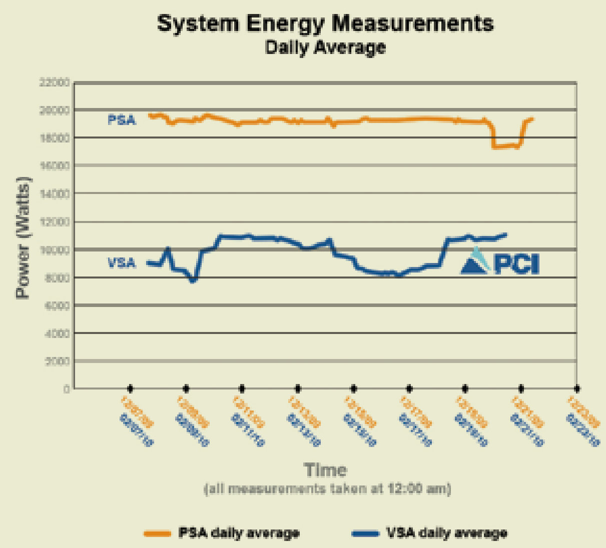
Figure 2. Energy Measurements



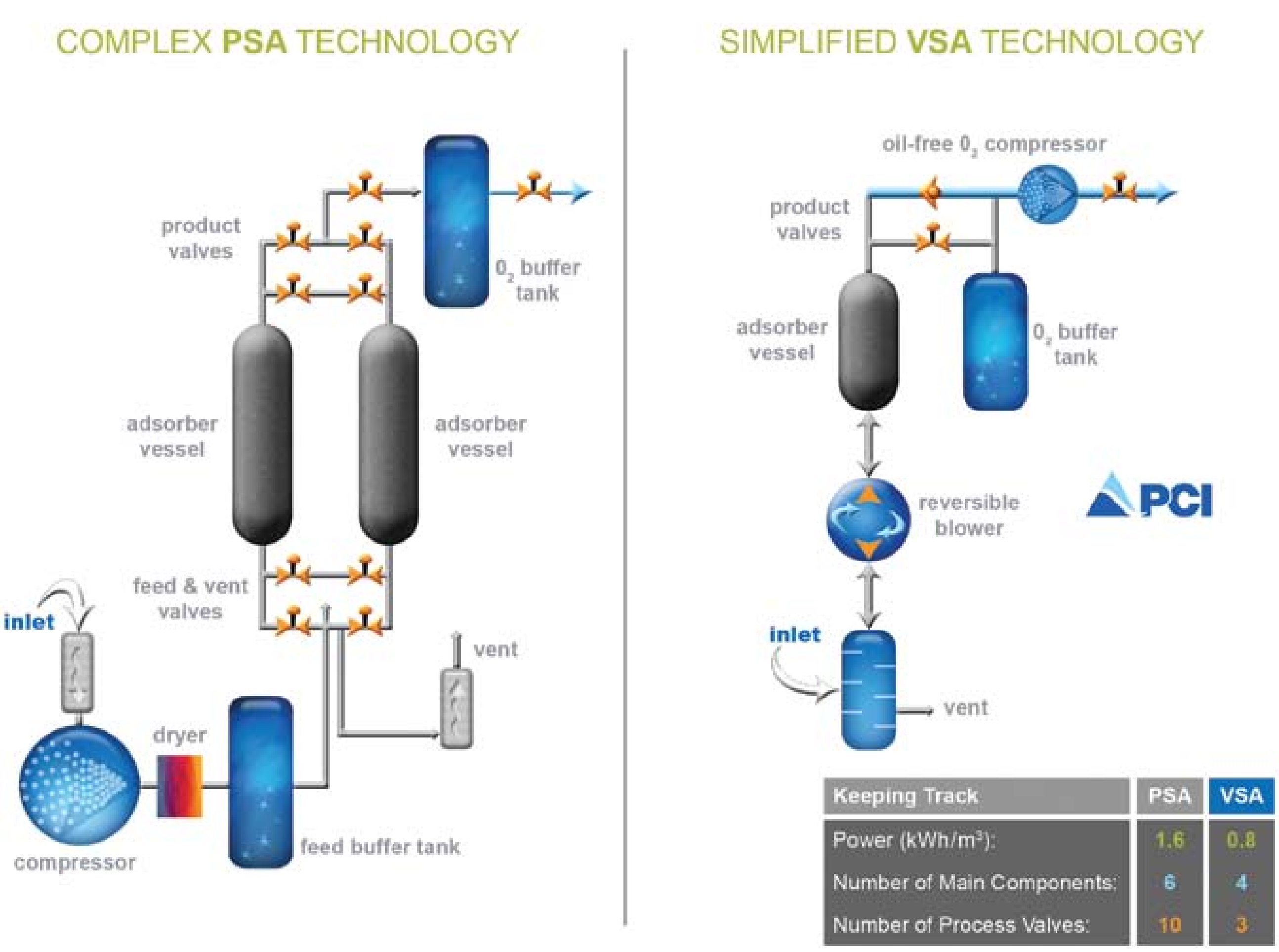
Onsite Oxygen Supply

Total cost of ownership and energy efficiency

By David Schneider, Bob Wimmer & Bill Goshay

Pacific Consolidated Industries (PCI), a California-based manufacturer of oxygen generators utilized in water and wastewater applications, conducted an energy study on behalf of a southern California municipality. This study compared life-cycle costs of two technologies used to generate onsite oxygen supply for two separate lift station odor control projects. Each lift station was supplied oxygen by the competing oxygen supply technologies: vacuum swing adsorption (VSA) and pressure swing adsorption (PSA).

Figure 1. PSA vs. VSA Oxygen Technologies



Keeping Track	PSA	VSA
Power (kWh/m³):	1.6	0.8
Number of Main Components:	6	4
Number of Process Valves:	10	3

Project Background

The city of Laguna Beach, Calif., had odor problems at several manholes near the discharge of a 3-mile-long force main. Hydrogen sulfide (H_2S) levels peaked at concentrations of 800 ppm, whereas the odor threshold from H_2S is less than 1 ppm. Additionally, the city was conscious of the potential corrosion issues associated with high concentrations of H_2S and decided to employ a pure-oxygen injection system from ECO2 Oxygen Technologies.

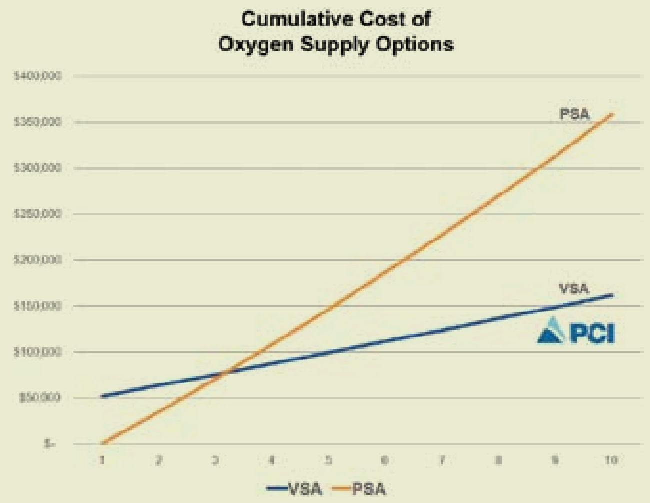
The solution system dissolves oxygen provided by onsite oxygen generation into a sidestream that is then blended back into the force main flow. The high dissolved oxygen (DO) levels create aerobic conditions preventing the formation of H_2S, eliminating odor complaints and significantly improving the longevity of the lift station infrastructure.

While this first odor control project was supplied with pure oxygen from a PSA system, in early 2009 the city installed a second ECO2 solution in which PCI's VSA system was used to supply the oxygen. While city staff members were aware of the power savings associated with the VSA, they commissioned PCI to perform a power monitoring study to compare the two oxygen supply systems.

