

Process of Air Separation

Air is a mixture of gases with nitrogen (N₂), oxygen (O₂) and argon (Ar) being its main components. These three gases have a wide range of applications in many industries, including semi-conductor, aeronautical, medical, steel and petrochemical industries, to name a few. These applications require clean gases conforming to defined purity specifications, each for their own reasons.

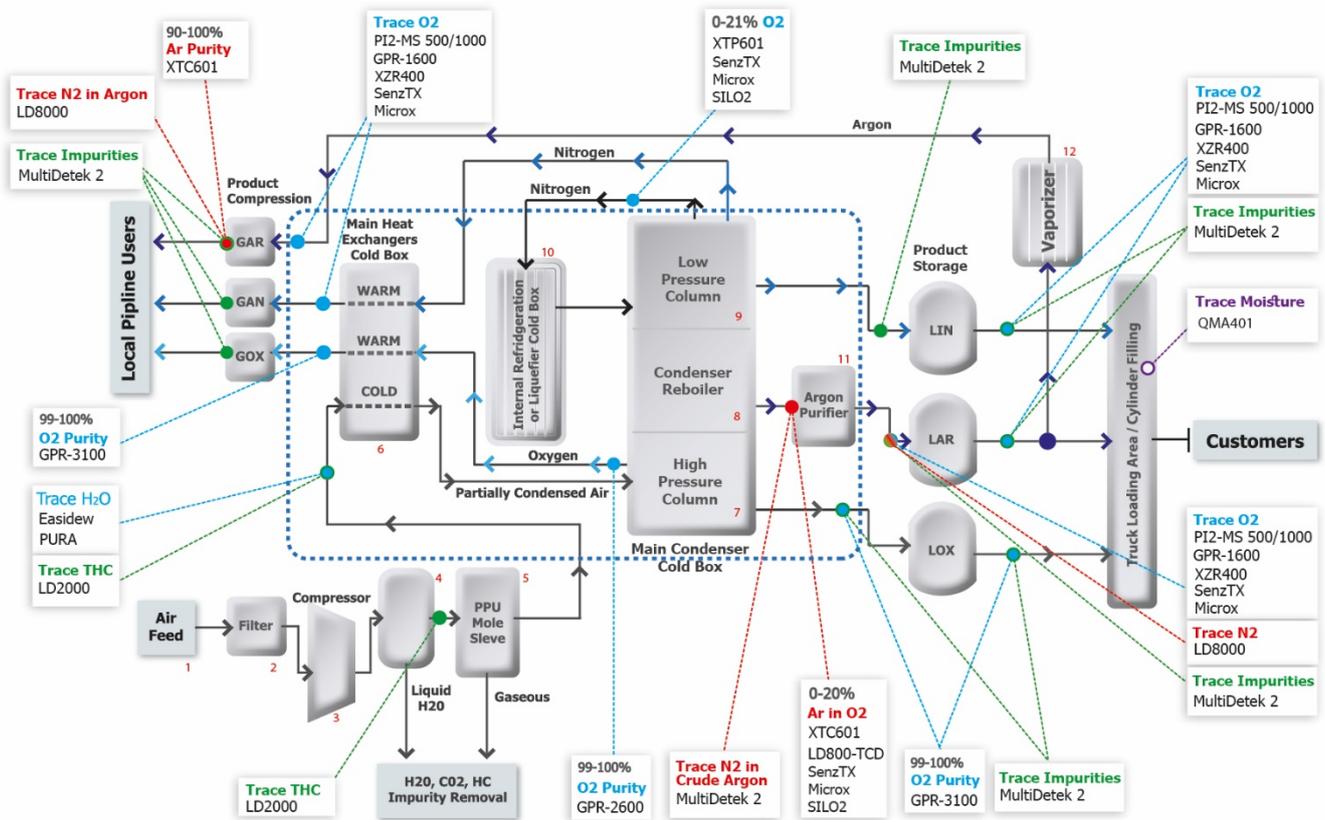
Air also contains trace levels of additional gases such as carbon dioxide (CO₂), helium (He), neon (Ne), methane (CH₄), nitrous oxide (N₂O) and water vapour (H₂O). Varying levels of trace impurities including flammables such as hydrocarbons, oxides of nitrogen or corrosive components are also found in air.

Air components are predominantly separated in three ways: Membranes separation, pressure swing adsorption or cryogenic distillation. The three separation techniques offer different benefits where gas purity which can be produced at varying costs according to their energy consumption, capital expenditure and real estate.

