Oxygen Concentrator

Biomedical Engineer/Technician Education Module

December 2024

These materials are intended to strengthen locally developed neonatal clinical and biomedical engineering trainings in pre- and in-service settings and are not intended to be comprehensive technical guidelines or device specific manuals.

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ABBREVIATIONS

BME/T	Biomedical Engineer/Technician
ESD	Electrostatic Discharge
LCD	Liquid crystal display
kPA	kilopascal
PSI	Pounds per square inch
AC	Alternating current
DC	Direct current
L/MIN	Litres per minutes
LED	Light emitting diode
NEST360	Newborn Essential Solutions and Technologies
O_2	Oxygen
PCB	Printed Circuit Board
PPM	Preventive Maintenance
PSA	Pressure Swing Adsorption
SpO_2	Peripheral blood oxygen saturation

NOMENCLATURE

Allen Keys	Hex keys
Control PCB	Main PCB
Flat head screwdriver	Slot head screwdriver
Nasal prongs	Oxygen catheter, oxygen cannula, oxygen prongs
Multimeter	Digital multimeter, Avometer
Star screwdriver	Philips screwdriver

Introduction

This Biomedical Engineer/Technician Education Module has been prepared to help BME/T staff and students understand when and how to use equipment essential to newborn care. The modules support staff in maintenance, troubleshooting and repair equipment when it breaks down or malfunctions.

This material may be used by teaching institutions to supplement BME/T curricula. BME/T and health care workers may use this to update their knowledge and to better facilitate the effective and safe use of newborn care equipment.

Every module has a similar structure with sections and subsections. The sections have similar headings and subheadings to make it easy for the user to navigate them. However, words may have different meanings for the various cadres of staff reading them and so to reduce misinterpretation, the heading titles are explained below.

1 CLINICAL USE

This section provides useful information on the clinical application of a device that would bear relevance to the biomedical team, not only to aid in their troubleshooting, but also for user training.

2 HOW IT WORKS

This section explains how the device works, and what kinds of patients it is useful for. This section also includes comprehensive diagrams of internal and external views of the devices, including consumables that may be used with the device. This section also contains detailed descriptions of key device components (including alarms) and includes a diagram of typical device flow (including components and how they interact with each other, electrical current and fluid movement through the device if relevant).

3 SETTING UP

Step by step preparation for setting up, checking, and using the equipment is described. This is followed by explanations of how to remove the equipment from an infant when it is no longer needed, how to clean it, and how to store it safely until further needed. Although a biomedical engineer or a technician will not be responsible for providing care, understanding these steps will be useful in training and when assessing the device.

4 INFECTION PREVENTION

In this section infection prevention measures are described for the equipment when in use, followed by instructions on how to disinfect the equipment.

5 PREVENTIVE MAINTENANCE

Biomedical engineers and technicians are responsible for second-line care and maintenance to ensure the equipment lasts to its potential lifetime; as such, this section also lists the necessary daily, weekly, monthly and annual preventive maintenance steps required to keep the device in good working condition. First-line care and maintenance is the responsibility of the user and is described in this section.

6 TESTING & CALIBRATION

This section describes the device components and tools that require testing and calibration.

7 TROUBLESHOOTING & REPAIR

This section describes steps that should be taken when a device malfunctions and first-line troubleshooting efforts have failed to address the issue. This section describes tools and spare parts that might be required to

prepare for repairs and to troubleshoot failures and provides a list of components commonly provided with the device to ensure that all components return to the ward post-repair. Finally, this section also explains steps for testing, repairing, and replacing specific parts of the device.

8 DECOMMISSIONING & DISPOSAL

This section describes the conditions for decommissioning and proposed methods of disposal for the medical devices and accessories.

9 ASSESSMENT QUESTIONS

A few questions are attached based on module content. These may be used, for example, during mentoring visits or to emphasise some of the points raised in teaching with the module.

References & Alerts

References and alert boxes are included within each module to provide clarity on areas where recommendations are governed by published standards, evidence and/or expert opinion.

When needed, **alert boxes** will be placed and can be found **at the end of a section** within the module.

Alert 0.0 Subject

QUERY ALERT BOXES appear where there may be controversy or disagreement. In these cases, alert boxes provide background to the recommendations that are made in the body of the document. Relevant documents are cited and brief explanation of reasoning for current module content provided.

Alert 0.0 Subject

RECOMMENDATION ALERT BOXES appear where there are recommendations based largely on expert opinion or consensus, or to emphasise an important element of care. Relevant documents are cited and brief explanation of reasoning for current module content provided.