VSA Oxygen Technology Benefits

While adsorption-based onsite oxygen systems are capable of delivering oxygen at concentrations ranging from 90% to 95% using a zeolite molecular

Figure 3. Cumulative Costs



sieve process, there are significant advantages in the main operating components of a VSA and the pressures at which the unit operates. The diagrams presented in Figure 1 (see page 48) highlight key differences between a typical onsite oxygen system and VSA technology.

Central to the operation of adsorption-based onsite oxygen system technologies is the ability of the molecular sieve to separate oxygen from nitrogen in the feed airstream. This VSA design of the feed air system uses a reversible blower that operates at an order of magnitude lower pressure than the air compressor used in typical onsite oxygen systems. The result is significant energy savings because higher pressures are directly proportional to higher energy consumption. In addition, VSAs do not require a dryer unit because water that would otherwise foul the adsorbent material is not condensed.

One common cause of high-cost maintenance repairs is oil contamination of the adsorbent material. This VSA design uses an oil-free blower to eliminate this fouling problem. Another benefit of the lower-pressure operating regime of VSA technology relates to the longevity of the adsorbent material. The higher-pressure swings associated with typical onsite oxygen systems may lead to attrition of the adsorbent material, limiting their useful life and requiring maintenance personnel or contractors to have to repack the bed at regular intervals. This VSA design, with its lower operating pressures, is designed so that the adsorbent material will last for the entire lifetime of the equipment.

