What does nitrogen gas purity mean?

Fact Sheet



When specifying a Parker nitrogen gas generation system, it is important to ensure that the gas purity selected is correct for the application or process.

Too higher purity and it could possibly waste energy and increase the pay-back on capital, too lower purity and it will not provide the protection required.

It is also important to note that "purity" generally applies to the oxygen level within the nitrogen gas output. It is prerequisite that appropriate compressed air pre-treatment is incorporate within the system design to ensure the inlet compressed air and hence outlet nitrogen gas is - clean, dry and oil-free as well as in compliance any legislation and statute where appropriate.

There are quite a few ways that nitrogen gas purity is referenced, and this may be quite confusing?

The traditional gas companies generally refer to the nitrogen gas content such as –

99,998%, meaning that the nitrogen content has 0.002% (20ppm) of impurities, typically oxygen and water vapour.

Purity Definitions

Typical Gas Company N_2 content	Parker (Gas Generation) O_2 content
95%	5%
98%	2%
99%	1%
99.5%	0.5%
99.9%	0.1%
99.95%	500ppm
99.99%	100ppm
99.995%	50ppm
99.999%	10ppm
99.9995%	5ppm
99.9999%	1ppm

This, however, is not strictly correct, because there is also residual argon within the nitrogen at levels of up to typically 0.5%. Therefore, the nitrogen cannot be 99,998% pure.

It is becoming more common now for the gas companies to state the nitrogen content with the caveat that it contains - "trace inert gases, mainly argon" within the gas purity specification.

The majority of nitrogen used within industry is produce by the gas companies using an air separation unit (ASU). This system very basically repeatedly compresses and expands clean, dry compressed air to create cooling, where the different gas species become liquid at different temperatures and can be harvested within a distillation column. In general, this technology provides relatively high purity gases, namely nitrogen, oxygen and argon.

Composition of dry air at sea level by volume

Gas	Symbol	Volume in Air %
Nitrogen	N_2	78.084
Oxygen	O_2	20.9476
Argon	Ar	0.934
Carbon Dioxide	CO_2	0.0383
Neon	Ne	0.001818
Methane	CH_4	0.0002
Helium	He	0.000524
Krypton	Kr	0.000114
Hydrogen	H_2	0.00005
Nitrous Oxide	N_2O	0.00003
Carbon Monoxide	CO	0.00001
Xenon	Xe	0.0000087
Ozone	O_3	0.000007
Nitrogen Dioxide	NO_2	0.000002
Iodine	I	0.000001
Ammonia	NH_3	Trace

The air we breathe, that is also the feed stock for both air separation units and nitrogen gas generators, contains many more gases species than just nitrogen and oxygen, these however, generally constitute negligible volumes within the part per billion, (PPB), range.

The main gases concerned are oxygen, carbon dioxide, water vapour and argon.

Nitrogen is specified for most application because it is generally inert and is used to displace oxygen within ambient air. The four main application groups are -

Oxidation prevention – for applications such as heat treatment, electronics, laser cutting and chemical blanketing

Fire / explosion prevention – used for chemical blanketing, pipe-line purging, autoclaves and mines

Microbial spoilage – Food processing, storage and packaging and pharmaceutical/ sterile applications.

Gas permeation – Tyre inflation, plastic bottle head space.

Sometime nitrogen is also used because it is normally very dry, with a pressure dew point, (PDP) in the region of >-40 °C, in place of compressed air. Typical applications would be optical equipment purging and filling along with blow guns for dusting/drying moisture sensitive components or equipment.

For all of these applications the main ambient air contaminants displaced are oxygen and moisture.

It should also be noted that both Parker PSA and membrane technology nitrogen gas generators are very effective at removing CO_2 as well.

With regards to argon -

The table indicates typical levels of argon that may be seen in the output gas stream with regards to MROC, (maximum remaining oxygen content) for PSA generators.

MROC	5%	3%	2%	1%	0.5%	0.1%	10ppm
AR	0.9%	1.0%	1.03%	1.13%	1.33%	1.43%	1.63%

The factors affecting this increase in argon can be attributed to –

The different ratio of gas species in the output gas stream created by the removal of the oxygen content. Not just the percentage difference but also the molar mass ratio change.

Molar mass of –

Air, (dry) = 29

Nitrogen = 14 naturally occurring as dinitrogen N_2 = 28

Oxygen = 16 naturally occurring as dioxygen O_2 = 32

Argon = 39.9

In addition, the adsorption kinetics of nitrogen gas generators, specifically PSA with regards to air to nitrogen ratios, gas contact time with the CMS, (carbon molecular sieve), column back-fill and column equalisation potentially contributing to argon concentration.

The relevance of trace argon in generated nitrogen

For almost all applications, argon is irrelevant and has no effect on the process or products requiring nitrogen gas.

Argon is in group 18 of the periodic table and is a noble gas, meaning it is truly unreactive and inert. Argon's outer shell of valence electrons is considered to be "full", giving it very little tendency to participate in chemical reactions.

Nitrogen is in group 15 of the periodic table, the pnictogens and is classed in the element category as a reactive non-metal.

(For all intents and purposes, at room temperature, nitrogen is considered completely unreactive and inert too).