1 Clinical Use

Oxygen concentrators (Figure 1.1) are used in newborn care units to provide supplemental therapeutic oxygen (above 82% purity) to patients with hypoxia and hypoxemia. Conditions that may cause hypoxia and hypoxemia in neonates include but not limited to birth asphyxia, respiratory distress syndrome (RDS), transient tachypnoea of neonates (TTN) and heart failure.

Concentrators may also be used to share oxygen between multiple patients using a flow splitter or used with other treatment devices such as continuous positive airway pressure (CPAP) devices. Supplemental oxygen is indicated for sick children, especially those with low blood oxygen saturation levels (typically SpO2<90%).

Figure 1.1 Common oxygen concentrators.

2 How It Works

An oxygen concentrator operates on the principle of Pressure Swing Adsorption (PSA) using a microporous granulated molecular sieve material called zeolite. Zeolite has the property of selectively adsorbing (trapping) nitrogen from air at high pressure and desorbing (releasing) nitrogen at low pressure hence the name pressure swing (swinging between low and high). For the purposes of an oxygen concentrator, the zeolite is contained in two cylindrical canisters called molecular sieve beds.

Air at atmospheric pressure of 14.7 psi (101 kPa, 1.01 bar) is filtered and drawn into the concentrator by the cabinet fan and compressor. The compressor feeds air into one of the molecular sieve beds (controlled by the feed valve) and raises the air pressure to about 30 psi (206 kPa, 2.1 bar). Nitrogen is adsorbed by the zeolite granules while oxygen is allowed to pass. The residual oxygen is collected at the molecular sieve bed outlet port into the product tank. After 10 to 15 seconds the zeolite will be saturated with nitrogen. At this point, it can no longer adsorb further, and the supply of compressed air is automatically switched to the second molecular sieve bed where it undergoes the same sieving process.

Concurrently, the pressure in the first molecular sieve bed is reduced to atmospheric pressure by venting it back to the atmosphere. This allows the trapped nitrogen to be released from the zeolite back to the atmosphere. By releasing nitrogen, the zeolite becomes regenerated and ready for the next cycle. By having two sieve beds a continuous supply of oxygen is ensured. There is no lag in production as the molecular sieve beds alternate between oxygen production and zeolite regeneration.

TYPICAL DEVICE FLOW

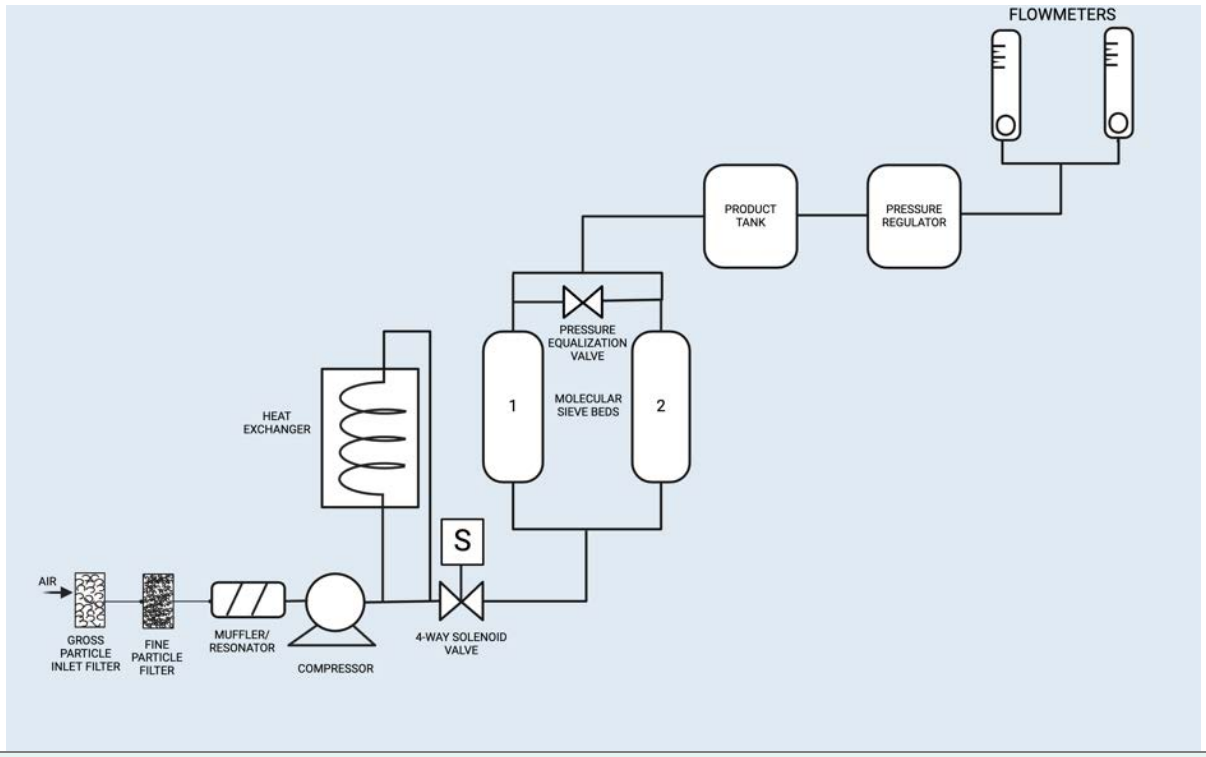
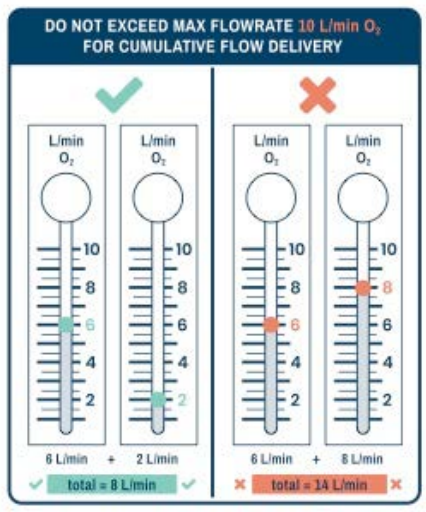


