

A collage of three medical images: on the left, two surgeons in blue scrubs and masks; in the center, a close-up of a blue pressure gauge with the needle pointing to 10; on the right, a patient lying down with a clear oxygen mask over their nose and mouth.

ON-SITE OXYGEN SOLUTIONS

Health and Wellness

..... Non U.S. Markets Edition

Improve productivity, reduce operating costs, and benefit the environment

TABLE OF CONTENTS



Content

About PCI Gases and its VSA Technology

- Introduction to PCI Gases & VSA Technology
- VSA Technology
- Load Following "Smart Control System"
- Remote Monitoring Capability
- VSA Adsorber Bed Guarantee
- VSA vs. PSA: Total Cost of Ownership & Energy Efficiency

Health and Wellness

- Health and Wellness Application Profile
- Selection of Installation Pictures
- Oxygen 93 vs. 99
- DOCS VSA Oxygen Quality
- Onsite Generation of Medical Oxygen

Product Profiles

- DOCS Product Line Overview for Medical
- DOCS 80 Medical Product Profile
- DOCS 200 Medical Product Profile
- DOCS 500 Medical Product Profile
- Boost 66 Product Profile
- Oxygen Storage and Distribution Product Profile

INTRODUCTION TO PCI GASES AND VSA TECHNOLOGY



Company Overview:

Pacific Consolidated Industries (PCI Gases) is a company based in Riverside, USA, that makes point-of-use air separation equipment that produce either nitrogen or oxygen. This equipment finds its use in markets such as Medical, Industrial, Oil & Gas, and Military. One of our key product lines is the DOCS (Deployable Oxygen Concentration System). This is used to make industrial and medical grade oxygen.



Unique VSA Technology:

We use a unique Vacuum Swing Adsorption (VSA) technology to generate oxygen that uses significantly less valves and rotating components than competing technologies. This in turn leads to inherently higher reliability, which is important in countries with under-developed or challenging infrastructures where oxygen supply is usually the most uncertain.

In addition, this unique technology leads to 50% less power consumption compared to its competitors. This results in very low operating costs and hence addresses another large problem for many countries, the high cost of oxygen for acute hospital care.

We've been manufacturing oxygen concentrators using this technology for over 10 years. During the period, we've built around 500 systems ranging from sizes of 4 m³/hr to 600 m³/hr. The units have found homes in 40+ countries across all continents in applications as diverse as civilian hospitals, mobile field hospitals, military medical use, high altitude oxygen enrichment, cylinder filling, water and wastewater treatment, aquaculture, pulp & paper, metal cutting, combustion, mining among others.

TECHNOLOGY PROFILE



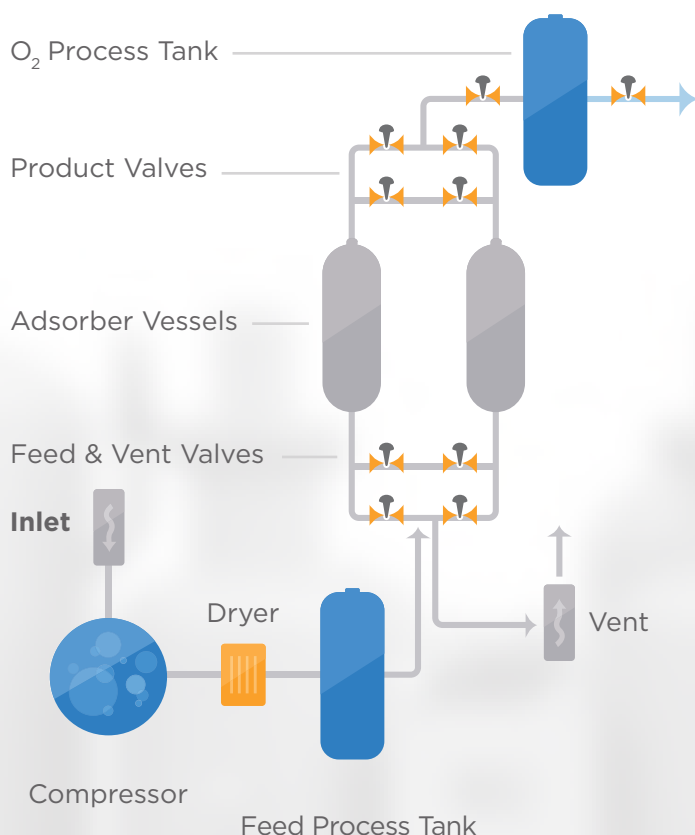
To produce oxygen from air, PCI uses a proprietary Vacuum Swing Adsorption (VSA) process that eliminates many of the design problems associated with traditional Pressure Swing Adsorption (PSA) systems.

Our innovative VSA system eliminates the need for process valves, feed air compressors, and associated dryers and feed air filtering systems.

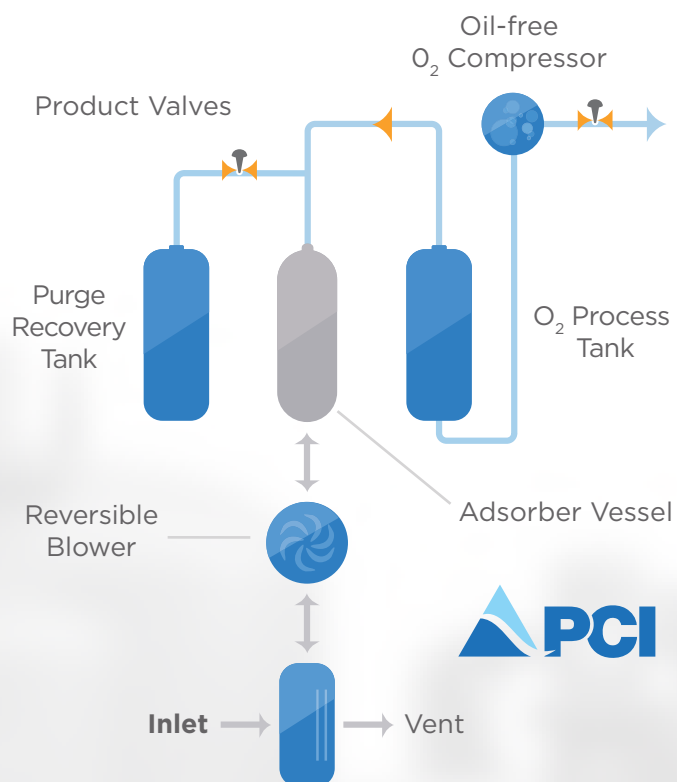
PCI's robust VSA process extracts maximum sieve and power efficiencies = low cost (both CapX and OpX) high purity oxygen generation.

