SERVOMEX SOLUTIONS

THE USE OF SERVOMEX 4100 GAS PURITY ANALYSER ON AIR SEPARATION PLANT

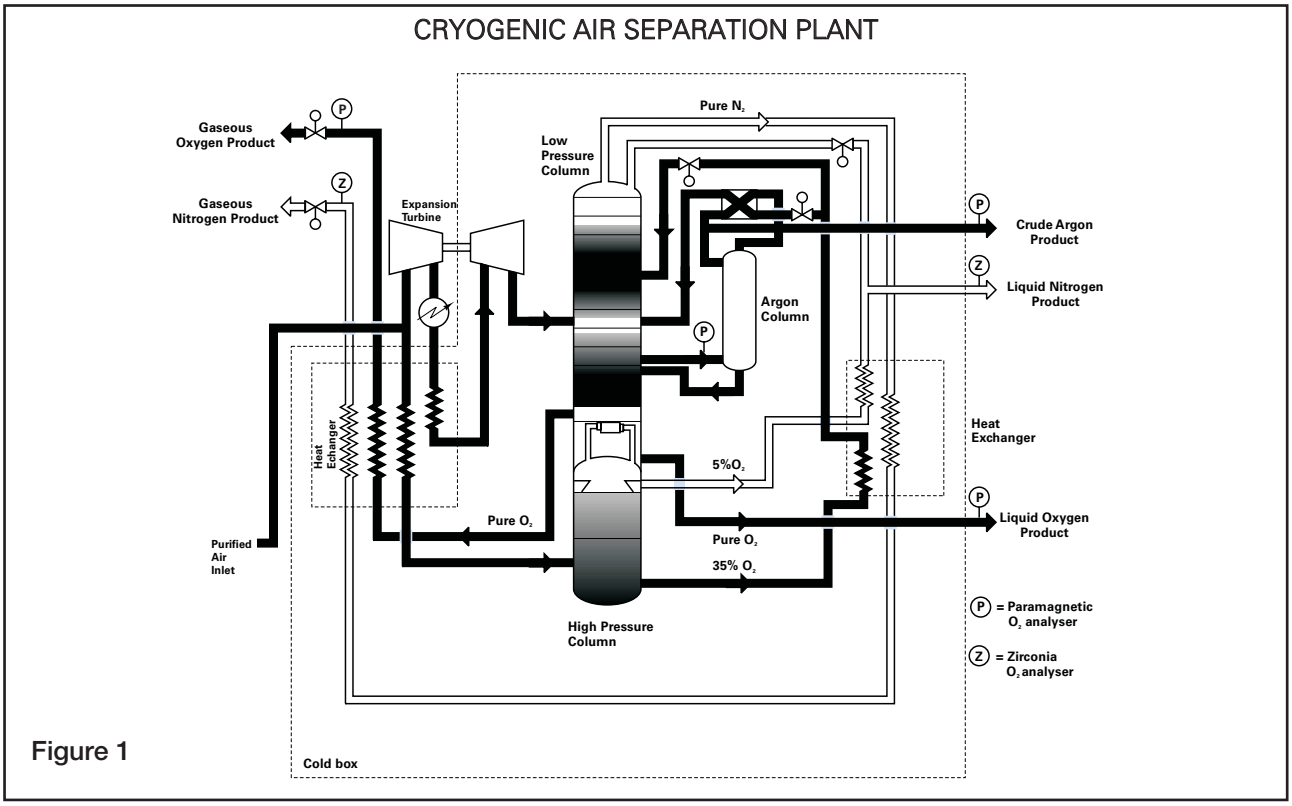

Figure 1

Extremely large quantities of nitrogen and oxygen, obtained from the air, are consumed by industry world wide each year. Air may be separated into these primary constituents by a number of techniques. The most important of these are cryogenic separation and the pressure swing absorption technique (PSA). The Servomex 4100 gas purity analyser has been designed specifically to monitor the quality of the high purity oxygen and nitrogen in plants using these processes. Up to four sample streams may be measured simultaneously. Each stream may be monitored for either oxygen purity using the paramagnetic transducer or trace levels of oxygen using the zirconia cell. The Servomex 4100 provides a single, compact, flexible and cost effective package for all the measurements required.

