

# Oxygen Concentrator

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**13.3.5 Maintain an oxygen concentrator**

**Unit B 13.3 Maintaining General Bedside Nursing Equipment**

**Module 279 18 B Medical Instrumentation I**

# Function: produce air with high Oxygen content

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**What is the purpose of an Oxygen concentrator ?**

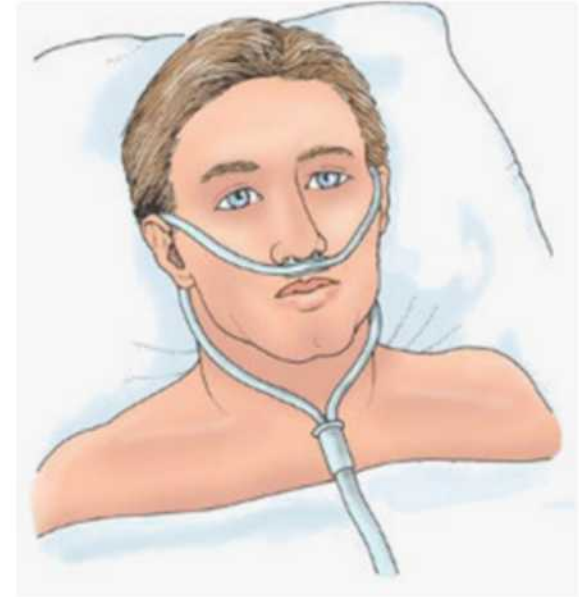
To provide patients with a reliable supply of oxygen.

**Why is it important ?**

Patients who have hypoxia, or an inadequate amount of oxygen, require extra oxygen

**What are normal values oxygen content ?**

Ambient air contains 21% oxygen ( $O_2$ ); the oxygen concentrator transforms this into nearly pure (95%) oxygen.



# Use: both hospital and home

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Oxygen is a widely prescribed medication in both the hospital and home setting, in case of **'hypoxia'**

Hypoxia can be caused by malfunctioning of the lung system as in include chronic obstructive pulmonary disease (COPD) - which refers to the restriction, inflammation, or infection of the lungs.

Hypoxia can also be caused by cardiovascular insufficiency, for example if an irregular heart rhythm, a decreased blood flow, or inefficient oxygen transport in the blood prevent adequate oxygen delivery to peripheral tissues.

In addition to these medical conditions, a reliable source of oxygen is essential wherever **anaesthetics** are administered, both to **supplement the inspired gas mixture** and for **resuscitation**.



# (Dis-)advantages of concentrators (vs cylinders)

Oxygen has traditionally been supplied in cylinders which are bulky and expensive. In isolated areas transportation of cylinders is difficult and may be unreliable. For these reasons, The World Health Organization recommends oxygen concentrators as a better long-term investment for smaller, remote hospitals in the developing world.

## Advantages of concentrators

- Oxygen is always available (when electricity is present)
- Produced oxygen is cheap

## Disadvantages of concentrators

- Electricity is always needed (power outages !)
- High power consumption (400 - 600 W)
- Battery back-up is not possible (due to high power requirement)
- Frequent maintenance is needed
- Spare parts like filters for maintenance are needed
- Special parts for repairs are needed
- Problematic in areas with high humidity



# Scientific principles: pressure swing adsorption

Ambient air contains 78% N (nitrogen), 21% O<sub>2</sub> (oxygen) and 1% trace gases. An oxygen concentrator works by separating and **removing the nitrogen** from the ambient air, leaving nearly pure (95%) oxygen.

Most machines now operate using **pressure swing adsorption (PSA)**. Pressure swing adsorption processes rely on the fact that under **high pressure**, gases tend to be attracted to solid surfaces, or "adsorbed". The higher the pressure, the more gas is adsorbed; when the pressure is reduced, the gas is released, or "desorbed".

PSA processes can be used to separate gases in a mixture because different gases tend to be attracted to different solid surfaces more or less strongly. If air is passed under pressure through a vessel containing an adsorbent bed of **zeolite that attracts nitrogen** more strongly than it does oxygen, part or all of the nitrogen will stay in the bed, and the gas coming out of the vessel will be enriched in oxygen.