VACUUM SWING ADSORPTION (VSA) VS PRESSURE SWING ADSORPTION (PSA)

COMPLEX **PSA** TECHNOLOGY



SIMPLY STATE-OF-THE-ART
VSA TECHNOLOGY BY PCI GASES



Keeping Track

	PSA	VSA
Power (kWh / m3)	1.3-1.5	0.65
Number of Main Components	6	4
Number of Process Valves	10	3

ADVANTAGES OF VSA OVER PSA PROCESS TECHNOLOGY

PCI's unique Vacuum Swing Adsorption (VSA) technology has several advantages over the more commonly used PSA process:

Energy Saving:

- Needs no feed air compressor (> 50% energy savings vs. conventional PSA systems)
- Load following capability reduces energy consumption even more at reduced flow rates

Installation / Operation / Maintenance / Advantages:

- Uses an oil-free blower, thus avoiding any oil carryover common with oil-lubricated compressors - great for medical applications
- Lower operating pressure minimizes the potential for water condensation
- Not as susceptible to humid environments as are PSA systems
- Single-bed VSA process eliminates virtually all process valves and required manifolds
- Low operating pressure minimizes sieve dusting (the sieve removes the nitrogen from the air), because the pressure swing is an order of magnitude lower, resulting also in lower operating cost
- VSA Adsorber sieve material has a much longer service life than that in PSA vessels - which commonly need repacking of sieve material every 3-5 years - again producing a much lower operating cost
- Shows no, or significantly less, degradation of performance at high altitude - unlike PSA technology
- Turn-key integrated solution—there is no need to size / source air compressors, dryer systems and product or feed buffer tanks

Environmental Advantages:

- No air compressor, therefore no disposal of oil saturated with compressor condensate
- Oil free design eliminating risk of oil carryover downstream of the oxygen system
- PCI utilizes a sealed adsorber bed that does not require opening to replace spent molecular sieve. Therefore there is no residual waste to dispose of
- Pollution free operation - use of electric energy
- Air cooled, no cooling water or the required chemicals for treatment

All of the above advantages reduce the cost of preventive maintenance and repairs, thereby reducing the operating cost.

LOAD FOLLOWING



PCI'S LOAD FOLLOWING "SMART CONTROL SYSTEM"

PCI's Load Following feature saves energy by slowing down the VSA blower motor during periods of reduced flow.

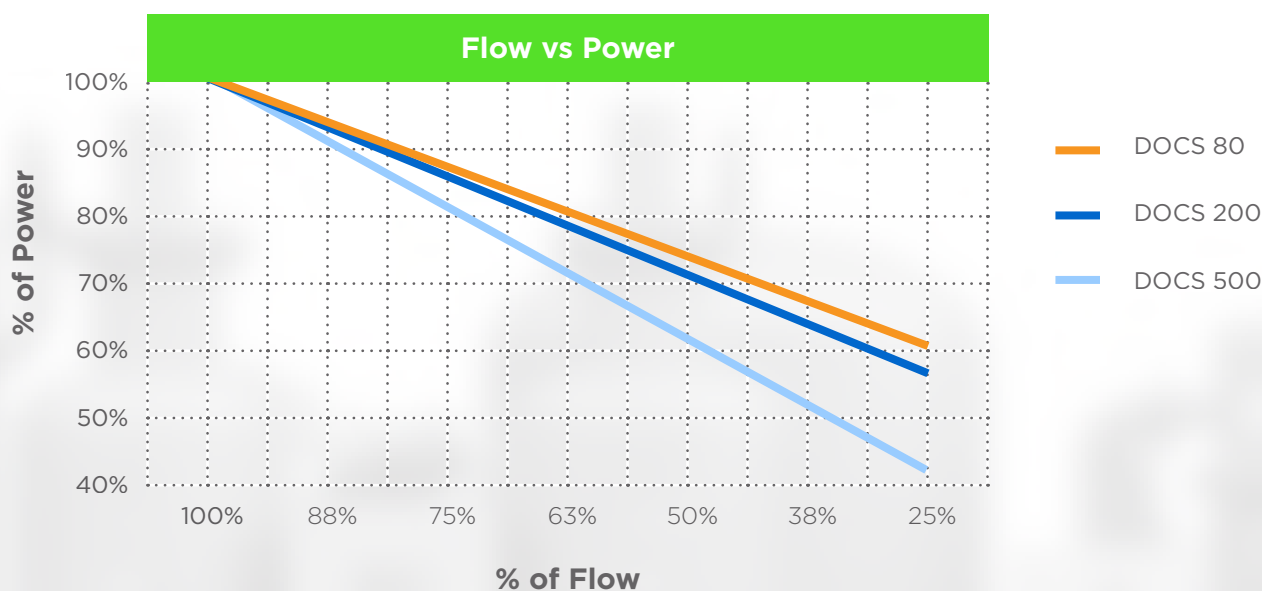
DOCS machines have a process tank which helps smooth out the vacuum swing adsorption process and provides uninterrupted gas flow. During the VSA process, the pressure in the process tank cycles between a maximum value and a minimum value. During periods of high flow demand, the minimum process tank pressure drops. When the demand decreases the minimum process tank pressure rises.

DOCS machines are programmed to maintain a minimum process tank pressure based on a Set Point which is determined at the factory. When the minimum pressure is above the Set Point, the VSA blower motor slows down to allow the minimum pressure to drop to the Set Point. Conversely, if the minimum pressure drops below the Set Point the VSA blower speeds up. Slowing the VSA blower during reduced flow saves energy. The minimum blower speed is usually set to 30-40% of full speed*.

Load Following occurs when the following conditions are met**:

1. Current minimum process tank pressure is above the set point.
2. The machine has been running for approximately 5 minutes or more.

Load following is enabled by default for all industrial units.



*Other settings are possible, contact the factory for details.

**During load following the sound of the machine changes with flow. For example, it takes longer for the machine to reverse the VSA blower's direction. It is possible to set a minimum acceptable purity value that the unit will increase blower speed in order to maintain.

REMOTE MONITORING CAPABILITY



BUILT-IN REMOTE MONITORING FEATURE

The oxygen concentrator control system includes the ability to remotely monitor critical system functions. All start/stop/alarm/monitoring can be performed from any computer once access to the internet has been established. This feature also provides the customer or PCI the ability to log-on and monitor system performance or troubleshoot operational issues.

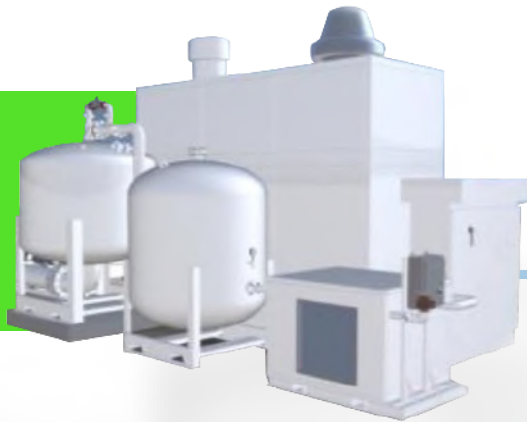
Features:

- Dashboard, diagnostic screen, data logging screen
- No special software required — just an Internet browser
- E-mail notifications
- Remote monitoring/start-stop capability

Benefits:

- View entire system status at a glance
- Helps prevent unscheduled downtime
- Receive alerts on faults or out-of-range conditions
- Increased productivity and reduced plant downtime with regular monitoring of on-site oxygen system

With a PCI Gases remote monitoring system, all you need is an internet browser to view the health and status of your DOCS units from anywhere in the world!



3G Router



Internet



Wi-Fi



Service and/or alarm messages can be sent via e-mail to a mobile device.

