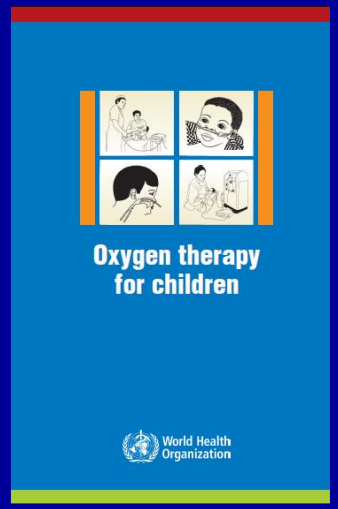

Oxygen therapy for the Pandemic

Prof Trevor Duke, March 2021

Test

Learning objectives

- Understand how to detect hypoxaemia
- Be confident in the use of pulse oximetry for detection of hypoxaemia and monitoring of oxygen therapy
- Understand oxygen concentrators, how they work and how to use and maintain them
- Understand maintenance of oxygen concentrators and use of oxygen analyser


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Second edition
World Health Organization

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Besides Covid-19, what else can cause hypoxaemia?

- Pneumonia or bronchiolitis from other causes
- Asthma
- Chronic bronchitis / bronchiectasis
- Tuberculosis
- Heart failure
- Upper airway obstruction, such as croup or foreign body
- Trauma (lung contusion, pneumothorax, haemothorax)
- HIV-related pneumonia – e.g. pneumocystis pneumonia
- Stroke / meningitis / seizures
- Malaria (sometimes)

An oxygen system

- Oxygen concentrators 5-10 L/min
- Flow devices (1 concentrator linked to 2-5)
- Viral filter
- Voltage regulator / surge protector

- Nasal oxygen prongs, adult, child, neonate
- Oxygen masks, adult

Pulse oximeter

- Oximeter sensor probes, adult, child, neonate

Set-up maintenance and servicing

- Tubing, conduit and accessories
- Spare course particle filters for concentrators

Oxygen analyser

Also need…

- Reliable power
- Training
- Guidelines
- Maintenance
- Procurement and replacement
- Auditing

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Clinical signs of hypoxaemia

1. Use of accessory muscles
2. Inability to talk
3. Cyanosis
4. Chest in-drawing
5. Head-nodding
6. Grunting
7. Apnoea / gasping

Detection of hypoxia using only clinical signs can be difficult
Oximetry detects many more children with hypoxaemia

Pulse oximetry: how does it work?

- Sensor consists of a light emitter and light detector
- Sensor emits 2 lights of different frequency
  - Infra-red light detects oxygenated Hb (red)
  - Red light detects de-oxygenated Hb (blue)
- Ratio of infra-red to red light that is absorbed indicates % of Hb that carries oxygen (SpO_2)

Oximeter

- Use the right sized sensor probe (adult, children, neonates)
- Can set alarm limits (adults, children, etc)
- Rechargeable Lithium-ion battery (no need to replace)
  - Always recharge when not in use
- Problems
  - ‘Movement artefact’ wait 15-30 secs until you get a steady wave form
  - Perfusion – if cold or in shock – warm limb

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SpO_2 and normal oxygen saturation

- **SpO_2** = arterial oxygen (O_2) Saturation measured by pulse oximetry
- The normal SpO_2 at sea-level is 95-100%
- SpO_2 is lower at higher altitudes due to the lower partial pressure of inspired oxygen

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Duration of hypoxaemia

- Children
  - Severe pneumonia: 3-4 days
  - Moderate pneumonia / bronchiolitis: 1-2 days (*but cough, fast breathing and wheeze can last for up to 3 weeks*)
  - Highlands: Severe pneumonia: 4-8 days (95% CI 3.3-11 days)
- Adults Covid-19: 1-3 weeks

Sometimes hypoxaemia is prolonged
(but patients can still survive)

- 1039 children with severe pneumonia, 65 deaths
- Still hypoxaemic at:

Day	Number	Survived	Died
10	212 (19%)	177 (83%)	28
20	76 (6.8%)	63 (83%)	10
30	39 (3.5%)	33 (84%)	4