Figure 2.1 Device flow for oxygen concentrator.

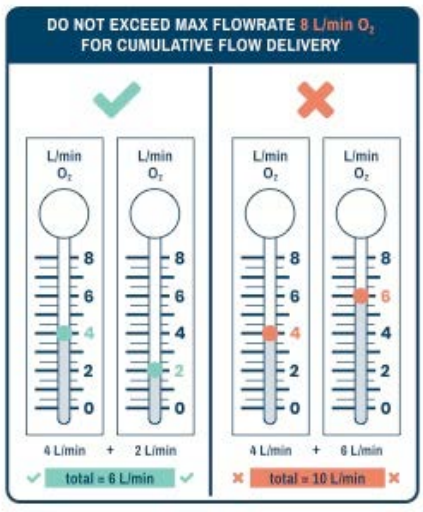
DUAL FLOW CONCENTRATORS

Oxygen concentrators may have one or two oxygen output ports that may be used to supply oxygen directly to one or two patients or to multiple patients at low flows using a flow splitter. Each output port has a flowmeter that can be adjusted to regulate flow from that port.

Each flowmeter is graduated to the maximum capacity of the device. e.g., a 10 L/MIN oxygen concentrator can only produce a combined 10 L/MIN of oxygen from both outlet ports at a time). An oxygen concentrator will return therapeutic oxygen concentration (>82%) across the range of oxygen output to the maximum**. Combined flowrate from all ports during use must not exceed the total recommended flow rate.** Should the combined flowrate go over the maximum capacity of the oxygen concentrator, the produced oxygen purity will drop, decreasing the oxygen delivered to the patient.



(A)



(B)

Figure 2.2 Sample safety labels for **(A)** 10 L/MIN and **(B)** 8 L/MIN concentrators: delivered oxygen from all oxygen ports should not exceed maximum oxygen capacity.

