration—either manually or through electronic control, as described above. This step is crucial to ensure that the membrane operates under optimal conditions and that the subsequent nitrogen separation process runs at maximum efficiency.

Equally important is the continuous monitoring of the separation process itself and the technical condition of all generator components. Every element of the system—filters, the flow regulator, purity sensors, and the inlet-pressure regulator—must function correctly, as they form an interconnected whole. Any malfunction, clogging, or improper operation of any of these components immediately affects the resulting nitrogen purity.

If any part of the generator is not functioning as it should, it becomes impossible to guarantee the quality of the nitrogen being produced. Output parameters may deviate from the required values, which can negatively impact downstream technologies or production processes. Regular inspection, maintenance, and proper adjustment of all components are therefore essential for stable, safe, and reliable operation of the entire nitrogen system.

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Thanks to its advanced electronic control system, the CADgen PRO nitrogen generator is able to continuously and in real time monitor both the quality of the nitrogen being produced and the condition of all key system components. The electronics evaluate every parameter instantly at the moment of production, and any undesirable deviation is detected immediately. The system then automatically performs a correction or alerts the operator to a developing issue, ensuring that nothing is left to human judgment or manual estimation.

The electronic control system also includes intelligent monitoring of the filter status. The generator tracks their load and monitors replacement intervals to ensure maximum filtration efficiency and trouble-free operation of the entire unit. This minimizes the risk of membrane contamination, a drop in nitrogen quality, or unplanned downtime.

The electronically controlled system therefore provides a high level of safety, precision, and reliability, as all critical processes run automatically with maximum control over operating conditions.

Low-cost solution

If the individual components of the nitrogen generator are not functioning correctly, it becomes impossible to objectively measure the actual purity of the nitrogen being produced. In such a situation, the quality can only be estimated, which is highly unreliable and operationally risky. A malfunction often becomes apparent only when it is already too late—for example, when products that require a stable inert atmosphere begin to fail, or when printed parts become brittle, fragile, or otherwise compromised. Such situations can lead to significant financial losses and can also damage the company's reputation.

If the system includes a nitrogen air tank, one of the first indirect signs of a malfunction is an extended filling time. If the air tank takes noticeably longer to fill than usual, it may indicate that the generator is not producing enough nitrogen or that one of its components is not working properly. However, this symptom appears only once the problem is already well developed, so it should not be relied upon as the sole indicator.

A low-cost solution may reduce the initial investment, but it significantly increases operational risks, because without precise nitrogen-quality control, stable and safe operation cannot be guaranteed.

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FINAL SUMMARY

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Low-cost solution

The CADgen PRO nitrogen generator offers a significantly higher level of reliability, safety, and long-term efficiency. The electronic control system automatically adjusts the inlet pressure, flow rate, and calibration after every startup, ensuring that the generator always operates under optimal conditions without relying on human intervention. This minimizes the risk of errors, membrane damage, and reductions in nitrogen purity.

The system continuously monitors the condition of all key components and reacts immediately to any deviation. As a result, faults are detected early, preventing operational downtime and production defects. The generator also includes intelligent monitoring of the filters and other elements, which extends the overall lifespan of the equipment and reduces maintenance costs.

Higher-quality purity sensors, often based on optical technology, provide accurate real-time measurements and do not require regular calibration. The result is stable and verifiable nitrogen quality, which is essential for all processes sensitive to gas purity.

Although the initial investment is higher, the more advanced solution pays off in the long run thanks to lower operating costs, reduced risk of failures, and consistently high nitrogen-output quality.

A lower-cost variant of a nitrogen generator may require a smaller initial investment, but its operation is significantly more demanding and far riskier. Most key tasks—setting the inlet pressure, regulating the flow, performing calibration, and checking nitrogen quality—must be carried out manually, which creates a high dependence on human intervention. Any operator error can lead to membrane damage, incorrect separation, or a drop in nitrogen purity.

Some generator components (such as the air tank) also require regular annual inspections or more frequent servicing. Purity sensors degrade over time, and regulators may lose accuracy or become stuck. Failures often become apparent only once they have already negatively affected production—for example, when products requiring a stable inert atmosphere begin to fail, or when the air tank starts filling noticeably more slowly than usual.

Without precise electronic control, it is impossible to guarantee the actual quality of the nitrogen being produced. Measurements become only approximate, and any issue in one part of the system immediately affects the entire process. Taken together, these factors make the low-cost solution more expensive, less stable, and less reliable in the long term than more advanced technical alternatives.

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CADgen PRO is an investment in certainty

ensures stable nitrogen quality, minimal risk of failures, and the lowest long-term total cost

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