Lancet 2002;359:474-480

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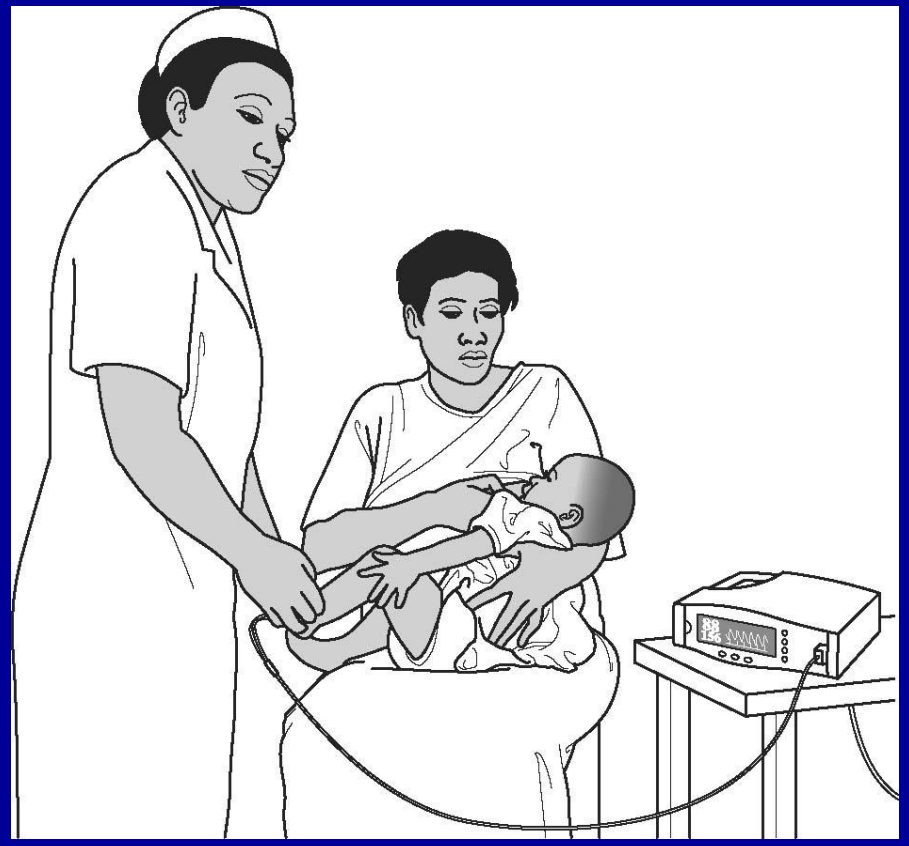
When to use pulse oximetry

- Pulse oximeters should be used to monitor:
  - Every patient at admission with respiratory or emergency signs (not just those with pneumonia)
  - During ward rounds and nursing observations to monitor progress
  - Any patient who deteriorates with respiratory distress, apnoea or decreased conscious state



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Getting the most accurate pulse oximeter reading

- Lie the baby comfortably in the mothers lap, or on a bed if very unwell
- Allow the baby to feed on the mother’s breast
- Use the correct sized probe for the child
- Calm or distract the child
- Warm the limb if it is cold

Test

Some patients are more susceptible to hypoxaemia

- Severe anaemia
- Heart failure
- Shock
- Reduced conscious state

Test

When to give oxygen

Give oxygen if:

1. SpO_2 <90%
2. Central cyanosis, nasal flaring, inability to drink or talk due to respiratory distress, grunting with every breath→ always give oxygen
3. If patients have *additional serious problems*: anaemia, heart failure, shock or reduced conscious state → give oxygen if SpO_2 <94%

Test

What flow rates to use

- Neonates (<1 month) 0.5-1 L/min
- Infants (1-12 months) 1-2 L/min
- Older children (>12 months) 2-4 L / min (lower flow rates may be effective in moderate illness)
- Adults 4-8 L/min

Test

How often do you check oximetry?