VSA ADSORBER VESSEL GUARANTEE



DOCS PLATFORM VSA ADSORBER BED GUARANTEE

The Vacuum Swing Adsorption (VSA) process used in our Deployable Oxygen Concentrator Systems (DOCS) is based on a totally reversible cycle. Different than systems using Pressure Swing Adsorption (PSA) process technology, the water vapor in the air does not condense out during our process cycle. As a result, the molecular sieve does not degrade over time.

In addition, our molecular sieve beds have a unique design that mechanically holds the sieve media in place, thus eliminating any material attrition.

Therefore, under normal operation, standard conditions, and sufficient air quality¹, the VSA adsorber bed life is expected to be at least 10 years.

Depending on the individual site factors, PCI will warranty² the VSA Adsorber Bed assembly for up to 10 years³.

This makes PCI the only company in the industry worldwide to offer such a warranty.



¹ Meets or exceeds ISO 8573-1 class 2 for particles and class 1 for oil; customer must provide test report from certified test laboratory before start-up and upon request during the warranty period. Meets all site conditions listed in PCI's DOCS standard O&M Manuals.

² Apart from the length of the warranty, all other provisions stated in PACIFIC CONSOLIDATED INDUSTRIES LLC TERMS AND CONDITIONS OF SALE apply.

³ Site location must qualify. Proof of operation in accordance with PCI's Operator's Manual must exist. Proper maintenance records must be available upon request.

VSA vs PSA ARTICLE



VSA VERSUS PSA

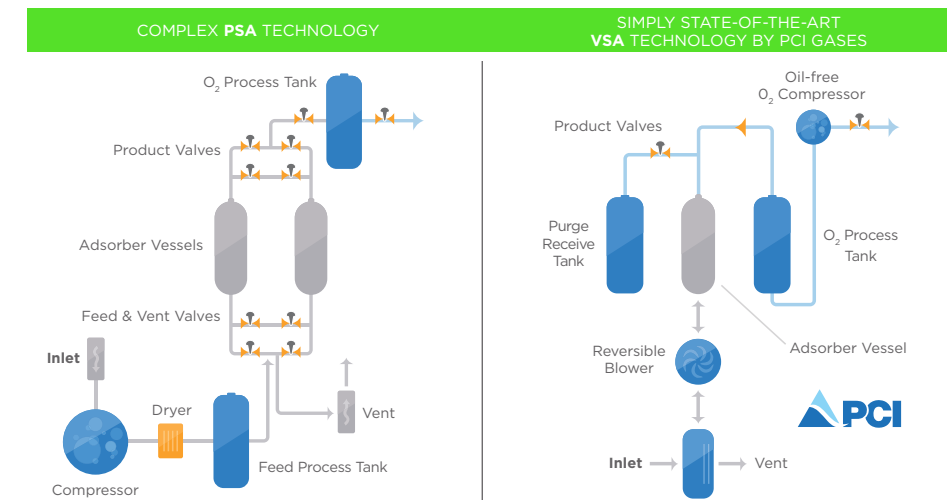
Total Cost of Ownership and Energy Efficiency

Drinking water requires the precise application of the oxygen molecule in several parts of a water treatment process train. On-site oxygen generators can be used for odor control applications and to generate ozone for disinfection or remediation. Oxygen also plays a role in wastewater treatment for aerobic digestion and in aquaculture where the demand for dissolved oxygen in a body of water rises as the number of aquatic species in the water increases. In this article, we look at on-site systems used to provide oxygen for odor control.

Pacific Consolidated Industries (PCI) (www.pcigases.com), a California-based manufacturer of oxygen generators used 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—Vacuum Swing Adsorption (VSA) and Pressure Swing Adsorption (PSA)—used to generate on-site oxygen supply for two separate lift station odor control projects. Each lift station was supplied oxygen by the competing oxygen supply technologies.

Project Background

The City of Laguna Beach, CA had odor problems at several manholes near the discharge of a three-mile-long force main (a force main is a pressurized main pipe, which can carry water, sewage, and other materials). 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 novel, pure oxygen injection system from ECO₂ Oxygen Technologies. The solution system dissolves oxygen provided by on-site oxygen generation into a sidestream, which 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 sta-



tion 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 where a VSA system was used to supply the oxygen. While the municipal staff was 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.

Oxygen Technology Comparison

While PSA and VSA are both capable of delivering oxygen at concentrations ranging from 90–95 percent and use a zeolite molecular sieve (adsorption) process, there are significant differences in the main operating components and the pressures at which the units operate. Figure 1 highlights the key differences between PSA and VSA process technologies.

Central to the operation of both technologies is the ability of the molecular sieve to separate oxygen from nitrogen in the feed air stream. The feed air system of this VSA uses a reversible blower that operates at a pressure of an order of magnitude lower than the air compressor found in PSAs. This results in significant energy savings when using VSA, because higher pressures are directly proportional to higher energy consumption. PSAs also require a dryer unit to remove condensed water vapor that would otherwise foul the adsorbent material. Because VSAs operate at lower pressures, water vapor does not condense on the adsorbent material and a dryer unit is not required.

One common cause of high cost main-

Keeping Track	PSA	VSA
Power (kWh / m ³)	1.5	0.65
Number of Main Components	6	4
Number of Process Valves	10	3

tenance repairs is oil contamination of the adsorbent material. Many PSA compressors utilize oil-flooded screw compressors, which lead to oil vapor mixed with the compressed air. 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 PSA systems lead to attrition of the adsorbent material. This limits their useful life and requires 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 vessel(s) allows the oxygen to pass through and produce 93 percent (+/- 3%) purity oxygen gas. In this VSA design a reversible blower is utilized for both generation and regeneration of a single adsorber vessel. PSAs, on the other hand, 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 on-site generation and detrimentally affect the reliability of the oxygen system.

While the PSA does deliver higher operating pressures for the product oxygen

VSA VERSUS PSA (continued)

gas, the VSA can deliver higher pressures with an oilfree 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. This represents about one-fifth of the gas compressed on a PSA where the compression is done prior to gas separation.

The benefits of a VSA are summarized in Figure 1 (see "Keeping Track" inset). A VSA will save approximately 50 percent of the energy consumption over a PSA of equivalent size and delivered pressure. A VSA also eliminates 33 percent of the main components and 70 percent of the process valves, which increases its reliability and significantly reduces its maintenance costs.

Energy Measurements and Analysis

As part of PCI's energy study for Laguna Beach, a power meter was attached to the power supply for the compressor on the PSA system located at one of the city's lift stations. Figure 2 shows the power consumption data recorded and indicates the average power demand of 19.2 kW. 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 PSA of 20.3 kW. Conversely, the competing 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 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 postprocessed to show the average power consumption. Assuming 90 percent utilization, the VSA reduces annual energy consumption by nearly 90,000 kWh or 55 percent of the PSA energy consumption. Since a VSA reduces energy consumption, there is often energy efficiency grant funding available that can offset the purchase price.

In addition to energy consumption savings associated with the VSA, the data also indicates that there is a

demand charge savings. The PSA peak demand occurs at approximately 26 kW and the VSA at 11.6 kW, resulting in a demand reduction of nearly 55 percent.

