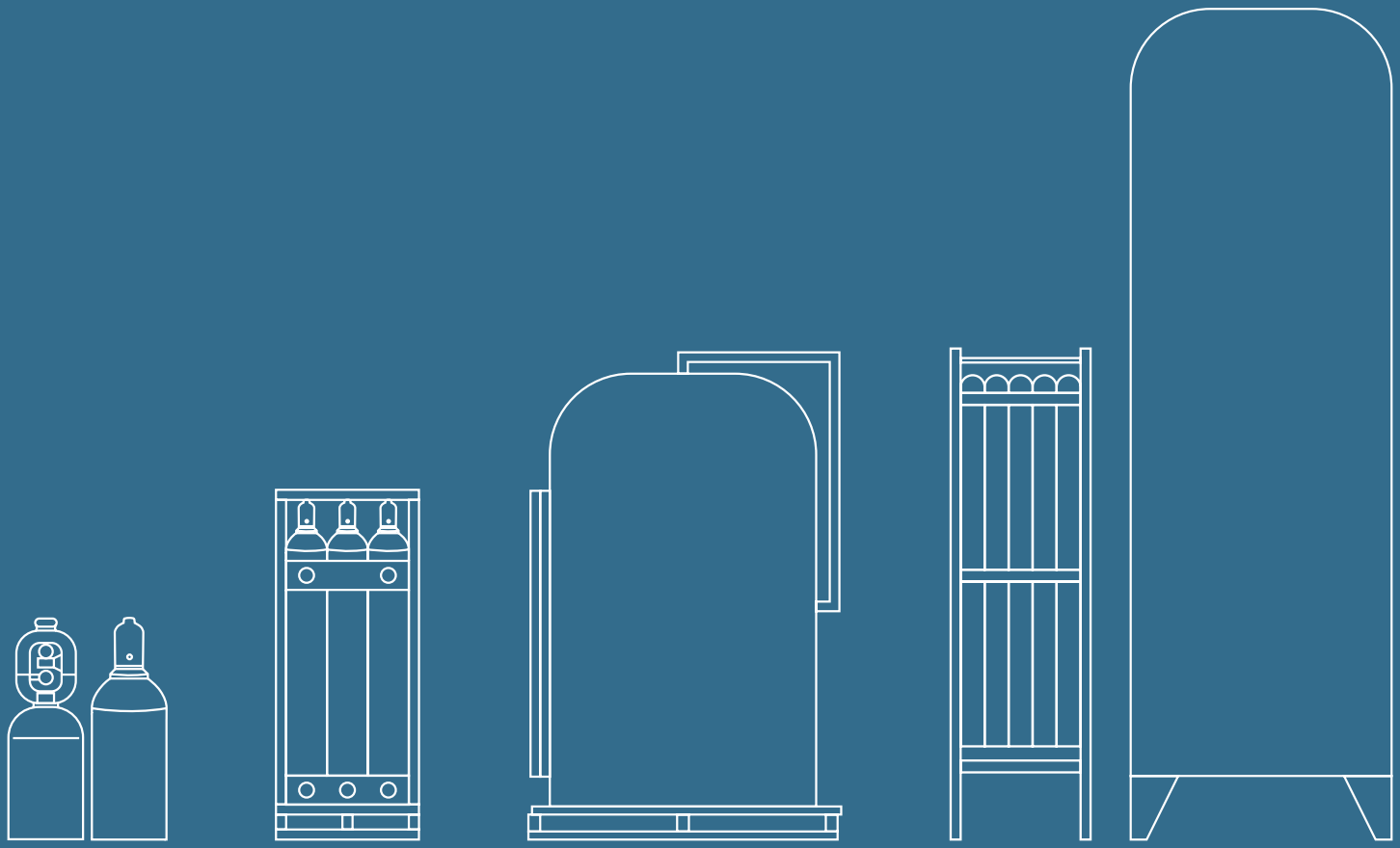
Additive Manufacturing

The right supply has many forms



Nippon Gases is more than just a supplier of industrial gases. As “The Gas Professionals” we are experts in gas manufacturing, gas supply and gas application.

