ECM ECO Monitoring

Environmental & Process Monitoring instrumentation & systems

Clean industrial gases

Total Solution for Gas Analysis on Cryogenic Air Separation Plants

Application

Gas analysers which have been specifically designed to meet the process control, quality assurance and safety monitoring requirements of air separation plants.

Background

Dry air contains approximately 78% nitrogen, 21% oxygen, and 1% argon plus low concentrations of noble gases, carbon dioxide, hydrocarbons and other impurities. Nitrogen, oxygen and argon are used by industry in large quantities and hence termed industrial gases. To support this need processes have been developed to produce these gases through the separation of air.

An air separation plant divides atmospheric air into the three pure gaseous components of nitrogen, oxygen and argon. Further separation may be performed on some plants to produce other gases such as neon, krypton and xenon. Other gas components of atmospheric air, such as water vapour, carbon dioxide and hydrocarbons must be removed to ensure safety, efficient plant operation and product quality.

There are different types of air separation plants but those based on cryogenic air separation are the most significant in terms of production value and volume. Cryogenic air separation presents the most opportunity for gas analysis and is now discussed in more detail.

Cryogenic Air Separation

Large air separation plants are based upon the cryogenic fractionation of air into its pure components. This process is based on the principle that the desired products have different boiling points and thus can be separated out from liquefied air. Due to differing user requirements there are a number of variations in the air separation cycles which are used to make industrial gas products. However all cryogenic air separation processes consist of a similar series of steps: see figure 1.

Air compression and filtering:

The ambient air feed is compressed by a multiple stage compressor with intercoolers to a pressure of about 6 bara. Dust is removed by a filter located at the inlet to the compressor.

Air cooling and purification:

The compressed air is then cooled to close-to-ambient temperature by passing through a direct contact water cooler. Chilling of the cooling water is done in an evaporation cooler using dry nitrogen waste gas from the process. Much of the water vapour in the incoming air is condensed and removed as the air passes through the compressor and cooler. Most of the remaining water vapour, carbon dioxide and hydrocarbons are removed by molecular sieve absorbers.

Refrigeration/Liquefaction:

The purified compressed air feed is then cooled by heat exchangers and refrigeration processes contained in the "cold box" where it reaches cryogenic temperature of around -180˚C. Final cooling is done by expanding the feed in an expansion engine. The resulting mixture of liquid and vapour air is separated and fed to the separation column.

Separation:

This separation column consists of a high pressure and low pressure column where air is separated into its pure components. The mixture of liquid and vapour air from the refrigeration/liquefaction stage is fed into the high pressure column. This mixture separates into nitrogen at the top and oxygen enriched air at the bottom.

This oxygen enriched air is fed into the low pressure column where it is further purified. Pure nitrogen is finally taken off the top of the high and low pressure columns and pure oxygen is withdrawn from the bottom of the low pressure column.

Argon is enriched in the middle part of the low pressure column, the so-called argon belly. It can be withdrawn from there and processed to pure argon in additional concentrating steps as follows.

Pure argon production:

In the past argon was produced by feeding the stream from the argon belly in the low pressure column to the crude argon column. Then the product from this is passed through a catalytic converter to remove the remaining oxygen before any nitrogen is removed in the pure argon column.

The modern process is to pass the stream from the low pressure column into the crude argon column for further separation. The remaining oxygen in this gas stream is completely removed in this packed column. The oxygen free argon stream is then fed into the pure argon column where the remaining nitrogen is removed by separation and the pure argon is liquefied.