Lifecycle Cost Analysis

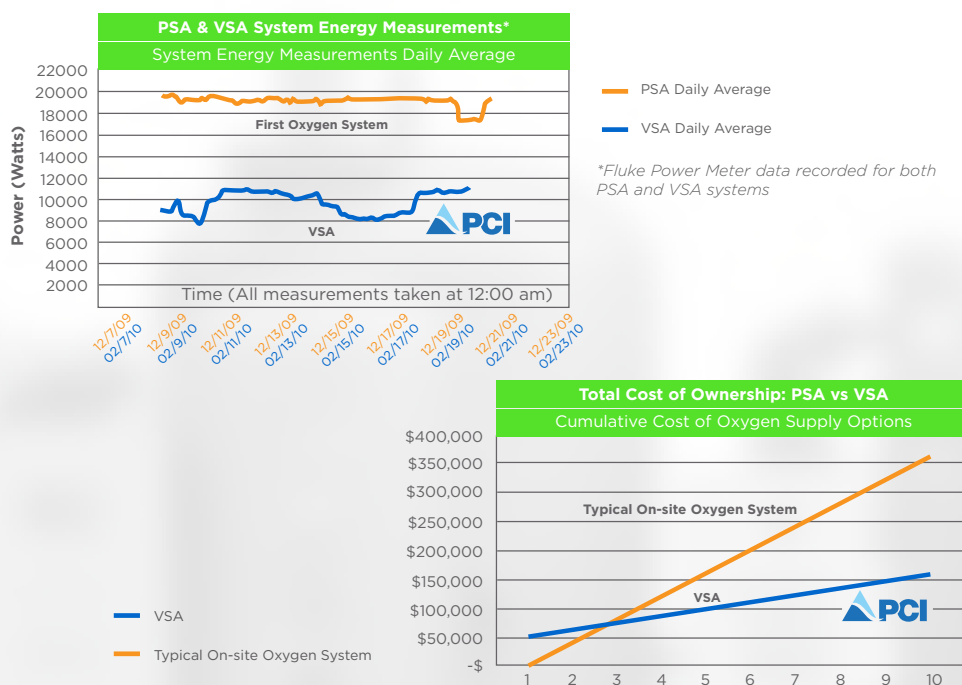
Utilizing the recorded power data for the Laguna Beach systems, an analysis was performed on total life cycle cost for both. In addition to the power cost savings, the simplified design of the VSA system significantly reduces the maintenance cost, which further improves the life cycle costs when compared to a PSA. Using information on actual maintenance costs and power costs, a discounted cash flow (DCF) model was performed comparing the VSA against the PSA. The 10-year DCF model assumptions were: a discount rate of 12 percent; no tax shield (municipal customer); maintenance escalation of two percent/year; and energy costs escalation of five percent/year.

Figure 3 shows the results of the DCF model for the cumulative cash flow for each supply system. It indicates that replacing the current four-year-old PSA system with a new VSA will result in a payback in 22 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 percent.

Summary

The power study conducted at Laguna Beach's two lift stations utilizing competing on-site oxygen generation technologies clearly indicates that there is a significant cost savings associated with VSA technology. Paybacks of less than two years can lead to significant cost savings over the lifetime of the system and save a substantial amount of energy that is directly related to greenhouse gas emissions. Over 10 years, the VSA will save the city: 870,000 kWh of energy consumption; avoid emitting approximately 3,500 metric tons of greenhouse gases emissions; and save \$260,000 in costs or 65 percent of the costs associated with a PSA. Based on the above analysis, the City of Laguna Beach decided to replace their existing PSA with a new VSA. The new 200 liter-per-minute system was installed in November 2010 and had the added benefit of a smaller footprint, which allowed the City to add additional equipment to improve the reliability of their main pump station.*



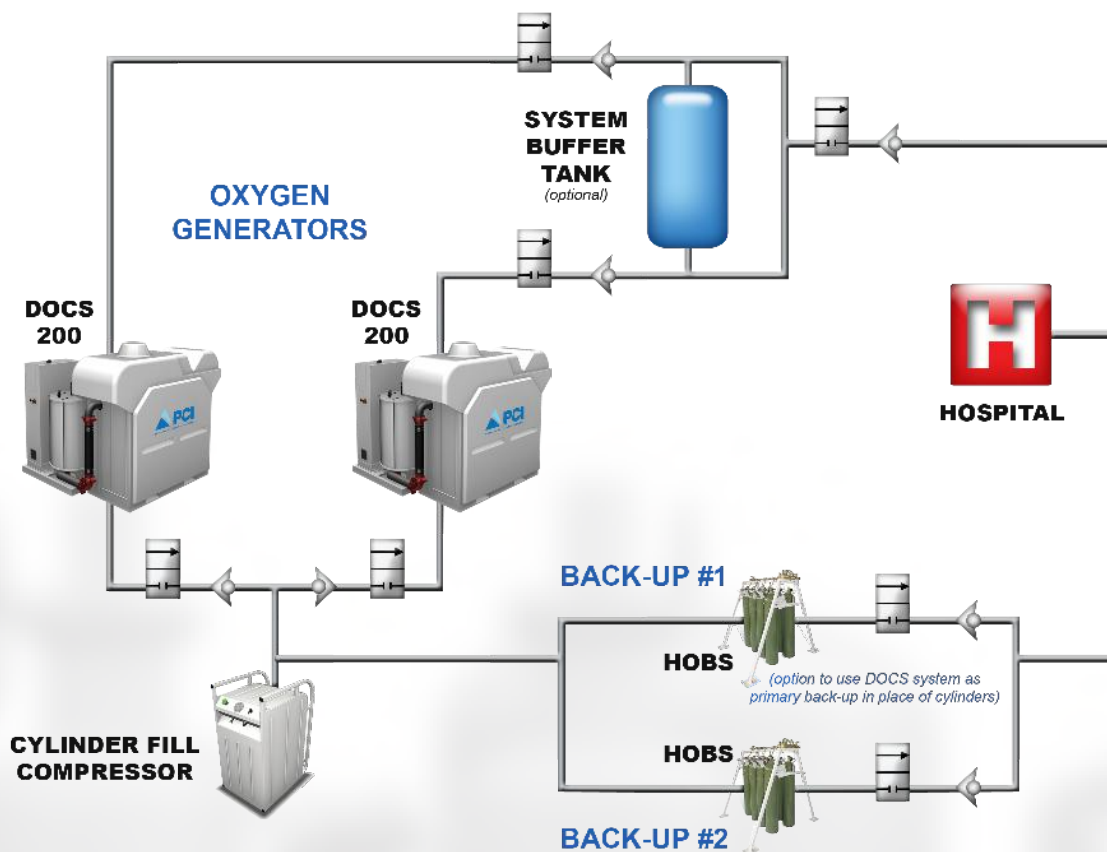
OVERVIEW OF APPLICATIONS

To produce oxygen from air, PCI uses a proprietary Vacuum Swing Adsorption (VSA) process that maximizes sieve and power efficiencies. Such efficiencies translate into low operating costs for oxygen generation.

Deploy and generate oxygen at the point-of-need, on-site, without resupply logistics

Civilian Hospitals

PCI offers a complete product line that fits your need, be it in a small rural hospital or a 500+ bed large hospital, whether it needs to be mobile or stationary. Our oxygen generators are built to be light weight, compact, and basically turn-key. The installation time is measured in hours and not days, which is the case for other systems.