Nippon Gases is one of the leading industrial gases companies in Europe and is part of Nippon Sanso Holdings Corporation - the parent company of the Japanese Taiyo Nippon Sanso, the American Matheson Tri-Gas Group and the European Nippon Gases.

Our Group was originally founded in 1910 in Tokyo and, since then, we have relentlessly developed our solutions and services for our customers. The key to target-oriented use of industrial gases is a customised analysis of your processes.

Application-orientated advice based on many years of international experience and excellent service, are for us the basis for a trusting customer-supplier relationship.

In everything we do, safety is always at the centre of our considerations. It is an inviolable part of our corporate culture, just as we are committed to protecting the environment and to acting sustainably and ethically.

Reliable gas supply from Nippon Gases

Separation of ambient air mainly produces N_2, O_2, Ar, but also rare gases (Ne, Kr and Xe).

Gases can be z v z v vlied in different ways:

- **Pipeline**
- **Truck/tank:** as cryogenic liquid
- **Cylinders:** compressed gas or directly produced on-site

Versatile
Tailor-made gas supply

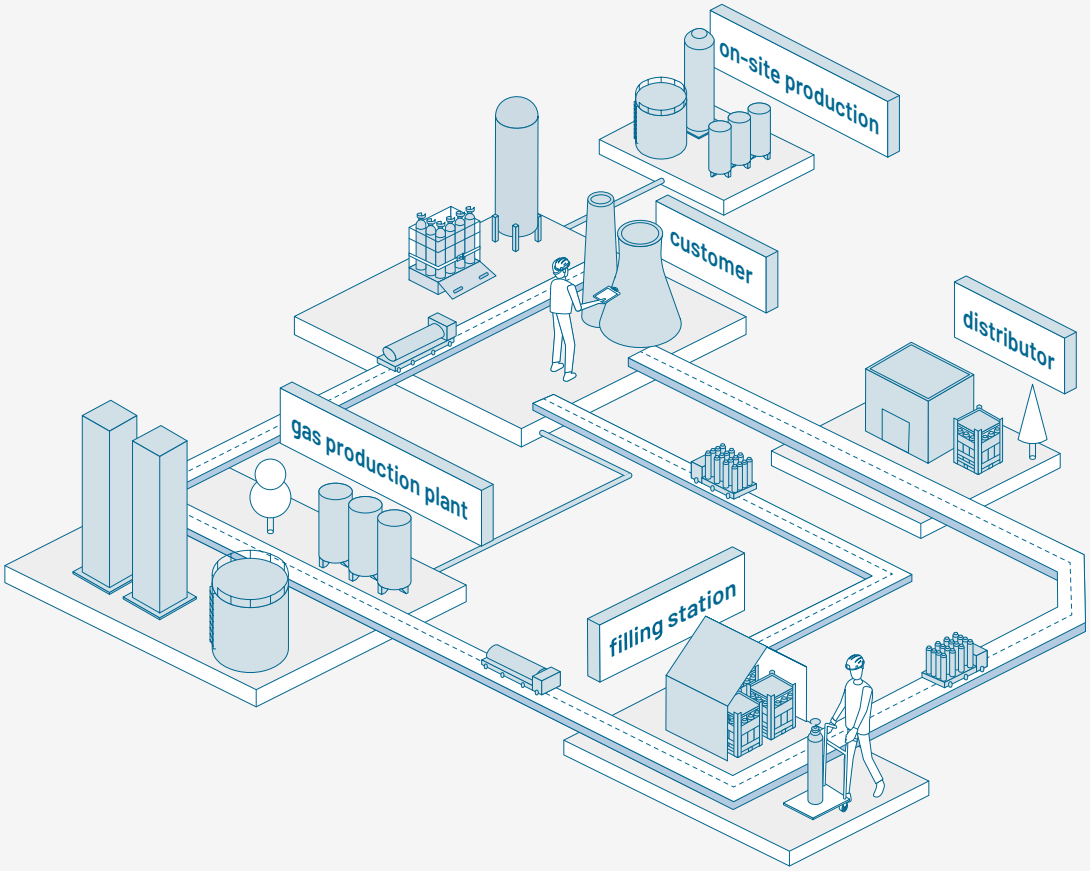
Gases influence the performance of your machines, the efficiency of your processes and ultimately the quality of your products.