- Monitor until SpO_2 >90% after starting oxygen
- Within 15 minutes of starting oxygen, then *at least three times daily*, but sometimes hourly observations are needed in very sick patients

Test

What to do if a patient's oximetry is still low after giving oxygen

- Check machine
  - Check that the oxygen is flowing (bubbles) and tubing is not leaking
  - Check nasal prongs fitted correctly
  - Check concentrator delivering >85% oxygen (amber light off)
- Check patient
  - Check for upper airway obstruction, pleural effusion, pneumothorax
  - Check the patient is making good effort to breath
- Escalate
  - Give higher flow oxygen (4 L/min in child or 8 L/min in adult)
  - Give CPAP
  - Communicate with a doctor

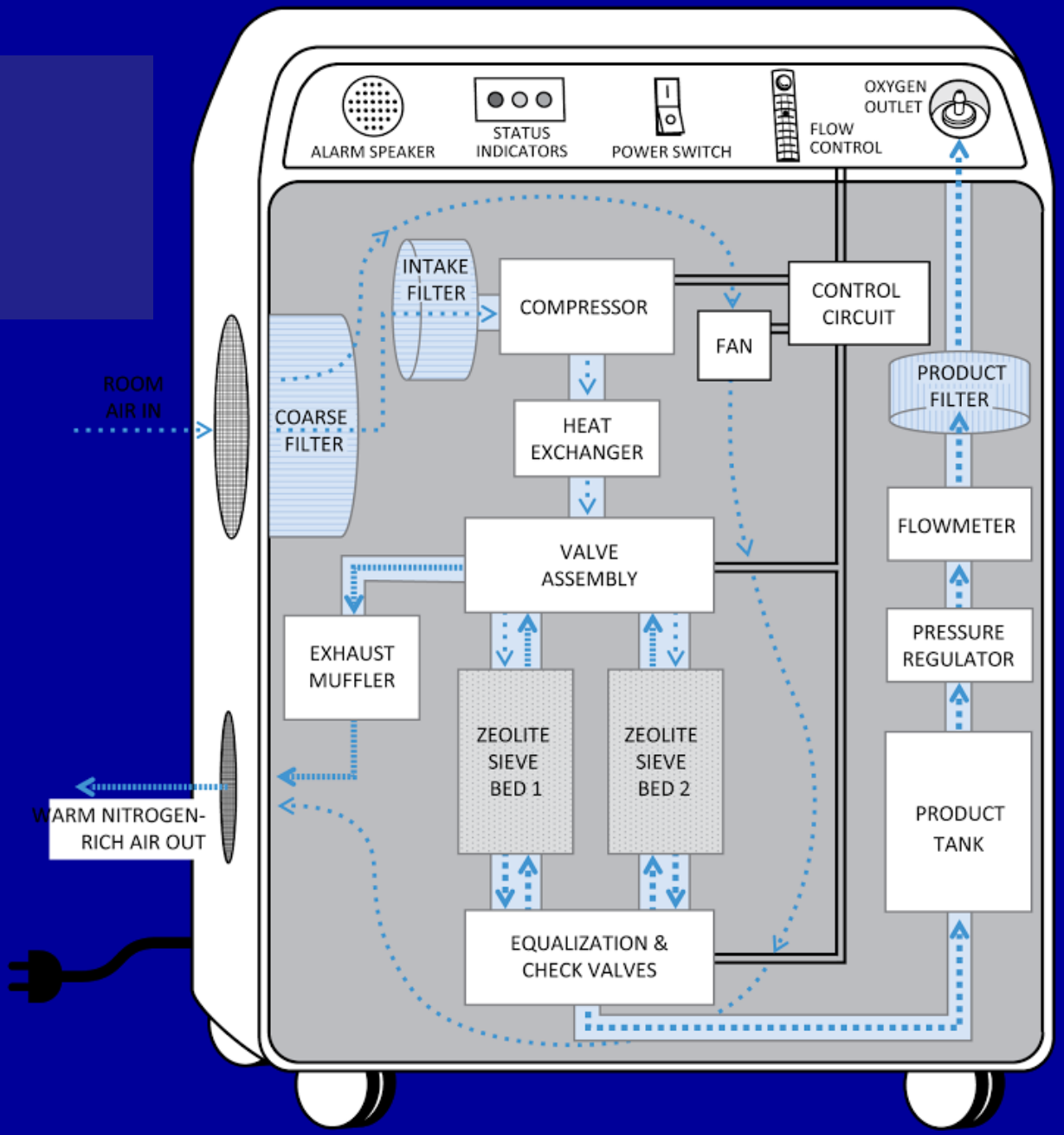
Test

Oxygen concentrators: how do they work?

