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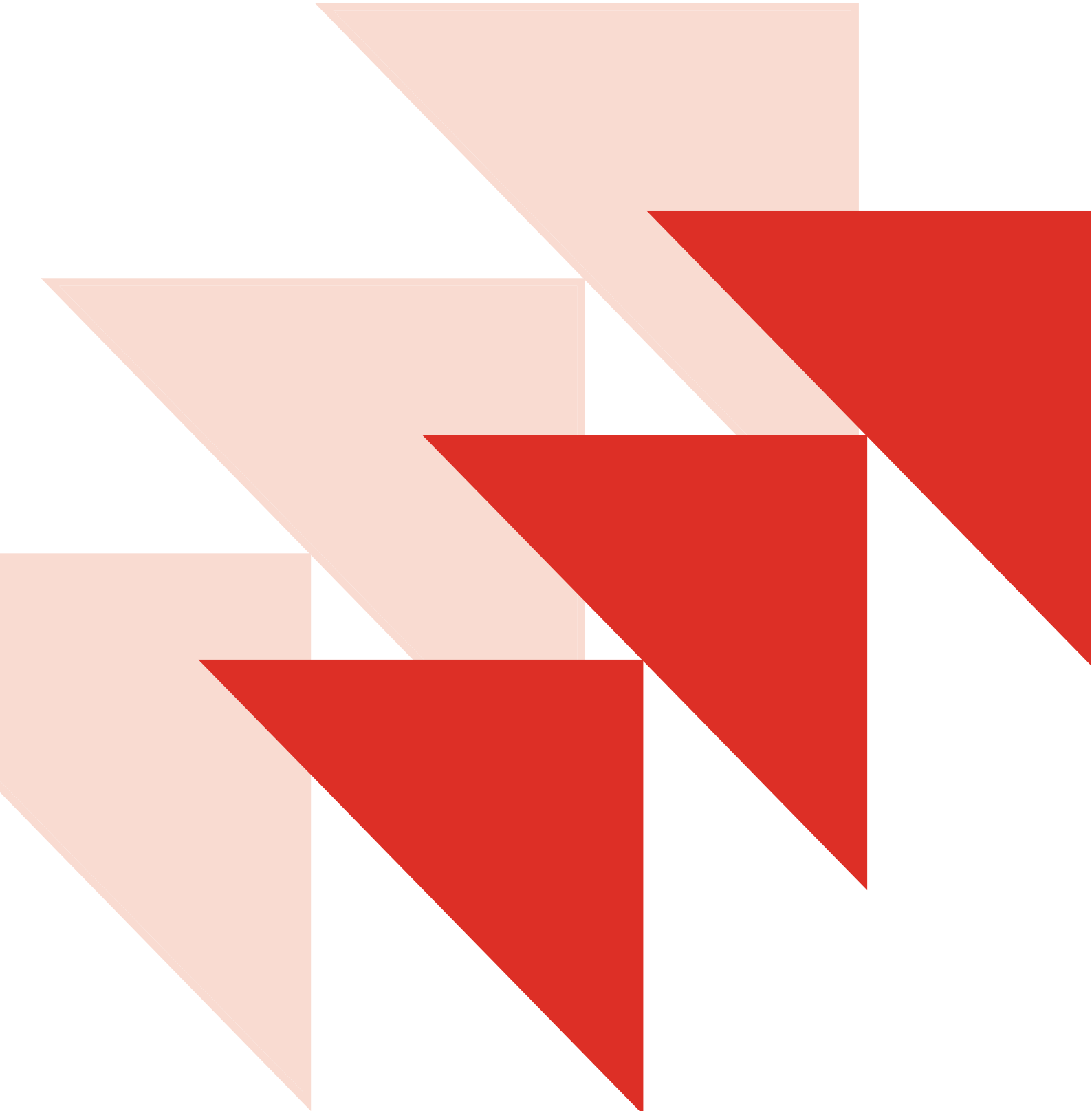
ON-SITE OXYGEN GENERATION
WHY PSA SYSTEMS ARE A GOOD CHOICE



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The consumption of oxygen in hospitals has been rising steadily for decades now. According to the sixth edition of Ward's Anaesthetic Equipment*, significant changes in postoperative and ventilatory management are among the drivers of this rise in oxygen consumption. Thus the amount of oxygen consumed by a large hospital is commonly measured in hundreds of cubic metres (HCMs). Naturally, the bill for oxygen represents a major expense incurred by a typical hospital.*

Source: http://medhanshhospital.com/anaesthesia.aspx

Hospitals obtain their supply of oxygen from one or more of these systems:

- *Liquid oxygen supply systems (also known as cryogenic liquid systems)*
- *High-pressure cylinders*
- *Pressure swing adsorption systems (PSA systems, or oxygen concentrators)*

This issue of Trident Notes *compares the merits of these systems and points out that there is a strong case for selecting PSA systems in preference to the others.*

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Liquid oxygen supply systems

At the heart of a liquid oxygen system is an insulated reservoir, known as a vacuum insulated evaporator, where cold liquid oxygen is stored in bulk. The reservoir may be a permanent installation or a portable, lightweight container. In either case it has a double-walled construction, with vacuum between the outer and inner shells. During normal operation, the liquid oxygen is made to flow out of the reservoir and pass through a device known as an ambient vaporizer. Heat from the surroundings warms the liquid oxygen in the vaporizer, causing it to turn into the gaseous form. This gaseous oxygen is heated further and delivered through a pressure regulator to the distribution line.