It does not matter whether you are producing or researching. Nippon Gases' product range includes all atmospheric gases as well as process and specialty gases. As standard gas or custom-made.

From industrial units to high purity gases and gas mixtures.

Ideal for proven processes or new technologies. Whether you need just a single cylinder or thousands of tons per day. With our gases, you're always well supplied.

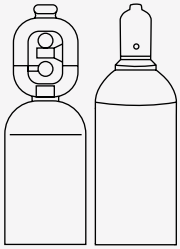
So that you achieve the results you expect.



Cylinders
The most versatiles

Cylinders are the standard for the wide range of shielding gases.

Plug&Work® is Nippon Gases integrated valve. Thanks to their integrated pressure regulator, cylinders with Plug&Work® are not only ready for use in just three steps, but also very easy to operate.

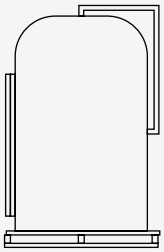


Installation variant: indoors

MicroBulk®
The medium ones

These tanks close the economic gap for medium consumption. Suitable for central gas supply systems, the product – Ar, N_2, O_2 and CO_2 - is stored liquified in small tanks.

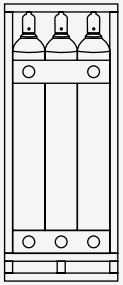
They offer all the advantages of a liquid supply with lower installation and licensing costs. They can be filled on site, and also be connected to gas mixing stations.



Installation option: outdoor

Bundles
The small ones

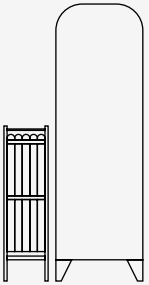
Bundles can be connected to the central gas supply. A bundle is about the size of a Euro-pallet and consist of several individual cylinders piped together with a common outlet.



Installation option: indoor or outdoor

Tanks
The large ones

Vacuum-insulated tank systems are suitable for air gases and connection to central gas supplies. The liquefied product is stored on-site in large quantities.