- Air is 21% oxygen, 78% nitrogen, 1% rare gases
- Concentrator takes in atmospheric air and removes *nitrogen*…. leaving >90% oxygen
- “Pressure swing adsorption” (PSA)

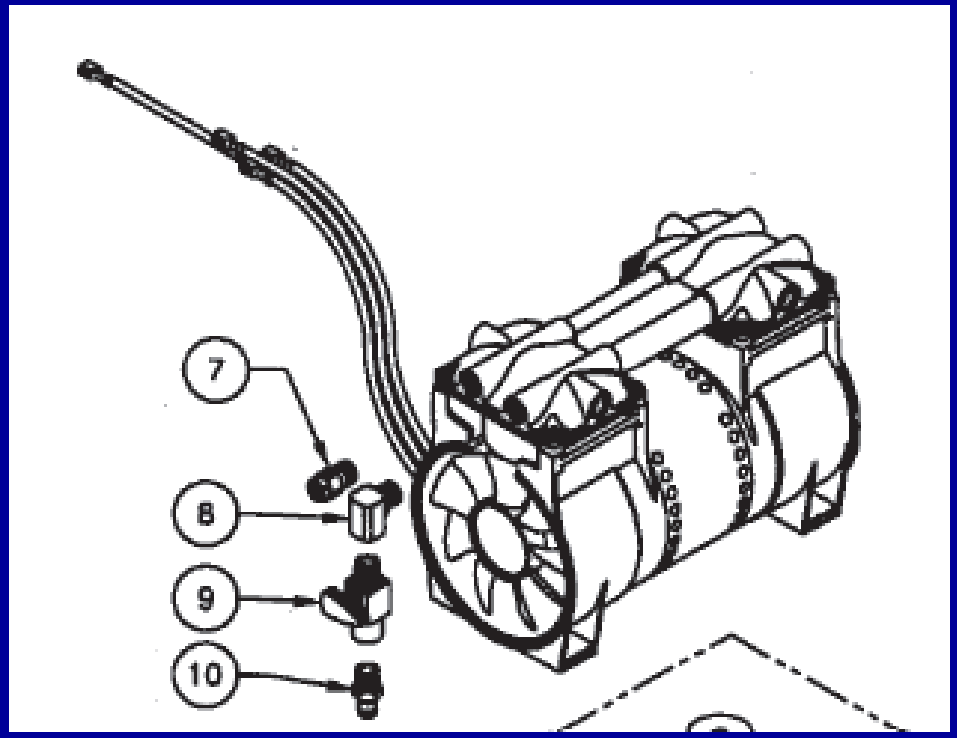
Major internal parts

1. Compressor
2. Valves
3. Sieve beds
4. Circuit board
5. Filters



1. Compressor

Pump that pushes room air into the sieve beds under pressure



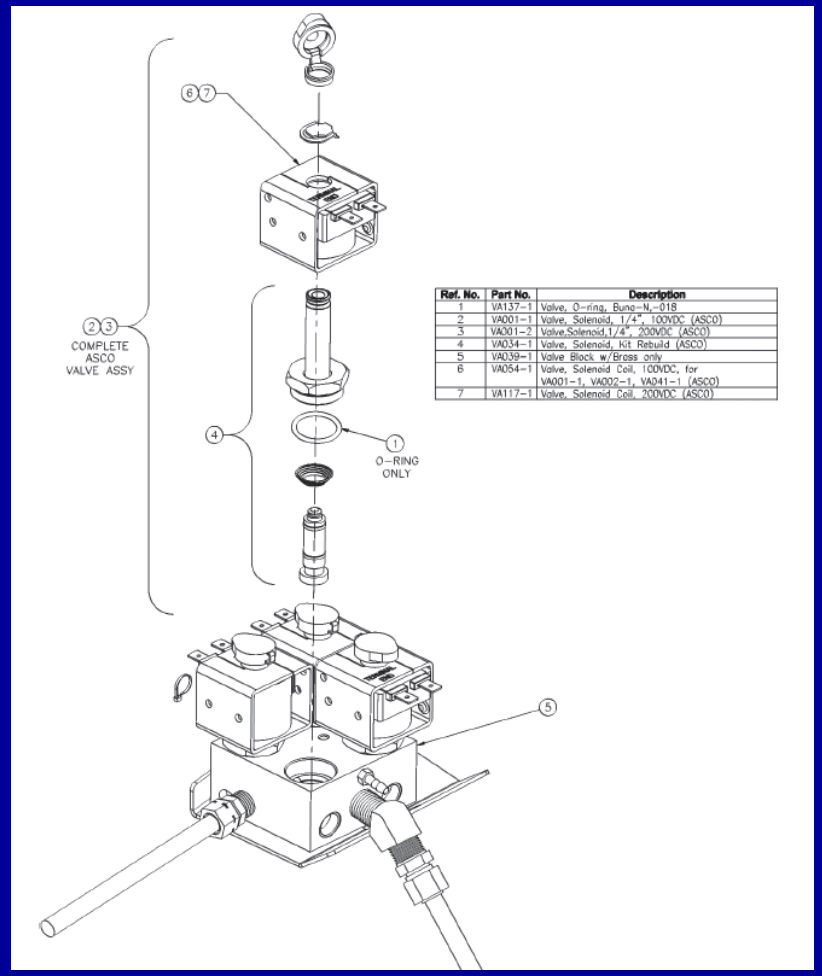
Problems

Cup seals (between pistons and cylinder wall) wear over time → less air pushed into sieve beds→ lower performance (↓% oxygen)

Bearings in compressor wear over time → more noise

2. Valves (5)

Control the pathway of the compressed air which feeds and pressurises one sieve bed, while the other sieve bed is allowed to depressurise and purge the nitrogen through the exhaust muffler



Ref. No.	Part No.	Description
1	VA137-1	Valve, O-ring, Buna-N,-018