When the bed reaches the end of its capacity to adsorb nitrogen, it can be **regenerated** by reducing the pressure, thereby releasing the adsorbed nitrogen. It is then ready for another cycle of producing oxygen enriched air.

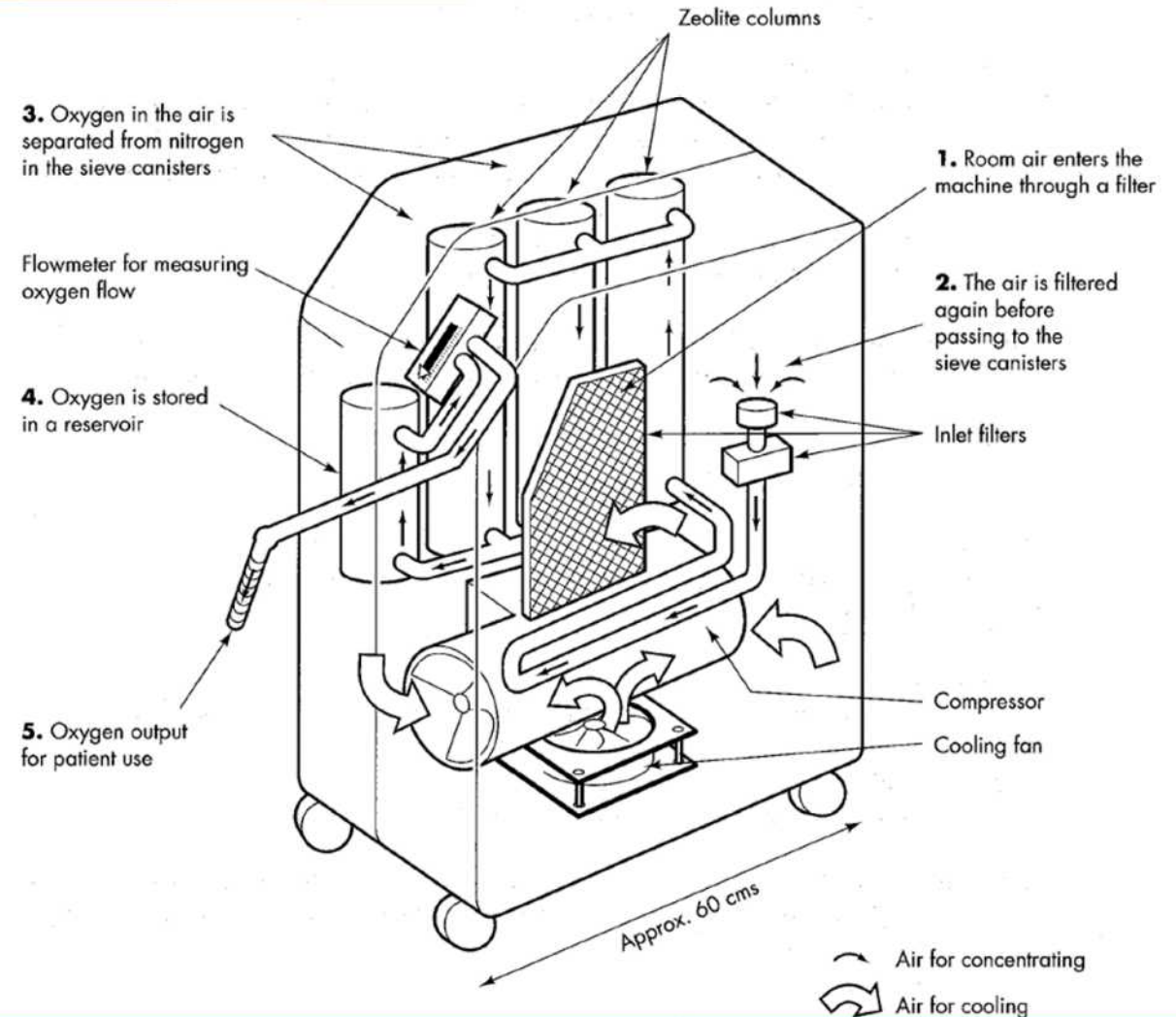


Zeolite (synthetic aluminum silicate) binds Nitrogen under high pressure

# Construction

Air is drawn into the machine by a compressor. After passing through a series of **filters** to cleanse it of bacteria and solid matter, the air is pumped into the concentrator where all nitrogen is extracted. The resulting oxygen is then fed into the oxygen reservoir from where it is administered to the patient at the prescribed rate.