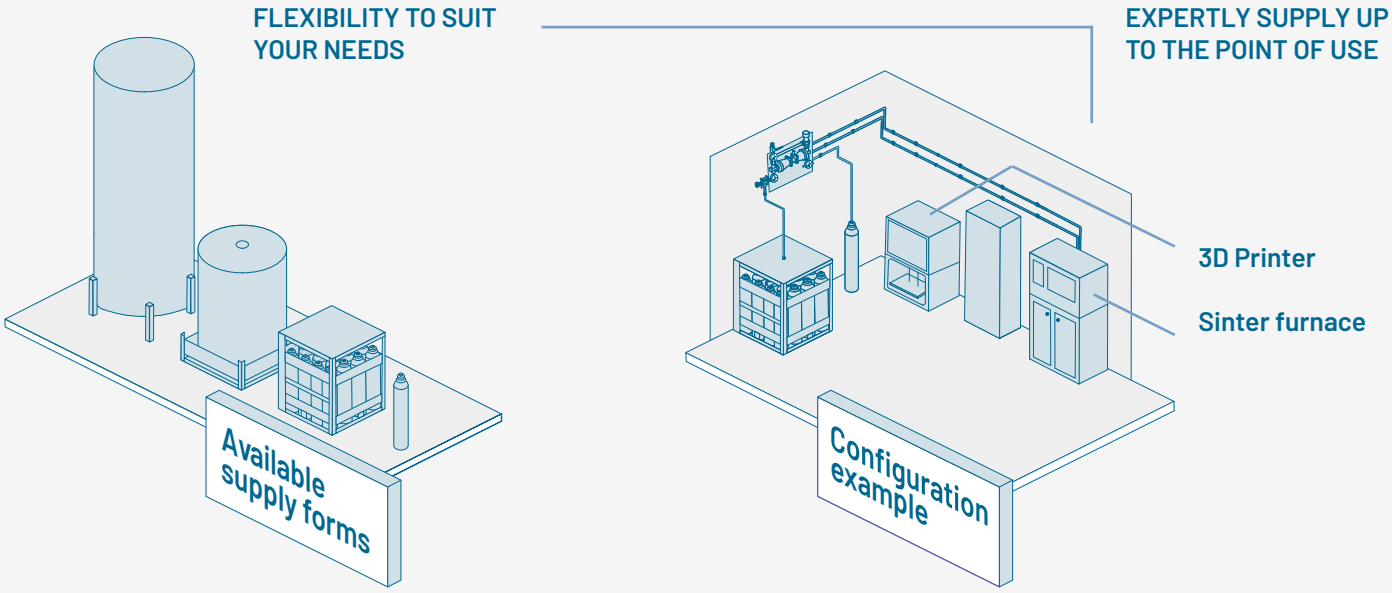
Installation option: outdoor

Adequate
Up to the point-of-use

The choice of the right supply solution directly influences the safety and quality of your operation.

Four criteria are decisive here, especially at the point of use:

- Continuous availability
- Required volume
- Purity
- Compliance with legal requirements for gas supply plants



Ad–hoc solutions

We analyse your needs based on key questions like:

- Gas supply layout?
- Available installation options/areas?
- Prerequisite for continuous gas supply?
- Material of gas supply line?
- Quality of the tapping/control equipment?

Our experts therefore support you from A to Z:

From the choice of form of supply, via the layout of the accessories to the delivery of the gas at the point of use.

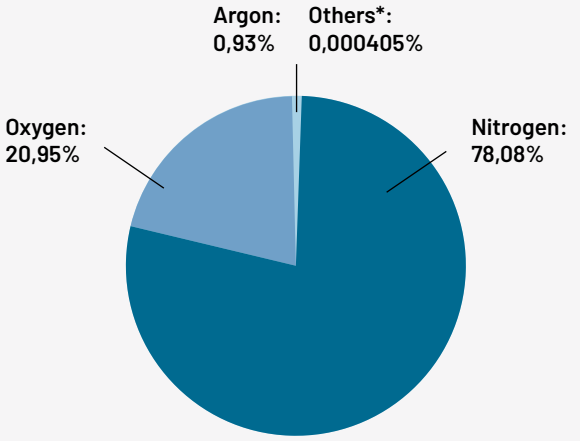
Where do gases come from?

Air

Is a mixture of several gases. Nitrogen, oxygen, argon, carbon dioxide, water vapor and trace amounts of other elements that make up the atmosphere.

Air Separation Units (ASU)

Air Separation Units (ASU) are industrial plants that separate oxygen, nitrogen and argon from all the other components and liquefy them.



***Others:**

- Xenon 0.000009%
- Neon 0.0018%
- Hydrogen 0.00005%
- Helium 0.005%
- Krypton 0.0001%
- Carbon dioxide 0.038%

The air liquefaction

In 1895, a technical method was patented that enables the liquefaction of air and the separation of the atmospheric components oxygen, nitrogen and argon in larger quantities. Since 1902, this method has been used industrially in air separation plants. Today, the separation process is still based on the Joule-Thomson effect: compression, expansion and cooling.

The different boiling points after purification and cooling are used to separate the air into its main components. This primarily involves the separation of liquid oxygen (LOX) and nitrogen (LIN). Liquid argon (LAR) must be generated by an additional process step in a further separation column.

Air Separation
Plant types

Cryogenic

Distillation

- Air Separation Unit (ASU/ASP)
- Multiproduct (O_2, N_2, Ar)
- Gas or Liquid
- Base Plant or onsite
- High purity

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N-Plant

- Single product (N_2)
- Gas Supply (no liquid)
- Onsite

Nitrogen: -196 ºC

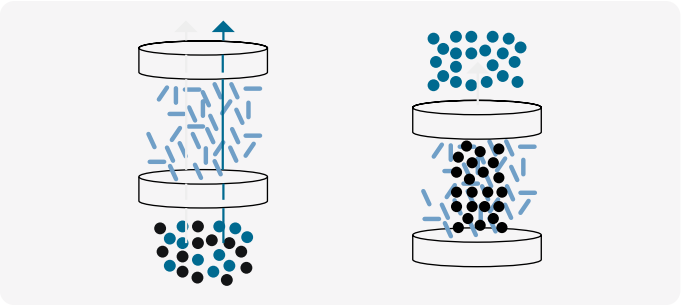
Argon: -185 ºC

Oxygen: -183 ºC

Non-cryogenic

Adsorption

Adsorbent retains the undesired gases from the compressed air and allows the desired pure gas to pass.