The adsorber vessels allow the oxygen to pass through to produce 93% (±3%) purity oxygen gas. A key difference in this VSA design is a reversible blower that is utilized for both generation and regeneration of a single adsorber vessel. Most onsite oxygen systems use complex valve systems to isolate two adsorber vessels for this generation and regeneration sequence. These valves are often one of the highest maintenance items associated with onsite generation and detrimentally affect the reliability of the oxygen system.

While many applications require pressures ranging from 10 to 100 psig, the VSA can deliver similar pressures to other onsite oxygen systems with an oil-free oxygen compressor on the outlet gas from the adsorber. The advantage of this design is that the oxygen compressor on a VSA is only compressing pure oxygen, about one-fifth of the gas that is compressed prior to gas separation. The benefits of a VSA are summarized in the table shown in Figure 1, which indicates the energy savings and reduced number of main component/valves. A VSA will save approximately 50% of the energy consumption of equivalent size and delivered pressure. A VSA also eliminates 33% of the main components and 70% of the process valves, increasing its reliability and significantly reducing maintenance costs.

Energy Measurements & Analysis

A power meter was attached to the power supply for the compressor on the first onsite oxygen system, located at one of the city's lift stations. According to the power consumption data recorded, the average power demand was 19.2 kW. In addition, another 1.1 kW of demand that was not measured on this power line can be attributed to the dryer and controls circuit, for a total average power demand for this oxygen system of 20.3 kW.

Conversely, the VSA system installed at the second lift station has a total average power demand of 9 kW, for a delivered pressure of 55 psig. This indicates that there was an average power savings of 11.1 kW for the VSA for an equivalent system in oxygen flow, purity and pressure. The raw data for energy consumption and demand was collected by Fluke Power Log 2.8.2 and post-processed to show the average power consumption.

The results of both the first installation of an onsite oxygen system and VSA data are shown in Figure 2 (see page 48). In addition to energy consumption savings associated with the VSA, the data also indicates that there is a demand/charge savings.

The first onsite oxygen system's peak demand occurs at approximately 26 kW, and the VSA at 11.6 kW, resulting in a demand reduction of nearly 55%. Assuming 90% utilization, the VSA reduces annual energy consumption by nearly 90,000 kWh, or 55% of the first onsite oxygen system's energy consumption. Because a VSA reduces energy consumption, there is often energy-efficiency grant funding available that can offset the purchase price.

Life-Cycle Cost Analysis

Utilizing the recorded power data, an analysis was performed on total life-cycle cost of the two systems. In addition to the power cost savings, the simplified design of the VSA system significantly reduces the maintenance cost, which further improves the life-cycle costs. Using information on actual maintenance and power costs, a discounted cash flow (DCF) model was performed comparing the two onsite oxygen systems. The 10-year DCF model assumptions were:

- Discount rate of 12%;
- No tax shield (municipal customer);
- Maintenance escalation of 2%/year; and
- Energy costs escalation of 5%/year.

Figure 3 shows the results of this DCF model for the cumulative cash flow for each supply system. It indicates that replacing the first onsite oxygen system with a new VSA will result in a payback in 27 months. The VSA will save the city approximately $265,000 over the next 10 years and will reduce the total cost of ownership by 65%.

Installation Approved

The power study conducted at two lift stations utilizing two onsite oxygen generation technologies clearly indicates that there is a significant cost savings associated with VSA technology. A short payback period can lead to significant cost savings over the lifetime of the system and save a substantial amount of energy, which is directly related to greenhouse gas emissions.

Over 10 years, the VSA will save the city of Laguna Beach 870,000 kWh of energy consumption, help it avoid approximately 3,500 metric tons of greenhouse gas emissions and eliminate $260,000 in costs, or 65% of the costs associated with the first onsite oxygen system.

Based on this analysis, the city has made the decision to move forward with a conversion of the first onsite oxygen system to a VSA system. It is expected that the VSA will be installed and operating in October 2011. WWD

David Schneider is sales director, commercial oxygen, for PCI. Bob Wimmer is product line manager, commercial oxygen, for PCI. Bill Goshay is senior electrical engineer for PCI. Schneider can be reached at dschneider@pcigases.com. Wimmer can be reached at bwimmer@pcigases.com. Goshay can be reached at bgoshay@pcigases.com.

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