After the zeolite is saturated with nitrogen, the valve leading to the oxygen tank is closed and the pressure is decreased in the zeolite tank. As the pressure drops the zeolite releases nitrogen which is vented into the air. A small quantity of enriched oxygen is then passed backwards through the zeolite canister to completely purge the zeolite of nitrogen. Since the patient probably needs a continuous supply of oxygen, a typical concentrator will have **two zeolite canisters**. One is concentrating oxygen while the other is being purged.



# Construction

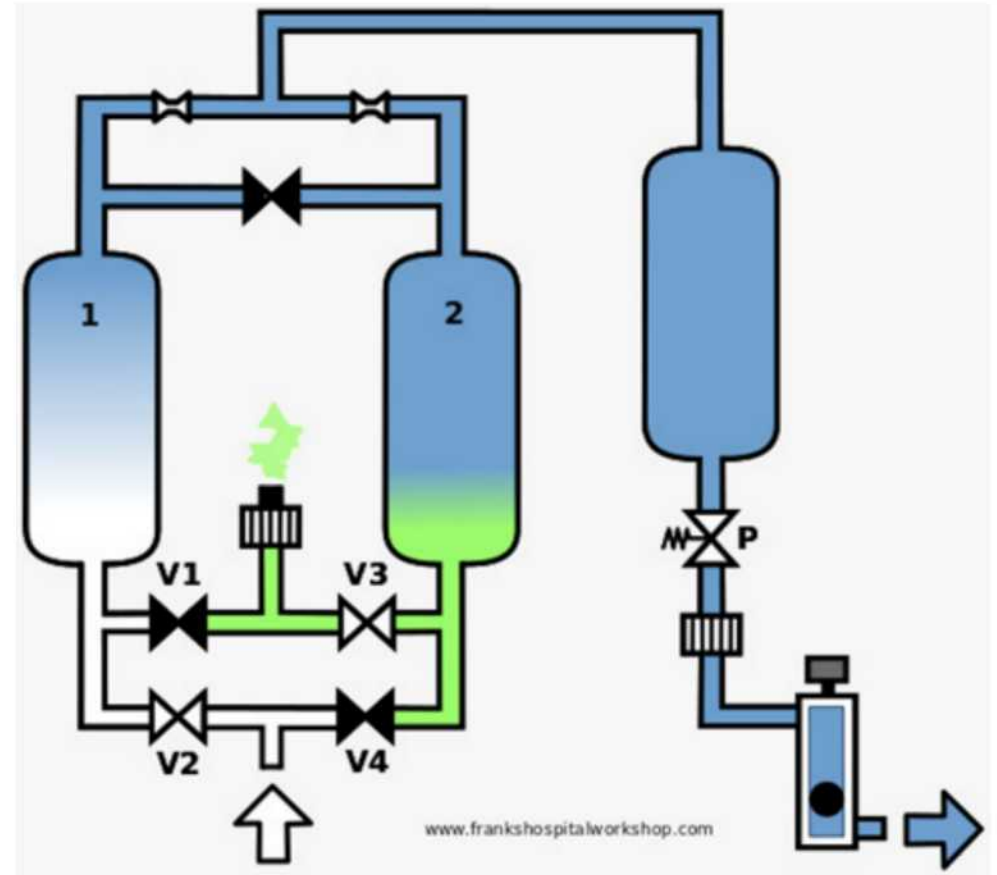
During pressurization, the inlet valve must be opened and the outlet valve must be closed. During filtering, which normally takes 8 to 20 seconds, both valves should be closed as nitrogen binds to the zeolite. During release of oxygen-concentrated air to the patient, only the outlet valve should be opened.