VPSA (Vacuum/Pressure Swing Adsorption)

- Single product (O_2)
- Gas
- Purity < 95 %
- Onsite

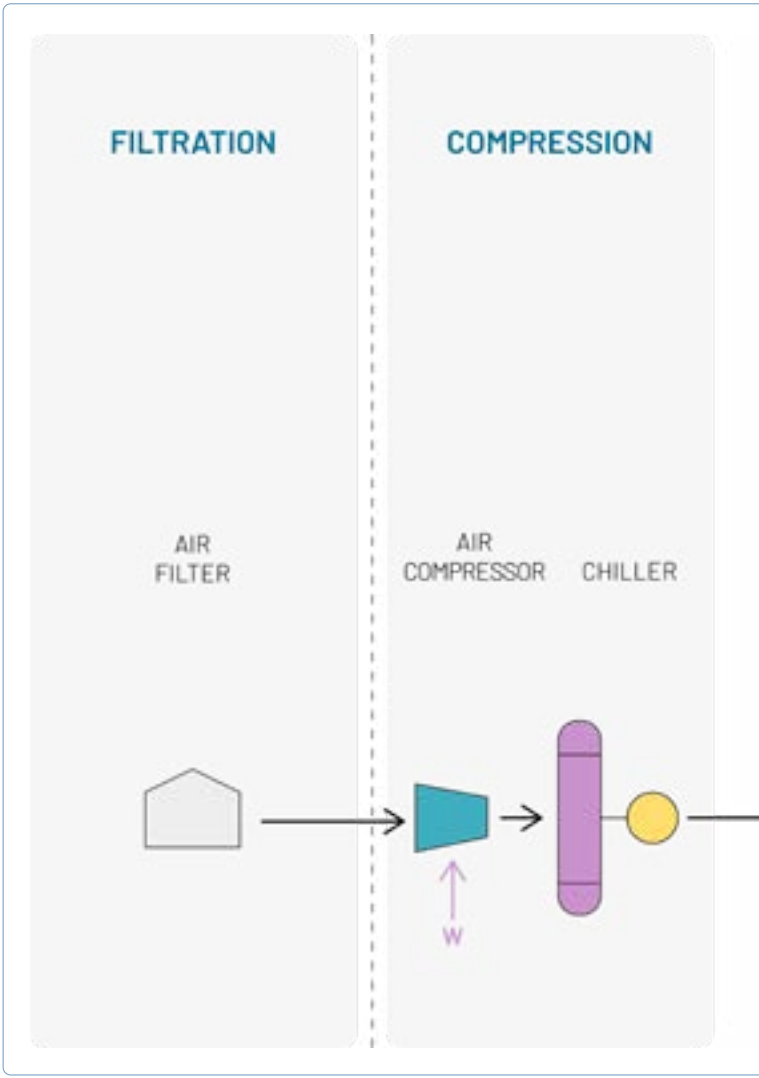
PSA (Micro On-site) (Pressure Swing Adsorption)