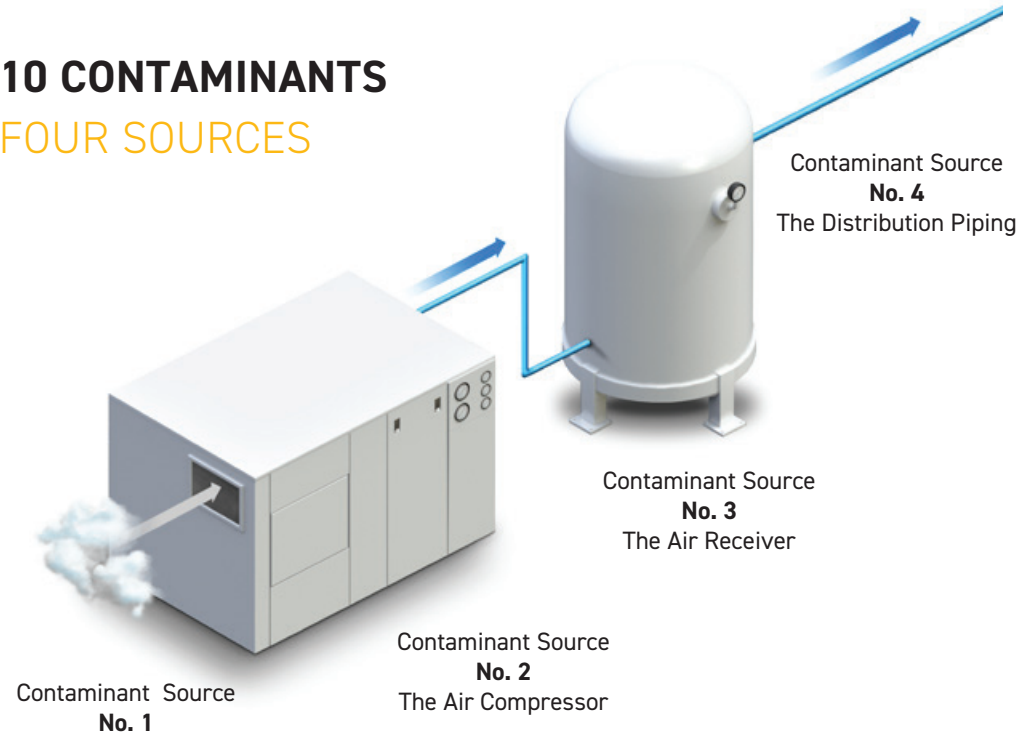
Therefore, in pure chemistry terms, argon is actually more inert than nitrogen.

Other potential contaminants

Compressed air is the main source of contaminants for any gas generation system be it a gas company air separation unit, or PSA / membrane technology, on-site package.



10 CONTAMINANTS
FOUR SOURCES



Contamination entering the compressed air system

Water	Oil	Particulates	Organic
Water Vapour	Oil Vapour	Atmospheric Particles	Micro-organ-isms
Liquid Water	Liquid Oil	Compressor Wear Particles	
Water Aerosols	Oil Aerosols	Rust / Pipescale	

Selecting the correct Parker compressed air pre-treatment package ensures that the minimum specification of 1.4.1 ISO8573-1 is attained and class Zero for oil odour and vapours being achievable even from a standard oil lubricated compressor.



Typical pdp of outlet nitrogen gas from a Parker PSA generator

NITROSource PSA - Average Moisture Content in Nitrogen Gas Output Flow with Desiccant Dried Inlet Air Quality @ -40°C pdp					
Nitrogen Outlet Pressure	**Pressure Dew Point °C**	**ppm(V)**	**ppm(W)**	**Absolute Humidity g/m³**	**Relative Humidity % @ 20°C**
1bara	-85.0	0.535	0.344	0.0004	0.0023
1barg	-80.9	0.517	0.332	0.0008	0.0044
2barg	-78.5	0.500	0.322	0.0011	0.0064
3barg	-76.7	0.492	0.317	0.0015	0.0084
4barg	-75.3	0.485	0.312	0.0018	0.0104
5barg	-74.1	0.482	0.310	0.0021	0.0124
6barg	-73.1	0.478	0.307	0.0025	0.0142
7barg	-72.2	0.475	0.306	0.0028	0.0163
8barg	-71.5	0.467	0.300	0.0031	0.0179
9barg	-70.8	0.463	0.298	0.0034	0.0198
10barg	-70.1	0.465	0.299	0.0038	0.0219
11barg	-69.5	0.463	0.298	0.0041	0.0238
12barg	-69.0	0.458	0.295	0.0044	0.0255

Conversion source – Michell Instruments UK - humidity calculator
NITROSource PSA measured ADP range -75°C to -100°C. Average ADP -85°C

Conclusions

When proposing a Parker nitrogen gas generator –

1. The gas purity should always be specified with reference to maximum remaining oxygen content, (MROC).
   Either as a percentage (%) or Parts per Million (PPM).
   This is the main contaminant that nitrogen gas is used to displace, normally emanating from ambient air, and is the gas species very accurately measured by the integral oxygen gas analysers incorporated within most Parker nitrogen gas generators.
2. The balance should be referred to as "Inert Gas – (nitrogen with trace inert gases mainly argon)"
3. The specification for the gas purity should be determined by the application and not the existing gas company supply. Generally, cylinder gas is 20ppm MROC and liquid nitrogen 10ppm MROC, regardless of the actual application needs. It's just a function of the ASU method of production. Sizing a generator at too higher purity will incur additional cost for operation, initial capital purchase, ancillary selection and energy usage (CO_2e).
   The majority of applications require only between 0.1% and 5% purity!
4. Selection of the correct Parker compressed air pre-treatment package is essential to ensure the minimum inlet requirements for the nitrogen generator are met.



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