In the regeneration stage a small amount of oxygen is released back into the canister to expel leftover nitrogen.

Canisters will be in different stages of the pressure swing cycle so that while one canister is filtering, the other is regenerating.

An oxygen concentrator is easy to operate with only a **power switch** and a **flow meter**. An alarm sounds if the pressure in the compression chamber falls below **20 psi**.

Some models include a built-in device called an OCSI (**oxygen concentration status indicator**) that measures the oxygen concentration just before the outlet. An alarm sounds if the concentration is low in these devices. Some machines automatically shut down if the concentration of oxygen falls below **70%**.



# Usage

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Before switching on the oxygen concentrator check the connected tubing for kinks and blockages. When the concentrator is used for therapy, fill the humidifier with the right amount of distilled water. The lid has to be closed firmly.

Switch on the concentrator and wait at least for two minutes. Only then the oxygen concentration is high enough for usage. But even with low concentration in the beginning the machine delivers air so that you can check the tubing and the humidifier. If everything is all right, **the humidifier makes bubbles**.

All concentrators have a **flow meter** with an **adjustment** option for the flow rate, which is indicated by a little ball floating in a glass tube. Set the flow meter to the required flow value.

Finally check the **alarm function**. Pull the mains plug without switching off the concentrator. An alarm must sound.

# Trouble shooting

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Concentrators do malfunction occasionally, and their repair can require considerable expertise; **worn parts on the compressor and valves may need replacement**. Assuming that all other parts function optimally, the machine is only limited by **the life of the zeolite crystals**, which is expected to be at least **20,000 hours** (e.g. 833 days at 24 hours/day). The primary complaints are **low oxygen concentrations** and **decreased gas flows**. Since this machine is so widely used and has few options on the interface, user error is unlikely.

A **clogged filter** may be the cause. The filter is located between the air source and the zeolite containers. Some models may have multiple filters. A dirty filter can lead to a decreased oxygen concentration and/or a decreased flow rate.

If the flow to the patient is insufficient, the tubing and connectors should be checked for **leaks**.

If the **motor or compressor is not functioning** properly, air in the zeolite canisters will not be pressurized enough to remove an adequate amount of nitrogen from the air. It is necessary in this case to check any seals/gaskets associated with these systems. Inside the chambers, **20psi** is the standard pressure.

The valves at the inlet and outlet of the zeolite canisters must be tight and timed correctly. Most models have valves that are coordinated between chambers. However, check the timing of valve opening and closing.

Always keep a spare full O2 cylinder for emergency use.

Calibration: leave the sensor in normal room air. After a minute or so, adjust the calibration knob on the monitor so that a reading of 21% is obtained.

# Safety and Testing

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- Keep equipment away from flames and cigarettes
- Keep equipment away from volatile gases and liquids.
- Keep children away from equipment
- Keep the machine dry.
- Disconnect the machine from the main electricity supply when it is not in use.
- Switch off the machine if fire breaks out.
- Install the machine **outside the risk zone** if it is being used in an operating theatre.
- Fit the humidifier **below the level of the patient's head** to prevent condensation flowing to the patient
- Run the concentrator for **five to ten minutes every week**, even if it is not in use

# Safety and Testing

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It is important that the machine achieve oxygen concentrations near 90% or above and provide gas flows in the manufacturer's range; for high flow rates (around 5 litres/minute) oxygen concentration will be lower.

It is not safe to trust flow meters and oxygen concentration indicators on the machine when releasing an oxygen concentrator to the floor. These variables need to be checked using a **separate oxygen analyser** and **flow meter**.

If you are unable to locate an oxygen concentration meter, **discuss the problem with the physician** before releasing the device to the floor without an oxygen concentration test. The measurement must be performed 10 minutes after switching the concentrator on to give the machine time to build up the concentration of oxygen.



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# END

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