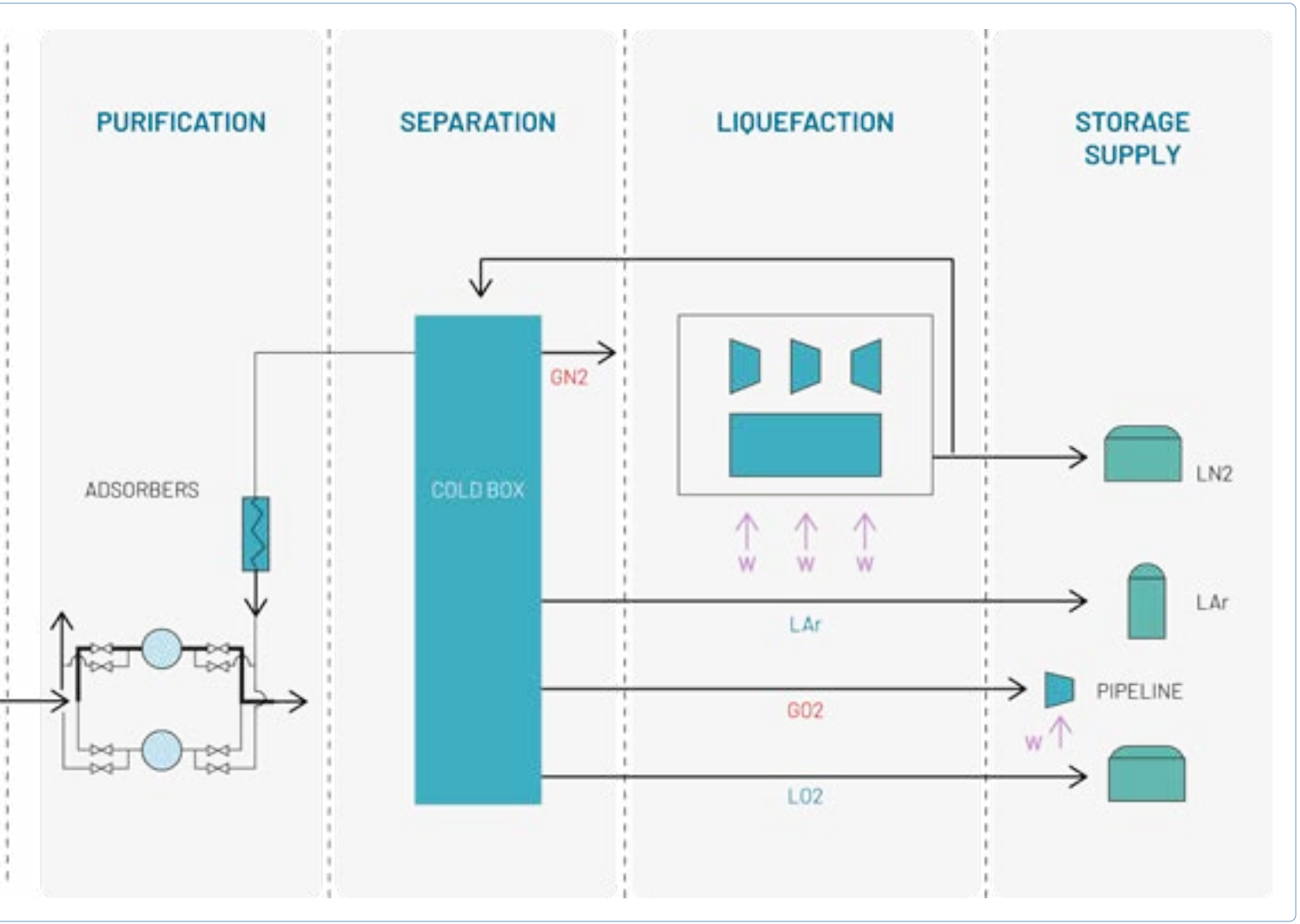
- Single product (N_2)
- Gas
- Purity < 99,5 %
- Onsite

Air gases properties

1. Air gases have different liquefaction temperature or boiling points.
   - Oxygen: -183°C
   - Argon: - 186°C
   - Nitrogen: -196°C
2. Air gases compression produces gas heating.
3. Air gases expansion produce gas cooling.
4. Liquefaction decrease its volumen more than 600 times.

Process overview




PURIFICATION
SEPARATION
LIQUEFACTION
STORAGE
SUPPLY
ADSORBERS
COLD BOX
GN2
LN2
W
W
W
LAr
LAr
PIPELINE
GO2
W
LO2

Air Gases

Oxygen (O_2)

Density, gaseous (1 bar, 15°C): 1,34 kg/m^3

Properties: odourless, tasteless, colourless

Boiling point: 183°C.

Extraction:	From the liquefaction of air with subsequent distillation
Oxygen in cylinder:	10 l, 200 bar / 300 bar 20 l, 200 bar / 300 bar 50 l, 200 bar / 300 bar
Properties:	Oxidising Non-flammable Heavier than air
Applications:	Flame cutting, heating, straightening For combustion Laser applications with O_2 3.5 Medical gases

Nitrogen (N_2)

Density, gaseous (1 bar, 15°C): 1,17 kg/m^3

Properties: odourless, tasteless, colourless

Boiling point: -196°C.