Figure 1 Typical Air Separation Process

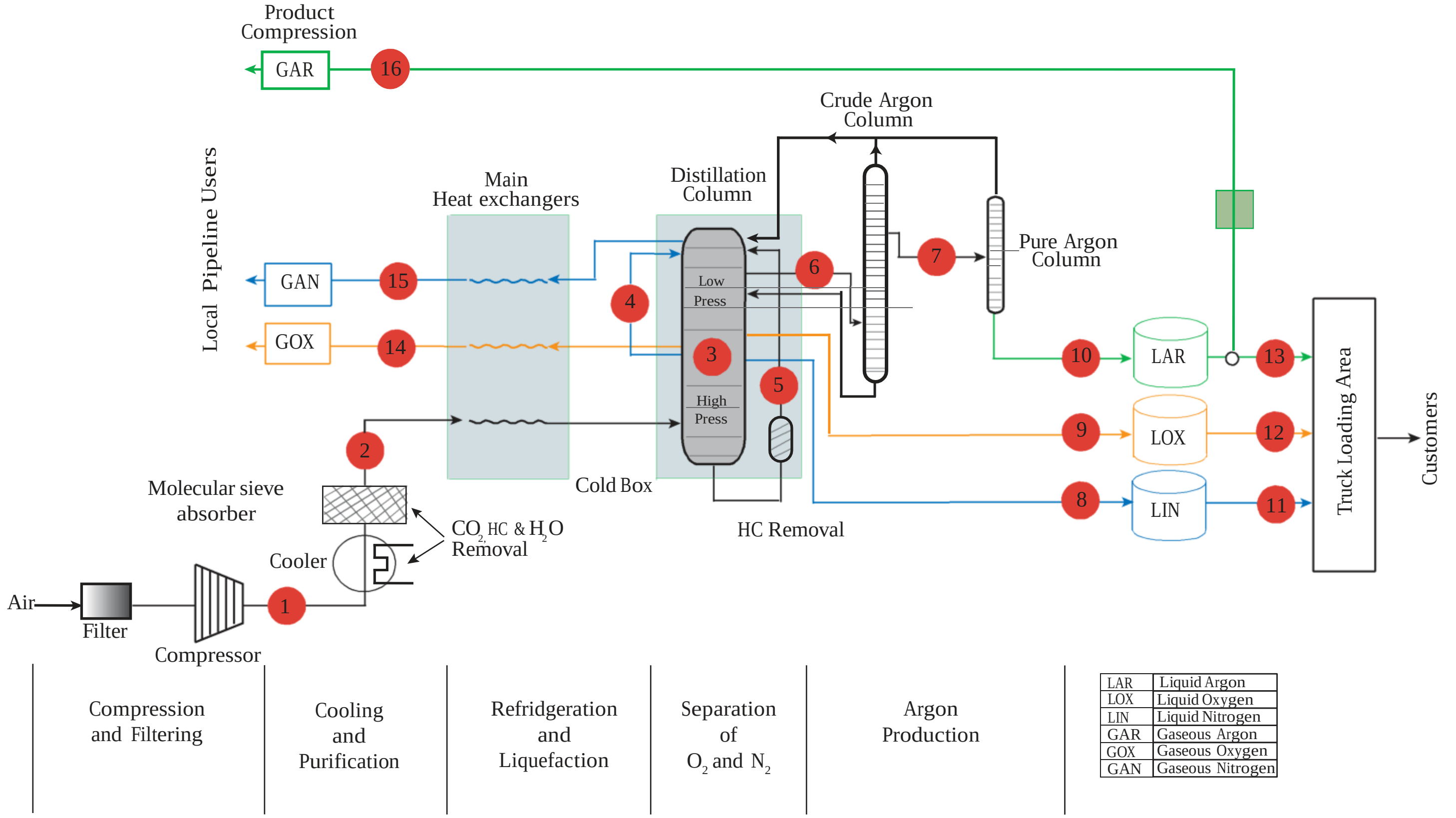

Table 1: Typical gas analysis (refer to ASU flow schematic Figure 1)

Analysis position	Sample stream	Measuring component	Typical range	Main purpose	Suitable analysers
1	Process air before molecular sieve	THC Impurities	0-10/100ppm 0-10/100ppm	Safety	FID (K1000) Chroma (K4000)
2	Feed to high pressure column	CO_2 THC	0-10ppm 0-10/100ppm	Safety	MultiExact,4100 FID (K1000)
3	Low pressure column liquid phase	O_2 CO_2 N_2O THC	98-100% 0-10ppm 0-20ppm 0-100/1000ppm	Control Safety	MultiExact,4100 MultiExact,4100 MultiExact,4100 FID (K1000)
4	Distillation column process stream	O_2	0-20%	Control	MultiExact,4100
5	Feed to low pressure column	O_2	0-50%	Control	MultiExact,4100
6	Crude argon column feed	O_2 N_2 Ar	80-100% 0-2000ppm 0-20%	Control	MultiExact,4100 Chroma (K4000) MultiExact
7*	Feed to pure argon column	O_2 N_2 Ar N_2/O_2	0-1/10ppm 0-5000ppm 80-100% 0-10%	Control	310E/MultiExact,4100 Plasma (K2001) MultiExact MultiExact
8, 11	Liquid nitrogen before and after storage	O_2 Impurities	0-1/10ppm 0-10ppm	Control/Quality	310E/MultiExact,4100 Chroma (K4000)
9, 12	Liquid oxygen before and after storage	O_2 Impurities	98-100% 0-10ppm	Control/Quality	MultiExact,4100 Chroma (K4000)
10, 13	Liquid argon before and after storage	O_2 N_2 Impurities Ar	0-1/10ppm 0-10ppm 0-10ppm 90-100%	Control/Quality	310E/MultiExact,4100 Plasma (K2001) Chroma (K4000) MultiExact
14	Gaseous oxygen	O_2 CO_2 THC Impurities	98-100% 0-10ppm 0-10ppm 0-10ppm	Quality	MultiExact,4100 MultiExact,4100 FID (K1000) Chroma (K4000)
15	Gaseous nitrogen	O_2 Impurities	0-1/10ppm 0-10ppm	Quality	310E/5400,4100 Chroma (K4000)
16	Gaseous argon	O_2 Impurities Ar	0-1/10ppm 0-10ppm 90-100%	Quality	310E/MultiExact,4100 Chroma (K4000) MultiExact

* Only applies to modern processes using packed crude argon columns

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