Air Separation

An air separation plant may be owned and operated by the consumer and is known as an 'on-site' plant, or the plant may be located off-site and product delivered by a short pipeline. In this case several customers may be served by a single air separation plant. Alternatively smaller customers may receive product transported by bottle or by tanker delivered to bulk storage on-site. PSA plant is normally only used on-site.

The purity of the oxygen produced may be from 95% upwards but is generally better than 99.5% for cryogenic air separation plant. The paramagnetic technique is ideal for monitoring high percentage levels of oxygen and the paramagnetic oxygen transducer used in the Servomex 4100 gas purity analyser is temperature controlled and pressure compensated giving excellent stability.

The level of oxygen remaining in the pure nitrogen product will be approximately 1vpm for cryogenic plant. The Servomex zirconia oxygen cell used in the 4100 analyser is inherently suited to measuring these low levels of oxygen since its output increases with decreasing oxygen concentration.

PRESSURE SWING ABSORBER SYSTEM

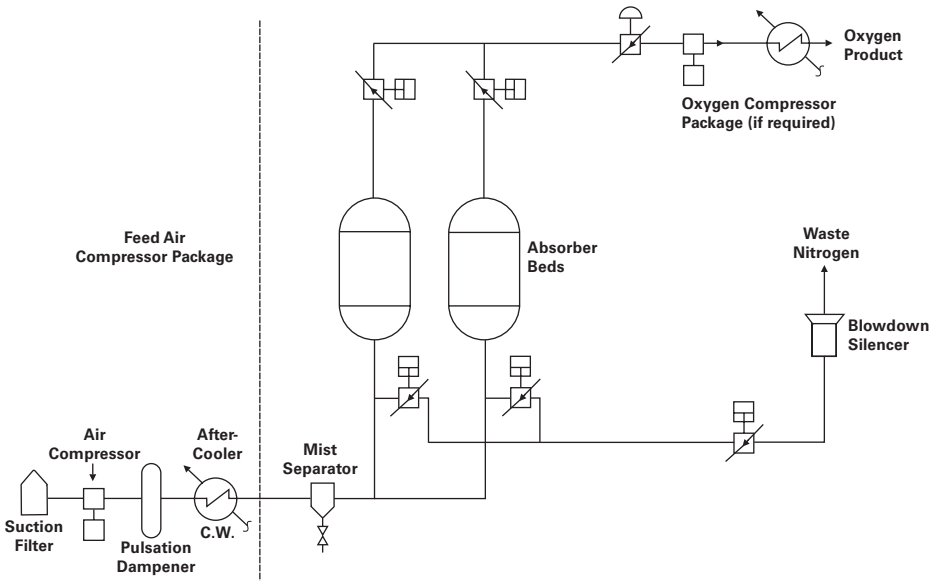

Figure 2

The principle uses of oxygen are in the production of steel, in open-hearth and basic oxygen furnaces and oxyacetylene cutting equipment. Large amounts of oxygen are also used in the production of acetylene and ethylene oxide, and in the partial oxidation of hydrocarbons to produce ammonia and methanol. Of course, oxygen is also used extensively for medical purposes and in aviation. The main uses of nitrogen are for inerting of storage tanks where flammable vapours may exist, the production of semiconductor electronic components, shrink fitting of components and rapid freezing of food for storage.

Pressure Swing Absorber (PSA)

This type of plant (Figure 2) varies in size considerably and is normally designed to satisfy a specific on-site requirement. Either oxygen or nitrogen may be produced and the size of plant will increase with required flow rate and purity level.

