Eco Oxygen Technologies Technical Bulletin

OPTIONS FOR SOURCE OF OXYGEN GAS - LOX OR ON-SITE GENERATION

Bulk Liquid Oxygen Storage (LOX)

Liquid oxygen is classified as an industrial gas and is widely used for industrial and medical purposes. Liquid oxygen is obtained from the oxygen found naturally in air by fractional distillation.

The typical setup for providing oxygen to the ECO2 Superoxygenation Cone using Liquid Oxygen (LOX) consists of a storage tank and evaporator. The storage tank holds liquid oxygen which is converted to the gaseous phase via the evaporator as necessary per the flow requirements of the system. A municipality or other user of this system normally leases this equipment, but can also opt to purchase. Liquid oxygen requires a sophisticated containment vessel to maintain the 250 psig pressure required to keep it in the liquid state. When the controls call for oxygen delivery, a control valve on the tank opens and releases liquid oxygen to the evaporator. The evaporatior is a pressurized, radiator-like device that raises the temperature of the liquid oxygen, causing it to vaporize. When the oxgen vaporizes, it creates its own pressure; thus, compressors are not required. Another control valve and regulator at the discharge end of the evaporator meters the vaporized oxygen to the point of application. Liquid oxygen systems can be found outside of nearly every hospital and most manufacturing facilities. They have been proven to be a safe and effective system for delivering pure O_2 in many applications.

As this equipment may be leased, all upkeep and maintenance is performed by the supplier. This requires access to the storage site by the 3rd party supplier, as well as protective measures to prevent tampering as the system must be placed outside. A fence or other similar enclosure should be constructed as well as barricades, bollards, or other similar devices to prevent vehicular damage to the system. The LOX system must be situated appropriately to provide access for a tractor-trailer or large tanker truck to facilitate filling of the storage tank. Additionally, concrete or crushed stone must be used as liquid oxygen can detonate unpredictably on subsequent contact with asphalt. The gaseous oxygen is available at 250 psi, which is adequate for most applications.

Oxygen Generation

Oxygen generation requires equipment purchase and attention to maintenance requirements. Oxygen generators are commonly used in water treatment, medical facilities, and manufacturing. Oxygen generators operate by passing an air stream through a molecular sieve which traps the nitrogen and discharges high purity oxygen for use. The nitrogen is then discharged into the atmosphere.

Pressure Swing Adsorption (PSA)

Pressure Swing Adsorption (PSA) is a technology used to separate some gas species from a mixture of gases under pressure according to the species' molecular characteristics and affinity for an adsorbent material. It operates at near-ambient temperatures and so differs from cryogenic distillation techniques of gas separation. Special adsorptive materials (e.g., zeolites) are used as a molecular sieve in the oxygen generator, preferentially adsorbing the target gas species at high pressure. The process then swings to low pressure to desorb the adsorbent material. The air compressor increases the pressure of atmospheric air, which is then passed through an air dryer and stored in a pressurized tank. The air storage tank feeds the pressurized air into the generator which then passes the oxygen through to the oxygen storage tank.

Using two adsorbent vessels allows near-continuous production of the target gas. It also permits so-called pressure equalization, where the gas leaving the vessel being depressurized is used to partially pressurize the second vessel. This results in significant energy savings, and is common industrial practice.

Vacuum Swing Adsorption (VSA)

Vacuum Swing Adsorption (VSA) differs from cryogenic distillation techniques of gas separation as well as Pressure Swing Adsorption (PSA) techniques due to the fact that it operates at near-ambient temperatures and pressures. VSA may actually be best described as a subset of the larger category of PSA. It differs primarily from PSA in that PSA typically vents to atmospheric pressures, and uses a pressurized gas feed into the separation process. VSA typically draws the gas through the separation process with a vacuum. For oxygen and nitrogen VSA systems, the vacuum is typically generated by a blower.

The simplicity of the VSA process may allow for greater efficiency and cost savings, and less maintenance vis-à-vis PSA systems. The VSA process operates on the steepest part of the isotherm curves and thus has the potential to extract maximum sieve and power efficiencies. The integrated blower, which also serves as a vacuum regenerator, results in low feed pressure. The dramatically lower pressure swings in the VSA system eliminate the need for a feed air compressor, which translates into lower power consumption for VSA systems. As a result, power savings of as much as 50% can be achieved, when compared to the most simple PSA systems. The low pressure air input into the adsorber vessel in combination with the high efficiency of the vacuum applied during the desorption stage means that a single adsorption vessel may be used. In contrast to traditional PSA systems, which require feed air compressors as well as process valves and associated dryers and feed air filtering systems, this single-vessel VSA system eliminates many of the design problems associated with a two-bed PSA.

Advantages to generating oxygen onsite are that oxygen is generated as the oxygen is being used eliminating the requirement for onsite bulk oxygen storage and a reduced system footprint. Oxygen generation produces oxygen as a gas, not as a liquid, so there is no truck traffic delivering LOX. Thus, safety issues centered on oxygen storage and truck delivery are negated by generating oxygen onsite. PSA oxygen generation equipment provides approximately 40~50 psi of pressure and the VSA equipment provides 100 psi of pressure, which may or may not be adequate for the ECO2 SuperOxygenation system. If increased oxygen pressure is required, a specialized oxygen compressor will also need to be supplied.

Cost Comparisons

Considering liquid oxygen at $0.05/lb, electrical costs at $0.10/kwhr and a capital recovery factor calculated at 8% over 10 years, the amortization and usage cost for 1 ton/day of O2 using the various systems is as follows:

LOX - $113.56
VSA - $102.07
PSA - $116.19