Extraction:	From the liquefaction of air with subsequent distillation
Nitrogen in cylinder:	10 l, 200 bar / 300 bar 20 l, 200 bar / 300 bar 50 l, 200 bar / 300 bar
Properties:	Inert Non-toxic Non-flammable Lighter than air Main-fraction
Applications:	Pressurise, inertise, purge Additive Manufacturing Gasmixture for beverage industry, food packaging Lab gas with different purity

Argon (Ar)

Density, gaseous (1 bar, 15°C): 1,67 kg/m^3

Properties: odourless, tasteless, colourless

Boiling point: -186°C.

Extraction:	From the liquefaction of air with subsequent distillation
Argon in cylinder:	10 l, 200 bar / 300 bar 20 l, 200 bar / 300 bar 50 l, 200 bar / 300 bar
Properties:	Inert Non-combustible Heavier than air
Applications:	Inert gas welding Additive Manufacturing Lab gas with different purity

Process Gases

Helium (He)

Density, gaseous (1 bar, 15°C): 0,17 kg/m^3

Properties: Highly flammable

Boiling point: -269°C.

Extraction:	From the liquefaction of air with subsequent distillation
Helium in cylinder:	3 l to 50 l (200 / 300 bar)
Properties:	Non-flammable Colourless noble gas Lighter than air Very high thermal conductivity Noble gas
Applications:	Gas mixture for welding Laboratory gas with different purity Laser applications Additive Manufacturing

Hydrogen (H_2)

Density, gaseous (1 bar, 15°C): 0,08 kg/m^3

Properties: Highly inflammable

Boiling point: -253°C.

Extraction:	From the chemical industry e.g. chlorinealkali electrolysis From the oil industry
Hydrogen in cylinder:	Significance in analytics with high purity (200/300 bar) Gas mixture with nitrogen as forming gas (200/300 bar) Gas mixture as welding gas (200/300 bar) Fuel gas in metallurgy (200/300 bar)
Properties:	Lightest gas Colourless Odourless Highly flammable
Applications:	Lab gas with different purity

Carbon dioxide (CO_2)

Density, gaseous (1 bar, 15°C): 1,85 kg/m^3

Properties: odourless, tasteless, colourless

Boiling point: -78°C.

Extraction:	From combustion processes in the chemical industry From natural sources
Carbon dioxide in cylinder:	Liquid in the bottle below 31°C At room temperature cylinder pressure approx. 60 bar Different bottles for gas and liquid extraction (riser tube)
Properties:	0.04% in air Non-flammable Heavier than air Good solubility in water
Applications:	Beverage carbonation Fire extinguishing agents Medical gases Welding (C18)

Acetylene (C_2H_2)

Density, gaseous (1 bar, 15°C): 1,09 kg/m^3

Properties: Highly flammable, colourless

Boiling point: -84,7°C.

Extraction:	Made from carbide and water Synthetic
Acetylene in cylinder:	The bottle contains calcium silicate hydrate as a porous mass. This is impregnated with acetone, which in turn can dissolve large amounts of acetylene.
Properties:	Explosion limit: 2.3 - 82 vol.% (air) Water solubility: At 20°C 1 litre ethyne/l water Other solubilities: Very good in acetone and alcohol
Applications:	Fuel gas

Process Gases

Neon (Ne)

Density, gaseous (1 bar, 15°C): 0,842 kg/m^3

Properties: Odourless, colourless

Boiling point: -246°C.

Extraction:	From the liquefaction of air with subsequent distillation
Neon in cylinder:	10 l (200 bar) 50 l (165 / 200 bar)
Properties:	Inert Non-flammable Noble gas
Applications:	Laser gases for electronics

Krypton (Kr)

Density, gaseous (1 bar, 15°C): 3,51 kg/m^3

Properties: odourless, colourless

Boiling point: -153°C.