To produce oxygen of a purity level from 90% upwards, air is compressed and passed through a 'bed' of zeolite (molecular sieve) adsorbent to remove nitrogen, carbon dioxide and water. The beds may operate at a pressure of 15 to 50 psig avoiding the need for further compression. Cooling water may be used to extract heat following compression of the air. A typical small PSA plant which may be skid mounted would consume 24 kW of electricity and have a capacity of 0.5 Tonnes per day at a flow rate of 14000 l/hour. The gas composition produced is as follows:

Oxygen	90 to 93%
Argon	4.5 to 5%
Nitrogen	0.5 to 5%
Water	<10 vpm

A typical large PSA plant would consume 300 kW of electricity and have a capacity of 15 Tonnes per day at a flow rate of 430000 l/hour.

Eventually the bed will become exhausted and a second bed will be switched in to allow uninterrupted supply of product while the first bed is regenerated. The exhausted bed is regenerated by releasing the pressure and allowing the nitrogen to desorb and vent to atmosphere. An enhancement of this process is the Vacuum Swing Absorber (VSA) where more efficient use of the bed is made by allowing regeneration under vacuum.

To allow uninterrupted supply during maintenance or where demand follows a high-peaking pattern a liquefaction and a storage tank may be provided.

When a supply of nitrogen is required, a carbon molecular sieve is used to absorb oxygen, otherwise the plant works in a similar fashion.

Cryogenic Air Separation

In this type of plant (Figure 1) the air is separated into oxygen and nitrogen by fractional distillation at cryogenic (extremely cold) temperatures, using high pressure and low pressure distillation columns. Large quantities of oxygen and nitrogen, as well as smaller quantities of other gases, are able to be produced.

Air is drawn through a filter and compressed by a turbo compressor. The air is then washed and cooled by direct contact with cooling water. The carbon dioxide and water are then removed from the air using dual molecular sieve beds on alternate duty. The purified air is cooled close to its liquefaction point in a heat exchanger against the outgoing gaseous nitrogen and oxygen products.

The cooled air passes to the high pressure column, and also the low pressure column via an expansion

turbine as shown in Figure 1. This expansion further cools and hence liquifies the air.
The high pressure lower column runs at approximately 600 KPa (6 Barg) and provides an initial separation between the oxygen and nitrogen. The oxygen which has a boiling point of 90.2°K, and the nitrogen which has a lower boiling point of 77.4°K, form into an oxygen rich liquid (35% oxygen) at the base and nitrogen gas (5% oxygen) at the top. The low pressure upper column completes the separation into high purity oxygen and nitrogen product and waste nitrogen.

Analysis Techniques

Servomex paramagnetic transducer for oxygen purity measurements

Oxygen is virtually unique in that it is paramagnetic and therefore attracted into a magnetic field. The Servomex paramagnetic oxygen transducer fitted in the 4100 uses this effect in its magneto dynamic cell. The output of the transducer is extremely linear and because the transducer is maintained in a temperature controlled environment and pressure compensated the output is extremely stable. This transducer is ideal for monitoring oxygen purity levels in air separation plant oxygen product and intermediate streams.

Servomex 704 Zirconia cell for trace oxygen measurements

The zirconia cell in the 4100 analyser consists of a disc of zirconia which when heated to several hundred degrees centigrade conducts oxygen ions. When the concentration of oxygen on each side of the disc is different there will be a flow of oxygen ions through the disc to produce a charge build up related to the difference in oxygen concentration. Air is maintained on one side of the disc as a constant reference level of oxygen, while sample gas to be measured is passed over the other side of the disc. The potential difference created is related to the difference in oxygen via the Nernst equation given overleaf.

$$\text{Cell output} \propto \frac{\text{reference oxygen concentration}}{\text{sample oxygen concentration}}$$

As can be seen from the equation the output of the cell increases with decreasing sample concentration, this makes the zirconia cell ideal for measuring the trace levels of oxygen in nitrogen product and other streams on an air separation plant.