Currently only N₂ can be retrieved by membrane separation. Pressure swing adsorption is used for N₂ or O₂ recovery, a single component at a time.

Cryogenic distillation is the most cost-effective approach for air separation, if large quantities of gases are required. It is the only way to recover N₂, O₂ and in smaller quantities, Ar, all at the same time.

Cryogenic distillation is the only air separation technique discussed here as it makes up more than 90% of the worldwide production. A flow diagram of a basic cryogenic plant design, consisting of a feed and a cryogenic section, is shown in **Figure 1**. (Next page)



Products:					Key:	
PURA	XTC601 / XTP601	GPR-3100	LD8000 / LD2000	SILO2	GAR	Gaseous Argon
XZR400	QMA401	GPR-1600 / GPR-2600	MultiDetek 2	SenzTX	GAN	Gaseous Nitrogen
Easidew	PI2-MS 500/1000	Microx			GOX	Gaseous Oxygen
					LAR	Liquid Argon
					LIN	Liquid Nitrogen
					LOX	Liquid Oxygen
					Cold Section	

Figure 1. Air Separation. Including suitable PST products.

Feed section

Atmospheric air is first filtered (2) and compressed (3), raising its temperature to 100°C. Subsequently it is water cooled (4) which has the added benefit of removing some corrosive impurities such as SO₂, SO₃, NH₃ and condensed water vapour.

CO₂ and H₂O are then removed from the saturated air, using dual molecular sieve absorbers (5), regenerating on alternating duty. Failing to do so would block the heat exchanger, located downstream in the cryogenic section.

Hydrocarbon components are also retained by the molecular sieve (5). Such flammable components must be removed, as they are less volatile than O₂ and would accumulate in the liquid O₂. This is critical for the plant's safety as hydrocarbons would combust with the distilled O₂, should ignition occur.

Cold section

The purified and compressed air enters the heat exchanger (6) to be cooled down, by the liquid oxygen (LOX) from the cold box column. LOX is, in turn, vaporised into a gas (GOX), to be compressed ready for supplying bulk customers.

The high-pressure air existing the heat exchanger is partly condensed, to be subsequently expanded into the bottom of the high-pressure column (7) via a throttle valve. This pressure reduction, or expansion, further reduces the partly condensed air temperature. The amount of condensate increases as air components with the highest boiling points liquify.

Air is fractionally separated as the vaporous N₂ accumulates at the top of the coldbox in the low-pressure column (9), and LOX is formed at the bottom of the high-pressure column (7), accordingly with their respective boiling temperatures as shown in the following table.

Gas	Boiling point at atmospheric pressure		
N ₂	-195.8 °C	-320 °F	77 K
Ar	-189.8 °C	-302.5 °F	87.3 K
O ₂	183 °C	-296.3 °F	90.2 K

LOX's purity will be reduced as it contains impurities with higher boiling points components. Insulation and optimal temperature control are critical as temperature fluctuations affect the impurity to condensate. From this point, LOX is sent for storage and to the heat exchanger (6) ready to be vaporised into GOX.

The gaseous N₂ (GAN) is liquified in the main condenser cold box by evaporating the remaining liquid oxygen from the low-pressure column (7). Part of GAN is used as reflux (10) for the low-pressure column (9).

GAN is withdrawn from the top of the low-pressure cryogenic column (9) and liquid N₂ (LIN) is withdrawn from the lower section of the low-pressure cryogenic column (9). In addition to LIN and LOX, there is a third liquid air fraction made of argon (8).

The feed gas into the crude argon purifier (11) is made of about 80% O₂ and ppm levels of N₂. The argon purifier is made of argon purifier made up of crude argon column & pure argon column. O₂ remains in the lower section of the crude argon column (11) and Ar rises to the top before going to the pure argon column (11).

Liquid Argon (LAR), in turn, condenses in the lower section of the pure argon column (11) while N₂ ascends to the top. LAR can either be stored or vaporised (12) as gaseous argon (GAR).

GAR, GAN and GOX is often supplied exclusively to bulk consumers. The plant's liquid production is stored in tanks and is distributed locally by trucks to smaller consumers.

Gas analysis is required throughout the air separation plant both for safety and gas purity. As such, PST instrumentation is used for monitoring of the production process, the liquid storage (LOX, LIN, LAR) and the certified gas filling of trucks & gas cylinders. Additionally, multiple gas analysis can be shared with a single instrument when carried out off-stream.