Oxygen Enrichment

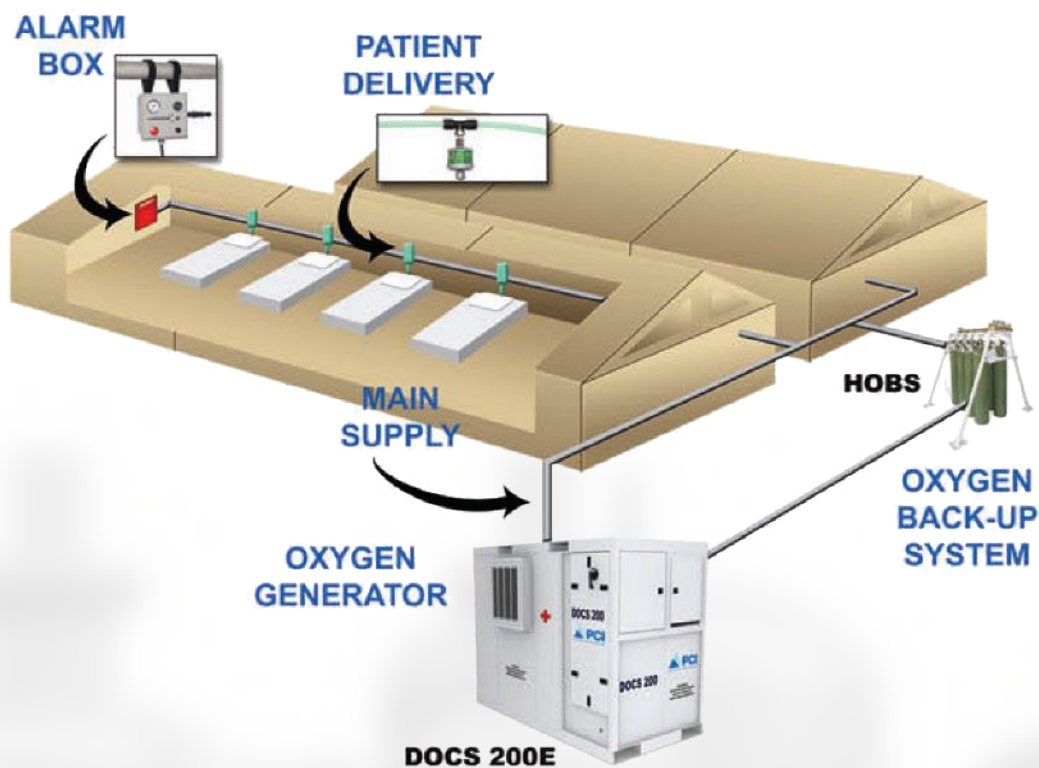
Oxygen Enrichment boosts productivity in high altitude. Mountaineers, miners, pilots, and astronomers; people in these professions attest to the irrefutable fact that high altitude affects people's physical and mental performances and quality of sleep. For those who work under these conditions, the result is impaired performance and productivity. One cost-effective measure to combat high-altitude conditions is oxygen enrichment of working and sleeping quarters via oxygen concentrators.

Military Medical

PCI is a leading supplier of the US Military for oxygen generators and storage systems for their Mobile Field Hospitals (MFH) and Casualty evacuation missions. Over their years of deployment PCI's solutions have saved many lives.

Disaster Preparedness

Our Deployable Oxygen Concentration Systems (DOCS) are the proven commodity in disaster relief applications and mobile field hospitals (MFH) - self contained, easy to operate and fully deployable system that does NOT require installation. The illustration to the right shows a typical oxygen solution for a Mobile Field Hospital:



INSTALLATION PHOTOS



Hospital Installation with Redundant
DOCS 500 Units



Hospital Installation DOCS 200 Unit
in Outside Enclosure



DOCS Units Used for Mobile Field
Hospital Supply and Cylinder Filling



Trailerized DOCS Unit for Disaster
Preparedness Application

OXYGEN 93% vs 99%



GUARANTEED EQUAL QUALITY PATIENT CARE

Oxygen 93% (O₂93) provides the same quality of patient care as oxygen 99% (O₂99). Clinical and scientific studies in Great Britain, Canada, and the United States have demonstrated that, regardless of whether the oxygen supply is O₂93 from oxygen concentrators or O₂99 from cylinders or liquid storage devices, the standard of clinical care remains the same. Several physiological studies have addressed the issue of inspired oxygen (FiO₂) in patients. In a study that examined the efficacy of different oxygen delivery systems, patients were administered both O₂93 and O₂99 at 2 L/min, 3 L/min, and 4 L/min. Results demonstrated that FiO₂ changed, but that the difference was due to different flow rates. At each flow rate, there was statistically no difference in FiO₂ between the different concentrations of oxygen.¹

Other studies have looked at overall patient health and care. In Canada, forty-eight hospitals were surveyed regarding their ten-year experience using oxygen concentrators as their primary oxygen supply. There were no reported adverse consequences as a result of the source of oxygen and the authors concluded that oxygen concentrators which meet Canadian standards are “safe, reliable, and cost effective.” Yet perhaps most revealing, many of the hospitals reported improved overall care and increased consumption after switching to oxygen concentrators, as the reliable and cost-effective supply of oxygen provided by concentrators allowed them to prescribe oxygen more frequently.²

Many international healthcare organizations recommend oxygen concentrators on an equal basis as cylinders for oxygen supply. WHO regards oxygen concentrators as an “effective means of supplying oxygen.”³ In a comparison between cylinders and concentrators, the Association of Anaesthetists of Great Britain and Ireland focused on cost, maintenance, reliability, and similar issues, not on the level of oxygen concentration, for choosing the best oxygen source.⁴ After years of using O₂93 in the field, the US military has declared O₂93 acceptable in any clinical application.

Beyond clinical considerations, switching to O₂93 does not require additional equipment vis-à-vis delivery systems. ISO has issued identical regulations regarding O₂93 and O₂99 delivery systems, and both the Canadian Standards Association (CSA) and the US military make no distinction between systems.⁵ In the previously mentioned study in Canada, all forty-eight hospitals sites used concentrators that provided O₂93 through existing O₂99 gas pipelines.

¹Mitchell, Brent E., Baker, Raymond, Gardner, Stephanie M., Holloway, I Aaron F., Todd, Larry A., “A Descriptive Study of the Percentage of Oxygen Delivered Using the Mercury Tube-Valve-Mask Breathing Circuit at 2 L/min Flow Rates,” Texas University Health Science Center, Defense Technical Information Center, 2002.

²Friesen, R.M., Raber, M.B., Reimer, D.H., “Oxygen concentrators: a primary oxygen supply source,” *Can J Anesth* 1999;46:1189.

³Department of Vaccines and Biologicals, “The Oxygen Concentrator,” in “WHO/UNICEF Product Information Sheets 2000,” World Health Organization, Geneva, 2000, p. 235.

⁴Association of Anaesthetists of Great Britain and Ireland, “Oxygen, Gas Supplies, Equipment, and Maintenance,” *Anaesthesia Resource Vol. 1*, 2004.

⁵Janny Enterprises, “The Clinical Utilization of 93% Oxygen in Civilian Commercial Markets,” 2005, p. 7.

DOCS VSA OXYGEN QUALITY



The oxygen of our DOCS units meets the requirements of the two pertinent monographs in the U.S. American and European Pharmacopeias, USP Oxygen 93 Percent and PH EUR Oxygen (93 PERCENT).