Conventional zirconia cells do not operate successfully in the presence of combustible gases such as hydrogen, carbon monoxide and hydrocarbons which may be encountered on air separation plant. This is because these gases combust on contact with the conventional zirconia cell which contains catalytic electrodes. This combustion consumes the oxygen and results in a low oxygen reading, and recovery from this state may take several minutes.
However the Servomex 704 zirconia cell has reduced catalytic activity and runs at a lower temperature than conventional zirconia cells, and the effect of combustible gases is therefore greatly reduced. Any residual effect is quickly removed when the combustible gas is no longer present.

Comparison of Servomex 704 Zirconia Cell and Electrochemical Cell

It is important that any upset conditions on air separation plant are detected quickly.
Electrochemical cells suffer from two problems which prevent them from meeting this requirement. Because of the construction of the electrochemical cell the response is inherently slower than zirconia technology. Following exposure to higher levels of oxygen the electrochemical cell will become saturated, rendering it unusable for several hours potentially resulting lost production. The speed of response of Servomex zirconia cell and fast recovery from exposure to higher levels of oxygen makes them ideal for this application.

Location of Analysers

Measurements are usually required at these points on cryogenic air separation plant:

- Trace oxygen in liquid nitrogen product (1 to 10 vpm oxygen)
- Trace oxygen in gaseous nitrogen product (1 to 10 vpm oxygen)
- Purity of liquid oxygen product (99.5% oxygen)
- Purity of gaseous oxygen product (99.5% oxygen)
- Low level oxygen in crude argon (2% oxygen)
- Purity of oxygen product storage (99.5%)
- Trace oxygen in nitrogen product storage (1 to 10 vpm)

On PSA plant the oxygen in nitrogen levels are higher so paramagnetic transducers may be used for the nitrogen product purity measurement.

Other Applications

Measurements of oxygen purity and trace oxygen in nitrogen are also required on tanker loading and bottle filling facilities and for verification of product quality. The Servomex 4100 is also suitable for these applications. In addition, several other Servomex oxygen analysers such as the 570A are available to provide portable spot check measurements where required.

Servomex companies, agents and representatives are located throughout the world. Your nearest contact is:

Visit www.servomex.com for technical data sheets, application and technology information for all Servomex analysers.

Servomex has a policy of constant product improvement and therefore reserves the right to change specifications without notice.

Certificate No. _____Q05166
BS EN ISO 9001

Servomex Group Limited, Jarvis Brook, Crowborough, East Sussex, TN6 3DU, England ☎ (44) 1892 652181. Fax: (44) 1892 662253
Servomex B.V., Stephensonstraat 20, 2723 RN Zoetermeer, Netherlands ☎ (31) 79-346 42 42. Fax: (31) 79-342 08 19
Servomex S.A., 8 Rue Proudhon, B.P. 50, 93212 St Denis La Plaine Cedex, France ☎ (33) 1 49 46 22 50. Fax: (33) 1 49 46 22 51
Servomex GmbH, Münsterstraße 5, 59065 Hamm, Germany ☎ (49) 23 81 68 82 13. Fax: (49) 23 81 68 81 75
Servomex Company Inc., 90 Kerry Place, Norwood, MA 02062, USA ☎ (1) 781-769-7710. Fax: (1) 781-769-2834
Servomex Company Inc., 525 Julie Rivers, Suite 185, Sugar Land, Texas 77478-2847, USA. ☎ (1) 281-295-5800. Fax: (1) 281-295-5899
Servomex Asia Pacific Ltd, 7F, No.88, Sec. 6, Chung Shan N. Rd., Taipei, Taiwan ☎ (886) 2-2833 8848. Fax: (886) 2-2833 8844
Servomex Asia Pacific Ltd, (Spectris Group China Ltd-Shanghai Representative Office)
B-1, 21/F, Phase 2 Shanghai East Ocean Centre, No.618,East Yan An Road,Shanghai 200001, PR China ☎ (86) 21 5385 5332 Fax: (86) 21 6375 8139
Global email: info@servomex.com **Website:** http://www.servomex.com

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