2	VA001-1	Valve, Solenoid, 1/4", 100VDC (ASCO)
3	VA001-2	Valve,Solenoid,1/4", 200VDC (ASCO)
4	VA034-1	Valve, Solenoid, Kit Rebuild (ASCO)
5	VA039-1	Valve Block w/Brass only
6	VA054-1	Valve, Solenoid Coil, 100VDC, for VA001-1, VA002-1, VA041-1 (ASCO)
7	VA117-1	Valve, Solenoid Coil, 200VDC (ASCO)

Problems

Particulates, dust, dirt, smoke, and corrosion caused by humidity can lead to valves sticking → valve becomes noisy

3. Sieve beds (usually 2)

Holds zeolite crystals, which holds nitrogen under pressure, but allows oxygen (and argon) to pass through

Pressure “swings” (alternates) from one sieve bed to another: under pressure nitrogen is adsorbed, when a sieve is depressurized nitrogen is released through the exhaust of the concentrator

4. Circuit board

Electronic control for operating the valve and alarm systems

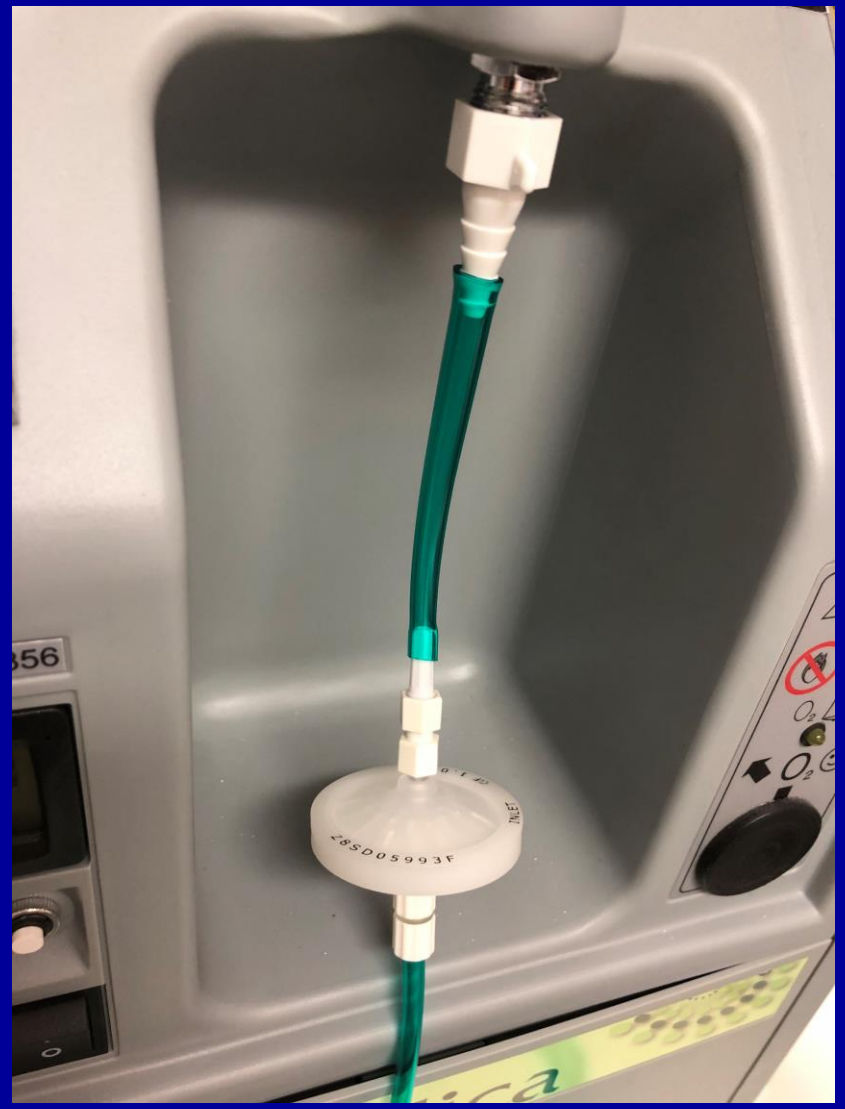
If circuit board fails the machine may not cycle properly