TYPICAL ANALYSIS RESULTS

Analyte	Source Air/Gas	Analyte Results	Specification Limits	Ambient Air/Gas	Reporting Limits*
Oxygen (Volume %)	95.7	Pass	90.0-96.0	N/A	0.5
Carbon Monoxide (ppmv)	<1	Pass	5	N/A	1
Total Gaseous Hydrocarbons including Methane (ppmv)	<5.0	N/A	N/A	N/A	1
Methane (ppmv)	<1	N/A	N/A	N/A	1
Carbon Dioxide (ppmv)	<25	Pass	300	N/A	25
Oil Mist & Particulate [COM:133] (mg/m ³)	<0.01	N/A	N/A	N/A	0.01
Oil Mist (mg/m ³)	<0.01	Pass	0.1	N/A	0.01
Particulate (mg/m ³)	<0.01	N/A	N/A	N/A	0.01
Nitric Oxide (ppmv)	<0.1	Pass	2	N/A	0.1
Nitrogen Oxide (ppmv)	<0.1	Pass	2	N/A	0.1
Sulfur Dioxide (ppmv)	<0.1	Pass	1	N/A	0.1
Water (ppmv)	<2	Pass	67	N/A	2

N/A = Not Applicable

COM: 133 Oil Mist and Particulate quantitative results are reported as a combined amount until the value approaches the Specification Limits.

ONSITE GENERATION OF MEDICAL OXYGEN



THE BLUEPRINT FOR MODERN MEDICAL DEMANDS

Onsite generation of medical oxygen

This article discusses the rise of onsite oxygen generation as a reliable and cost-effective solution for the high demands of the medical market.

Up until 40 years ago oxygen was only produced commercially by the cryogenic distillation of air. Product was either delivered as gas or a cryogenic liquid (LOX). This cryogenic process is very energy intensive, results in a high operating cost and, by virtue of the very low operating temperatures, uses many special components that are both expensive and costly to maintain.

Oxygen produced by the cryogenic process is typically produced at greater than 99 percent purity so that it can be used for essentially all applications. For very small applications oxygen is delivered in cylinders. As the demand increases it is more economical to use vaporized LOX delivered in cryogenic transports to onsite cryogenic storage vessels. For large industrial applications gaseous oxygen is generated onsite.

To optimize the delivered oxygen cost it is necessary to balance the capital required to build the oxygen generation and delivery equipment (CAPEX) and the operational costs of production Third Quarter 2012 • Specialty Gas Report 29 and transportation to the use site (OPEX).

In the 1970s Pressure Swing Adsorption (PSA) to produce oxygen was commercialized. Operating at atmospheric temperature, nitrogen is adsorbed using a molecular sieve material. PSA systems utilize commonly available components, that greatly reduces the CAPEX. Because the oxygen is generated onsite there is no delivery cost. However, the power consumption is very high, resulting in a high OPEX.

The other consideration is that the PSA process produces oxygen at a purity of 93 +/- 3 percent so the process can only be used for applications that do not need the higher purity oxygen produced by the cryogenic process. Further, sub-optimal delivered oxygen cost limits the penetration of PSA systems to small requirements such as homecare oxygen therapy.

To lower the operating costs, several companies developed a variant of the PSA process that uses a vacuum cycle rather than high pressure. This significantly lowers the operating cost, but at the expense of a higher capital cost as it requires larger adsorber beds and a separate air blower and vacuum pump. This variant is known as VPSA.

PCI was asked by the US Military to supply an oxygen generator to meet the needs of its field hospitals in the Gulf War.

In 2001 PCI was asked by the US Military to supply an oxygen generator to meet the needs of its field hospitals in the Gulf War. Their requirement was for a system that was easily deployable, robust, simple to operate and with low operating and maintenance costs.

To meet this requirement PCI developed the Expeditionary Deployable Oxygen Concentration System (EDOCS 120 superseded by the EDOCS 120B) which is shown in Fig 1 (below, left).

Besides generating oxygen, the Expeditionary Deployable Oxygen Concentration System (EDOCS 120) has the capability to fill cylinders and also has a built-in cylinder bank. Therefore, with these capabilities, the EDOCS 120 ensures the hospitals always get the oxygen they need including those needs for peak requirements and during times when the generator was down for power failure and/or maintenance. These units have now been used by the US military for over 10 years.

In 2007, PCI recognized that there was a market need for a line of commercial oxygen generators that from a market perspective would fit between the PSA and VPSA systems (Fig 2, below right). Maintaining the concept of a simple design that has low operating and maintenance costs, the Deployable Oxygen Concentration System (DOCS) design evolved.

The DOCS 200, shown in Fig 2, produces 200 lpm of 93 +/- 3 percent oxygen at a delivery pressure of up to 100 psig. The DOCS has several key advantages over the conventional PSA. With a compact single package design and a LP, oil-free process the DOCS is simpler and cheaper to install, is more reliable and has less than half the power consumption and maintenance cost of a PSA. The result is a lower delivered oxygen cost. A detailed comparison between VSA and PSA is provided in the following references [1][2].

By utilizing VFD drives on both the air blower and the oxygen compressor, the DOCS efficiently adjust the production to match the end-user process needs. Fig 3 shows the typical turn-down performance. This is very important for hospital supply systems as the oxygen requirement varies greatly through any 24-hour period.

Further additional features of the DOCS include the ability to remotely monitor and control all functions via an internet connection - no special software is required, just a unique IP

SEE NEXT PAGE >>



THE BLUEPRINT FOR MODERN MEDICAL DEMANDS (continued)

address. Both of these features reduce the need for plant visits reducing costs and improving on-stream performance.

PCI's initial focus for the DOCS was the supply of oxygen to hospitals. It has designed and manufactures three DOCS sizes for medical applications that produce 80, 200 and 500 lpm of oxygen. Oxygen is one of the most important drugs in acute hospital care. Unfortunately, over 60 percent of the world's population does not have a reliable cost-effective oxygen supply (from traditional cryogenic sources).

Extensive clinical tests have led to the conclusion that 93 +/- 3 percent oxygen presented no negative physiological effect on patients.

The specification for oxygen allowed to be delivered to hospitals is defined by monographs in Pharmacopeias – USP in the US. Because oxygen had traditionally been delivered from cryogenic sources, the original USP monograph for medical grade oxygen specified that the gas had to have a purity greater than 99 percent.

However, extensive clinical tests performed in Canada and other countries [3][4][5]&[6] have led to the conclusion that 93 +/- 3 percent oxygen presented no negative physiological effect on patients. USP 93 oxygen is now acceptable for use in hospitals as a back-up emergency oxygen supply. The FDA also cleared the DOCS 66, 200 and 500 units for use as a back-up supply for disaster relief, crisis response and ambulatory patient use in the US.

In 2010, the Europe Community issued an Oxygen 93 monograph allowing non-cryogenic generated oxygen to be used in hospitals. Further, to ensure that the patient's safety and wellbeing cannot be compromised, it added limits to the allowable concentrations for SO₂ and oil.

With these two major health bodies accepting the use of oxygen in the range of 90 percent to 96 percent in hospitals, it will only be a matter of time before other MoH organizations around the world will follow suit.