Liquid oxygen installation (Source: http://rc.rcjournal.com/content/58/1/173)

Advantages. *Liquid oxygen systems are very effective sources of oxygen.*

Disadvantages. *(1) Refilling portable tanks requires dexterity. (2) Larger, permanent reservoirs require a lot of space and must be sited such that they are accessible to the tankers that refill them. Bulk liquid oxygen supply systems should be located in open areas without any overhead power lines. (3) Liquid oxygen cannot be stored for extended periods as it evaporates. Up to 20% of the oxygen may be lost to evaporation. Refilling must be carried out frequently.*

(4) The greatest disadvantage is the risk of a large volume of oxygen being released by the pressure release system. The oxygen could be vented accidentally into a fire, acting as an accelerant. There is even the possibility of an uncontrolled release of liquid oxygen from the vacuum insulated evaporator.
In one instance, 7000 litres of liquid oxygen escaped from a tank at a hospital (https://drive.google.com/drive/folders/0BxLdUrvxk-2MSlhESV8tLTJFc28?usp=sharing). Liquid oxygen can react violently with organic materials. It forms explosive mixtures with substances such as tar and asphalt. (5) Liquid oxygen is more expensive than compressed gaseous oxygen.

High-pressure cylinders

Oxygen may be stored and supplied as a compressed gas in cylinders. The oxygen from a cylinder is admitted to the distribution line through a pressure regulator. The regulator reduces the pressure of the oxygen to a level that can be used safely. Typically a group of cylinders, known as a cylinder manifold, is used to supply oxygen through a pipeline to a hospital. Oxygen is drawn from all the cylinders of a manifold simultaneously. Often, the cylinders are arranged in a primary group and a secondary group. A pressure transducer switches to the secondary manifold once the pressure in the cylinders of the first manifold drops below a certain limit. The primary manifold is replenished when this happens.

Oxygen manifold (Source: http://www.ijaweb.org/article.asp?issn=0019-5049;year=2013;volume=57;issue=5;spage=489;epage=499;aulast=Das)

Advantages. *These cylinders provide a relatively convenient form of storage, without the need for insulation.*

Disadvantages. *(1) Handling compressed gas cylinders is not very convenient. Improper handling may result in accidents involving sprains, bruises or broken bones. (2) There is a loss of oxygen from cylinder-based systems as well, more than 3%. (3) As with liquid oxygen supply systems, there is a risk of damage to property and of injury or loss of life. Fires, explosions, chemical burns, poisoning and cold burns could be caused if the gas escapes accidentally from a cylinder.*

Visit-https://drive.google.com/drive/folders/0BxLdUrvxk-2MSlhESV8tLTJFc28?usp=sharing for reports of oxygen cylinders exploding at hospitals.

PSA systems

Medical oxygen can be generated on-site at any hospital, clinic, or health care centre using PSA systems. The major input in the production of oxygen using PSA systems is air. The two major gases present in air are oxygen (20.95%) and nitrogen (78.09%). In a PSA process, air is pressurised and passed through a bed of adsorbent. PSA processes rely on the fact that under such conditions gases tend to be adsorbed by solids. The adsorbent used in PSA-based oxygen production attracts nitrogen more strongly than it does oxygen.

The operation of PSA systems has been described in detail in Number 3 (March 2017) of Trident Notes.

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PSA enables a health care centre to produce its own oxygen.

On-site generation of medical oxygen using PSA is safe, reliable and cost- effective compared with the other two methods described. The energy and area requirements of PSA systems are reasonable. The PSA process is an ex-tremely clean operation.

The design and fabrication of on-site oxygen production systems are governed by the ISO 10083:2006 and ISO 7396-1:2016 standards.

Comparison

Factor	On-site oxygen production using PSA processes	Liquid oxygen supply systems	High-pressure cylinders
Capital cost	Investment required; but pay-back period (compared with high-pressure cylinders) less than 15 months	Investment not required	Investment not required
Recurring costs	Electricity	Cost of liquid oxygen and rent	Cost of oxygen
Space requirement	Medium	Most	Least; but depends on num-ber of cylinders
Administration	Easy	Difficult	Difficult
Safety	Safe	Risk of uncontrolled release of oxygen	Risk of explosion
Logistics management	One-time—installation of the plant	Issues might arise when a tanker needs access to bulk-storage tank to refill liquid oxygen.	Issues might arise with the transport, storage and ac-cessing of the cylinders.
Evaporation loss	None	Up to 20%	3% unusable

From the foregoing comparison it is evident that on-site oxygen production using PSA is a very attractive option. Unnecessary overhead costs are eliminated with PSA systems. This option saves money. PSA systems are far safer than the other methods.

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Further benefits of using on-site oxygen plants:

- *Oxygen needs to be produced only according to demand*
- *Cylinder availability issues are eliminated*
- *Faster payback period (just over 1 year—see the following comparison)*
- *Risks associated with handling high-pressure cylinders are eliminated*

Recovery of investment

	High-pressure Cylinders	On-site oxygen plant
Basis of estimates	Usage: 30 cylinders per day Cost of one cylinder: ₹200	Investment: ₹19,00,000 (all-inclusive) Power requirement: 11 kw
Total expenses per month (₹)	30 cylinders per day × 30 days × ₹200 per cylinder = 1,80,000	Monthly power bill: 11 kw × 75% loading time × 24 hours × 30 days × ₹8 per kW hour = 47,520
Savings per month (₹)	—	1,80,000 – 47,520 = ₹1,32,480
Payback Period	—	19,00,000/1,32,480 = 14.35 months

The investment in an on-site oxygen plant can be recovered in less than 15 months.

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