5. Filters (3)

- External air intake gross particle filter – change weekly
- Internal felt filter – change every 5000 hours of use
- Product / oxygen filter – no need to change

+ Viral filter

- 99.99% viral / fine particle filter



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Positioning a concentrator in a ward

- Close to a power outlet
- Cool part of the ward, not in direct sunlight
- Away from curtains
- At least 1.5 m away from any source of heat
- Good air supply - ward should be well ventilated with good air circulation around the concentrator
- Exhaust fan

Test

Starting the concentrator

- Have oxygen flow meter turned on first before power switch
- Listen for power alarm to go off
- May take up to 5 minutes for the concentrator to stabilize at or above the minimal performance of 85% O_2

Test

Alarms: low O_2 concentration **light**

Amber light when concentrator turned on, light **turns off** when oxygen fully concentrated (usually 5-10 minutes).

Test

Constant sounding of alarm

- The alarm *should* sound every time the concentrator is turned on, but it should *go off* within 10 seconds, indicating the power is connected and reaching the machine.
- If constant sound → is the machine unplugged, is the power on?
- Alarm also constantly sounds if there is a defective circuit board, faulty electrical connections or broken on-off switch

Test

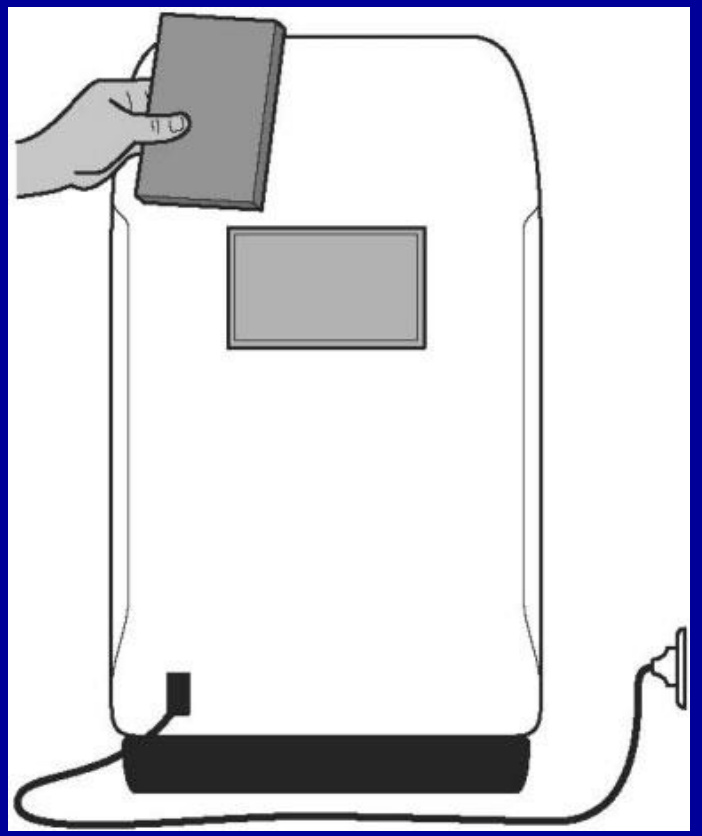
Intermittent sounding of alarm

- Means a high or low pressure alarm
  - May be a leak in the internal tubing, or defective internal parts (sieve beds, solenoid valve or compressor).