Extraction:	From the liquefaction of air with subsequent distillation
Krypton in cylinder:	2 l (82 bar) 10 l (82 / 144 bar) 50 l (144 bar)
Properties:	Inert Non-flammable Non-toxic Noble gas
Applications:	Gas for lamp fillings Filling for insulating glass Surface treatment for tools Research Laser gases for electronics Ion propulsion for satellities

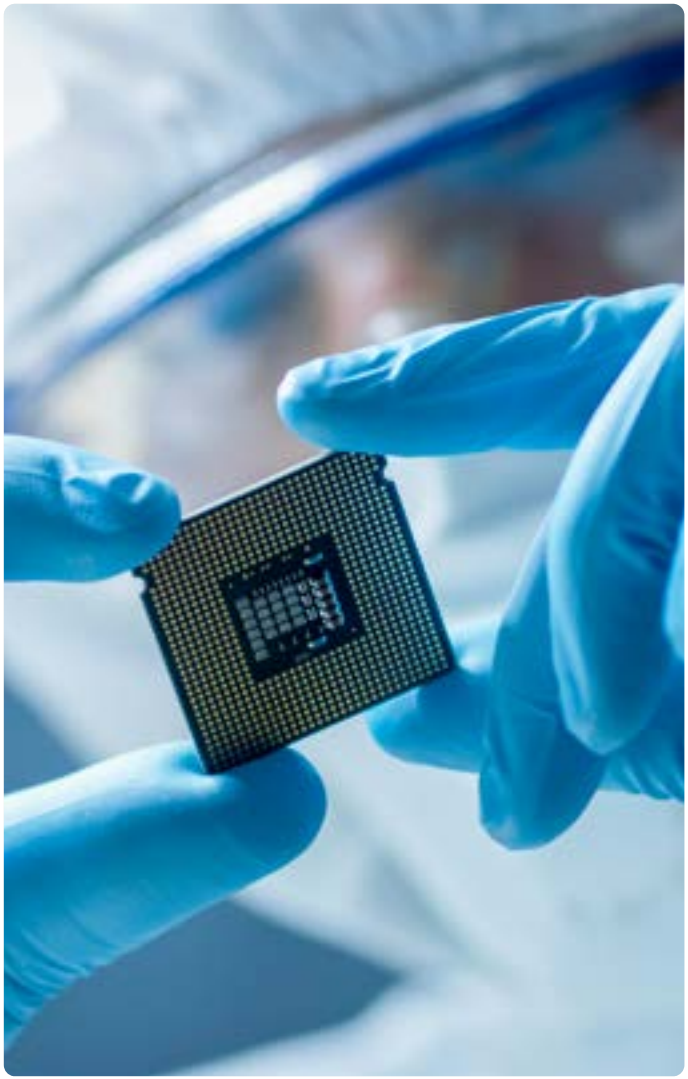
Xenon (Xe)

Density, gaseous (1 bar, 15°C): 5,51 kg/m^3

Properties: odourless, colourless

Boiling point: -108°C.

Extraction:	From the liquefaction of air with subsequent distillation
Xenon in cylinder:	2 l (58,4 bar) 10 l (58,4 bar) 50 l (58,4 bar)
Properties:	Noble gas Xenon reacts directly with fluorine only
Applications:	Gas for lamp fillings Filling for insulating glass Surface treatment for tools Research Laser gases for electronics Ion propulsion for satellities



Properties of Cryogenic gases

Conversion table for cryogenic liquefied gases

Oxygen O_2	**90,05 K**	1 m^3	^ 1.171 /	^ 1.337 kg
	-183,10 °C	1 l	^ 0.854 m^3	^ 1.142 kg
	Boiling temperature at 1 bar	1 k	^ 0.748 m^3	^ 0.876 l
Nitrogen N_2	**90,05 K**	1 m^3	^ 1.449 /	^ 1.170 kg
	-183,10 °C	1 l	^ 0.690 m^3	^ 1.808 kg
	Boiling temperature at 1 bar	1 kg	^ 0.855 m^3	^ 1.238 l
Argon Ar	**90,05 K**	1 m^3	^ 1.198 /	^ 1.669 kg
	-183,10 °C	1 l	^ 0.835 m^3	^ 1.395 kg
	Boiling temperature at 1 bar	1 kg	^ 0.599 m^3	^ 0.717 l
Carbon dioxide CO_2	**90,05 K**	1 m^3	^ 1.757 /	^ 1.849 kg
	-183,10 °C	1 l	^ 0.569 m^3	^ 1.052 kg
	Boiling temperature at 1 bar	1 kg	^ 0.541 m^3	^ 0.951 l

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nippongases.com

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info@nippongases.com

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@nippongases
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info@nippongases.com