An ISO standard that recommends the required system for an onsite oxygen supply for hospitals – ISO 10083 (oxygen concentrators for use with medical gas pipeline systems) – has been published. Many countries around the world have started using this standard as the blueprint for their own onsite medical oxygen supply system standard.

Oxygen requirements at hospitals vary greatly depending on the needs of operating rooms and intensive care units. As it is imperative that the hospitals always get the oxygen they need, the design of an onsite oxygen system must address this varying need. In many cases the peak requirement may be three to four times the average rate. While the DOCS has the capability to adjust its production rate, clearly it cannot meet the requirement when the machine has to be taken down for maintenance or for periods of loss of power. To cover all these eventualities ISO 10083 recommends two additional redundancies besides a primary generator. The second source can be another generator, vaporized LOX or a cylinder bank. The third source must be a dual cylinder bank with automatic switching between the banks.

With a DOCS system PCI can provide a cylinder filling compressor that can refill all the cylinder banks with surplus oxygen production, typically at night, when the operating rooms are not functioning. With this type of system the hospital can be made essentially independent of the costs and logistical issues of outside supplies. Fig 4 shows an example of such a system.

No two hospitals are the same, so it is very important to analyze the oxygen needs before designing the appropriate system. Therefore it can be stated that with the right DOCS system design any hospital in the world can have a reliable oxygen supply with a delivered oxygen cost at least 20

percent (and as high as 50 percent) less than from any alternate source.

Besides hospitals there are many other applications that can benefit from a reliable cost-effective oxygen supply. Many processes that currently use air as an oxidant can benefit from a conversion to oxygen that improves productivity and/or reduces NOX emissions.

Other potential markets include steel production, oil refining, chemical processing, mineral processing, pulp and paper, glass, ground water remediation, disaster preparedness, military medical, aquaculture, water treatment, oxygen enrichment and clean energy – and PCI offers larger oxygen generators to meet these needs.*

[1] D. Schneider et al 'Onsite Oxygen Generation' CryoGas International August/September 2010

[2] D. Schneider et al 'PSA v's VSA' CryoGas International February 2011

[3] The World Health Organization 'Informal Consultation on Clinical Use of Oxygen' Meeting report October 2/3, 2003

[4] M. B. Dobson et al 'Oxygen Concentrators and Cylinders' Int J Tuberc Lung Dis 5 (6): 520-523

[5] R. M. Friesen et al 'Oxygen Concentrators: A primary Oxygen Supply Source' Can J Anesth 1999,46:12, pp. 1185-1190

[6] L. Walker 'Effects of Oxygen Concentrators on Ventilator Oxygen Delivery' Can J Anesth/JCan. Anesth (2010) 57: 708-709

*Original article was published in Specialty Gas Report in Q3 2012.

DOCS PRODUCT LINE OVERVIEW FOR MEDICAL



DEPLOYABLE OXYGEN CONCENTRATION SYSTEMS (DOCS)

Deploy and generate oxygen at the point of need, on-site, without resupply logistics. PCI's VSA products flows range from 80 liters per minute to 500 liters per minute and delivery pressures from 55 psig to 2250 psig suitable for cylinder filling capabilities.

Deployable Oxygen Centration Systems (DOCS)

DOCS 80

80 lpm | 4.8 m³ per hour | 340 lbs per day | 170 scfh Dimensions:
60" L x 45" W x 55" H | 152 cm x 114 cm x 140 cm

DOCS 200

200 lpm | 12 m³ per hour | 840 lbs per day | 425 scfh Dimensions:
72" L x 85" W x 66" H | 183 cm x 216 cm x 169 cm

DOCS 500

500 lpm | 30 m³ per hour | 1 tpd | 2100 lbs per day | 1060 scfh
Dimensions: 76" L x 119" W x 81" H | 193 cm x 302 cm x 207 cm

Special configurations available upon request

- FDA (United States)
- CE (compliant with MDD 93/42/EEC Class IIb)
- CFDA (China)

Cylinder Fill Boosters

PCI offers oxygen boosters of size that match the output of the DOCS 80, 200, and 500 units.

Oxygen Storage and Distribution

PCI offers various oxygen storage and distribution solutions that when coupled with the DOCS oxygen generator and an oxygen booster provides a complete solution for a stationary or mobile hospital solution

Cost-In-Use Comparison

Example of Savings - PCI O₂ Concentrator vs Conventional Delivery Methods

Product	Operating Cost of O ₂ Concentrator						Savings vs Delivered O ₂		
	per ton	per lb	per kg	per m ³	per 100 scf	per month	price of \$0.15 per m ³	price of \$0.35 per m ³	price of \$1.00 per m ³
DOCS 80 Output Pressure 55 psig	\$68	\$0.034	\$0.08	\$0.10	\$0.28	\$345	43%	72%	86%
DOCS 200 Output Pressure 55 psig	\$57	\$0.028	\$0.06	\$0.08	\$0.24	\$715	53%	76%	88%
DOCS 500 Output Pressure 55 psig	\$46	\$0.023	\$0.05	\$0.07	\$0.19	\$1460	62%	81%	90%

Note: Measured at USD 0.1 per kWh cost of electricity.



DOCS 80

Medical Configuration

Superior Reliability - Easy Serviceability

Modular and Turn-Key System For Easy Installation

ON-SITE OXYGEN GENERATOR

Characteristic	Value / Description
Discharge flow rate	80 lpm 4.8 m3 per hour 170 scfh 340 lbs per day 153 kg per day
O ₂ purity @ discharge flow rate	93% +/- 3%
O ₂ output pressure	20 – 100 psig 1.4 – 6.9 barg
Operating temperature	0°F to 120°F -18°C – 49°C
Power requirements	
Site power source	208/220 VAC +/- 10%, 50/60 Hz +/- 3%, 3-Phase, 50 Ampere
Plant	208/220 VAC, 50/60 Hz, 3-Phase, 28 FLA
Average power consumption	3.2 kW at 20 psig (1.4 barg) output pressure 3.4 kW at 55 psig (3.8 barg) output pressure 3.9 kW at 100 psig (6.9 barg) output pressure
Process outlet connection	1/2" Internal NPT Fitting
Unit footprint dimensions (nom.)	60" L x 45" W x 55" H 152 cm L x 114 cm W x 140 cm H
Crated dimensions (nom.)	78" L x 56" W x 67" H 200 cm L x 142 cm W x 170 cm H
Unit weight (nom.)	1,316 lbs 597 kg
Crated Weight (nom.)	1,910 lbs 867 kg
Average scheduled maintenance cost	\$80 - \$100 per month
Average operating cost @ 55 psig	\$0.24 - \$0.32 per 100 scf \$0.09 - \$0.11 per m ³
Additional available options	Remote monitoring & diagnostics suite 4-20 mA Communication to external controller (0-10V standard) Mass flow control assembly Automatic sleep mode feature for low-demand situations Platinum 3 plus 10 Warranty

¹ Performance parameters stated at standard conditions (59°F 14.7 psia 0% RH | 15°C 101.325kPa 0% RH). Operation in atypical conditions may affect performance. For more information, please consult with your PCI technical representative.

² Available in CE compliant configuration.

³ Electrical enclosure cUL listed.