Test

Routine maintenance: clean and replace filter

- Replace coarse particle filter each week with a clean, dry one
- Wash in detergent, rinse thoroughly and allow to dry
- 2 filters needed



Test

Routine maintenance: external cleaning

- Clean exterior of the concentrator weekly with antiseptic (70% alcohol) or 0.5% sodium hypochlorite (bleach).
- Wipe the surface with a damp cloth and then dry

Test

Routine checking of concentrator

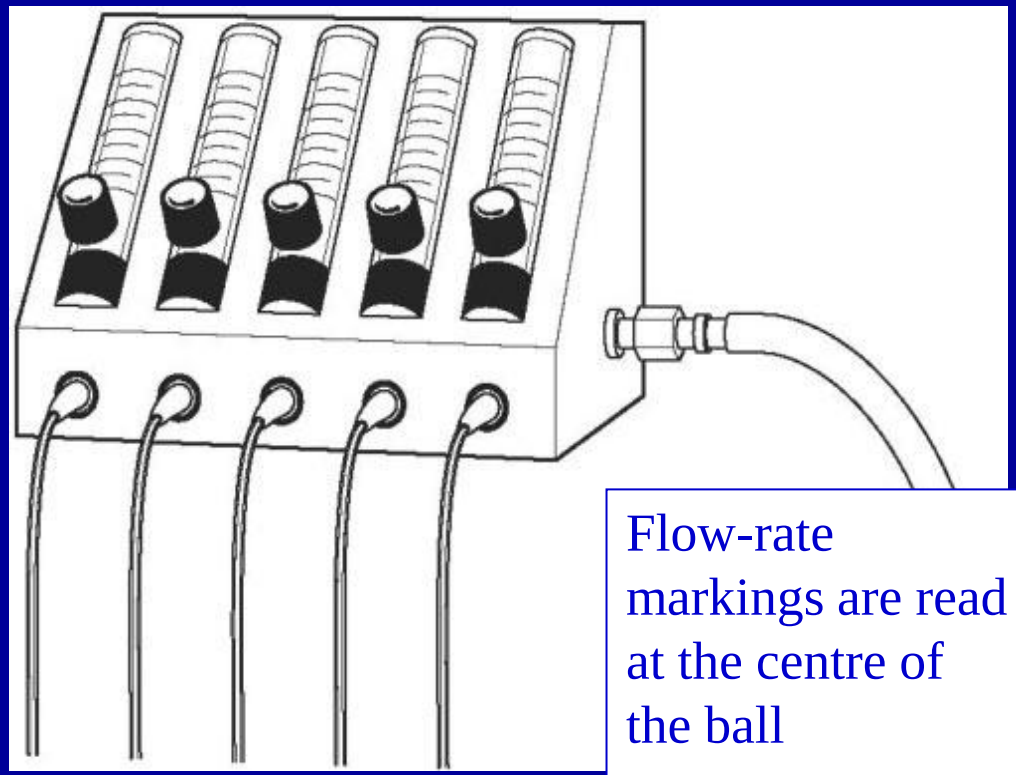
- Check the amber light is off 2-5 minutes after the concentrator is switched on.
- Check that there are no leaks from the oxygen tubing, and the tubing and nasal prongs are properly cleaned
- Use the oxygen analyser each week
  - Check the flow rate is accurate
  - Check the oxygen concentration is >85% oxygen

Test

Oxygen fire and infection safety

- No smoking
- No oil, grease and petroleum-based products
- Do not leave nasal catheters or prongs in the bed sheets or blankets (infection risk)
- Cleaning of face masks and oxygen tubing
  1. Soap and water
  2. Soak in dilute bleach solution
  3. Rinse in water to remove chlorine residues
  4. Allow to dry before re-using

Flow-meter assembly –oxygen to more than one patient at the same time



Flow-rate markings are read at the centre of the ball

Up to 2L/min flow from each flow-meter