DOCS 200

Medical Configuration

Superior Reliability - Easy Serviceability
Modular and Turn-Key System For Easy Installation

ON-SITE OXYGEN GENERATOR

Characteristic	Value / Description
Discharge flow rate	200 lpm 12 m3 per hour 425 scfh 840 lbs per day 380 kg per day
O ₂ purity @ discharge flow rate	93% +/- 3%
O ₂ output pressure	20 – 100 psig 1.4 – 6.9 barg
Operating temperature	0°F to 120°F -18°C – 49°C
Power requirements	
Site power source	380/460 VAC +/- 10%, 50/60 Hz +/- 3%, 3-Phase, 60/50 Ampere
Plant	380/460 VAC , 50/60 Hz, 3-Phase, 42/36 FLA
Average power consumption	7.7 kW at 20 psig (1.4 barg) output pressure 8.0 kW at 55 psig (3.8 barg) output pressure 8.4 kW at 100 psig (6.9 barg) output pressure
Process outlet connection	1/2" Internal NPT Fitting
Unit footprint dimensions (nom.)	72" L x 85" W x 66" H 183 cm L x 216 cm W x 169 cm H
Crated dimensions (nom.)	82" L x 96" W x 79" H 208 cm L x 244 cm W x 201 cm H
Unit weight (nom.)	3,148 lbs 1428 kg
Crated Weight (nom.)	4,200 lbs 1907 kg
Average scheduled maintenance cost	\$120 - \$150 per month
Average operating cost @ 55 psig	\$0.20 - \$0.27 per 100 scf \$0.07 - \$0.10 per m ³
Additional available options	Remote monitoring & diagnostics suite 4-20 mA Communication to external controller (0-10V standard) Mass flow control assembly Automatic sleep mode feature for low-demand situations Platinum 3 plus 10 Warranty

¹ Performance parameters stated at standard conditions (59°F 14.7 psia 0% RH | 15°C 101.325kPa 0% RH). Operation in atypical conditions may affect performance. For more information, please consult with your PCI technical representative.

² Available in CE compliant and FDA cleared configurations.

³ Electrical enclosure cUL listed.





DOCS 500

Medical Configuration

Superior Reliability - Easy Serviceability
Modular and Turn-Key System For Easy Installation

ON-SITE OXYGEN GENERATOR

Characteristic	Value / Description
Discharge flow rate	500 lpm 30 m ³ per hour 1060 scfh 2100 lbs per day 954 kg per day
O ₂ purity @ discharge flow rate	93% +/- 3%
O ₂ output pressure	20 – 100 psig 1.4 – 6.9 barg
Operating temperature	0°F to 120°F -18°C – 49°C
Power requirements	
Site power source	380/460 VAC +/- 10%, 50/60 Hz +/- 3%, 3-Phase, 120/100 Ampere
Plant	380/460 VAC , 50/60 Hz, 3-Phase, 100/80 FLA
Average power consumption	17.7 kW at 20 psig (1.4 barg) output pressure 18.0 kW at 55 psig (3.8 barg) output pressure 19.5 kW at 100 psig (6.9 barg) output pressure
Process outlet connection	3/4" Internal NPT Fitting
Unit footprint dimensions (nom.)	76" L x 119" W x 81" H 193 cm L x 302 cm W x 207 cm H
Crated dimensions (nom.)	
Crate 1	82" L x 67" W x 91" H 208 cm L x 170 cm W x 231 cm H
Crate 2	85" L x 82" W x 91" H 216 cm L x 208 cm W x 231 cm H
Unit weight (nom.)	5,958 lbs 2702 kg
Crated Weight (nom.)	Crate 1: 3,000 lbs 1362 kg Crate 2: 5,300 lbs 2406 kg
Average scheduled maintenance cost	\$160 - \$180 per month
Average operating cost @ 55 psig	\$0.16 - \$0.23 per 100 scf \$0.06 - \$0.08 per m ³
Additional available options	Remote monitoring & diagnostics suite 4-20 mA Communication to external controller (0-10V standard) Mass flow control assembly Automatic sleep mode feature for low-demand situations Platinum 3 plus 10 Warranty

¹ Performance parameters stated at standard conditions (59°F 14.7 psia 0% RH | 15°C 101.325kPa 0% RH). Operation in atypical conditions may affect performance. For more information, please consult with your PCI technical representative.

² Available in CE compliant and FDA cleared configurations.

³ Electrical enclosure cUL listed.





BOOST 66

Boost 66 can compress oxygen to a pressure of up to 2,250 psig (approximately 155 bar) to fill cylinders. Easily connects through a high pressure hose to the DOCS 66 or can be used as a stand alone oxygen compressor.

ON-SITE OXYGEN BOOSTER

Characteristic	Value / Description
Discharge flow rate	60 lpm 3.6 m ³ per hour (60 Hz configuration) 50 lpm 3 m ³ per hour (50 Hz configuration)
O ₂ output pressure	Up to 2,250 psig 155 bar
Dimensions:	20" (width) x 26.3" (depth) x 39" (height) 51 cm x 67 cm x 99 cm
Weight	290 lbs (131.5 kg)
Operating power	208/240 VAC, 3-phase, 50/60 Hz or 380 VAC, 3-phase, 50/60 Hz
Average power consumption	1.9 kW (208 VAC) 2.3 kW (380 VAC)
Cooling system	Air cooled (on board)
Operating temperature	0°F to 120°F

Product Description

When connected to a DOCS unit, the Boost 66 is supplied with 30-70 psig and will pump 15-60 lpm up to 2250 psig. The Boost 66 contains an oil-less two stage reciprocating compressor that is designed and manufactured for oxygen service. The Boost 66 is designed to fill industrial oxygen cylinders. Includes automatic shutdowns for low inlet pressure and high discharge pressure. Also includes automatic restart when discharge pressure falls below 1900 psig.



OXYGEN STORAGE & DISTRIBUTION PRODUCT PROFILE



STORAGE

MOST



Mobile Oxygen Storage Tank

Oxygen storage and distribution system consisting of lightweight, high strength, high pressure composite wound brass lined cylinders secured within a rugged water resistant case.

SC MOST



Single Cylinder Most

Ready-to-go multi-patient 17,000 liter O₂ storage & delivery system on wheels. Provides 17,000 liters of oxygen at 50 psig service pressure.

HOBS



Hospital Oxygen Backup Supply

Designed to provide oxygen continuity in an emergency. Four-legged stand assembly with a manifold unit for grouping up to eight "H" size oxygen cylinders.

DISTRIBUTION

CODS



Civilian Oxygen Distribution System

PCI's oxygen delivery system designed for MFHs uses a modular approach so that it can be easily tailored and scaled to MFH bed capacities.

PODS



Patient Oxygen Distribution Systems

A system of flow regulators to mount at patients bedside and multiple hoses with quick disconnect fittings to provide the distribution of the oxygen at a regulated pressure and flow.

SSODS



Surgical Suite Oxygen Distribution System

Provides oxygen to the surgical suite for operating equipment such as ventilators, respirators and anesthesia machines.



BREATHE EASY WITH PCI GASES

- ✓ *Protect your **PATIENT***
- ✓ *Protect your **PROCESS***
- ✓ *Protect your **POCKET***

ON-SITE OXYGEN SOLUTIONS

12201 Magnolia Avenue, Riverside, CA 92503
phone: +1 951.479.0860
fax: +1 951.479.0861
email: oxygen@pcigases.com