MAIN DEVICE COMPONENTS

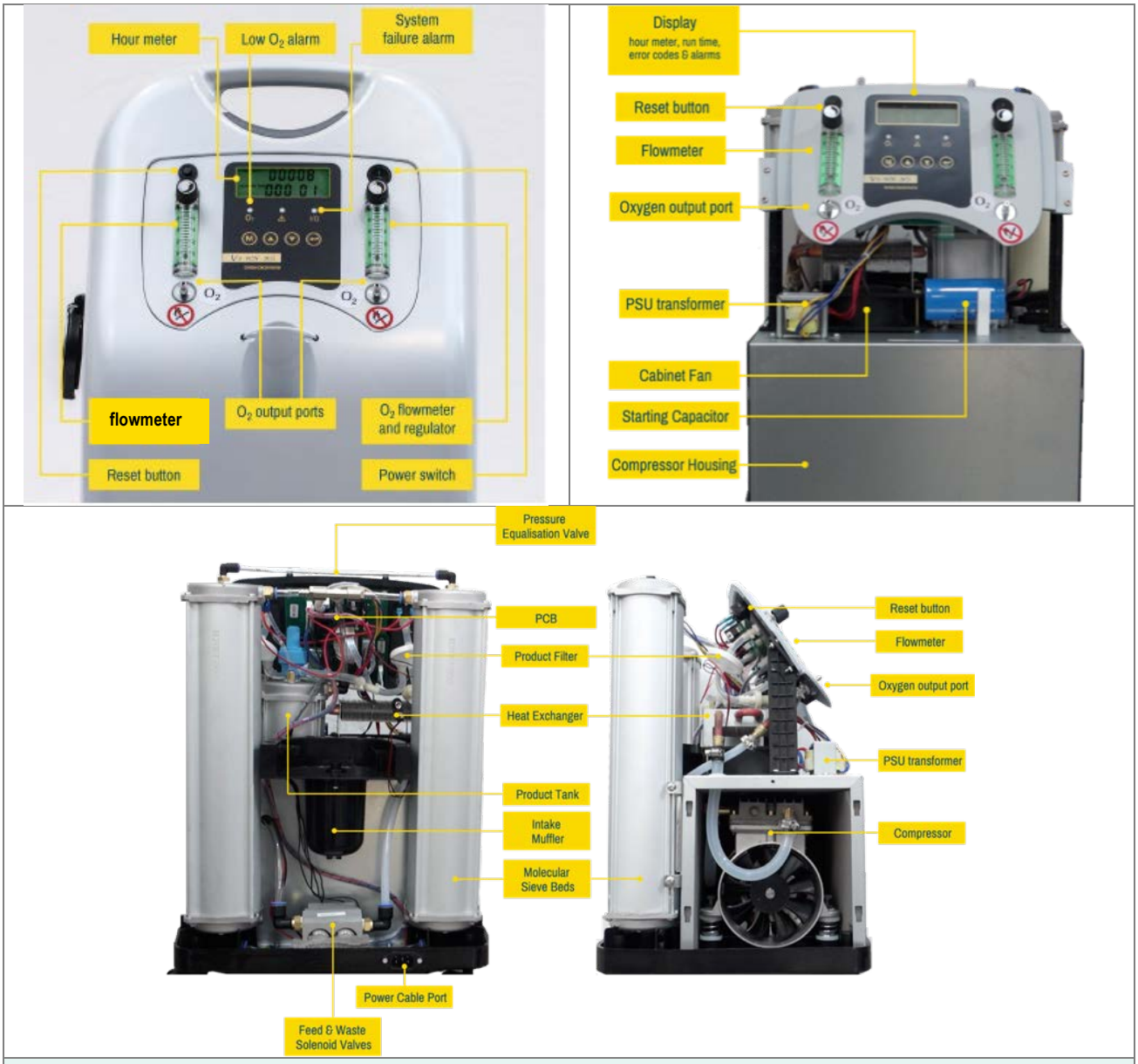


Figure 2.3 External and internal components.

The following device components should be similar regardless of model. However, specific locations, visual setup and component type may vary by brand and device model. Refer to model service and user manuals if different from the displayed model for more device-specific information.

Compressor

Draws in ambient air and pressurizes it into the molecular sieve beds. The compressor type that is used in concentrators is oil-free reciprocating piston. Compressor flow rate refers to how much compressed air the compressor can produce. This depends upon the model of the compressor, stroke size, bore size and cup seal condition. Compressors may have a pressure relief valve (an automatic, typically spring-loaded mechanism that opens when the compressor experiences increased pressure to discharge the excess air into the atmosphere).

Starting capacitor

Starts and runs the compressor and keeps the auxiliary compressor motor coil running.

Heat exchanger

Reduces the temperature of the compressed air which has heated during the compression process.

Thermal switch

Cuts power to the compressor once the compressor running temperature exceeds maximum heat threshold.

Control PCB

Controls and times the opening and closing of the solenoid valves. It also controls all electronic and electrical components of the unit including alarms, pressure transducers and oxygen monitor circuits.

Molecular sieve beds

Canisters that contain zeolite (typically aluminium silicate), which adsorbs nitrogen from air at high pressures. Compressed air enters the sieve beds from the compressor at high pressure which allows the zeolite to adsorb the nitrogen in air, leaving 83-95.5% oxygen-enriched gas.

Oxygen monitoring PCB

Consists of an in-built oxygen analyzer, typically ultrasonic, which monitors oxygen concentration in produced airflow. The oxygen monitoring PCB also processes output signal of the analyzer in a pass/fail fashion.

Solenoid valves

Solenoid valves are electrically controlled valves with two main components: a solenoid (an electric coil with a movable electromagnetic plunger) and a valve. Solenoid valves remain at their “normal” position (open or closed) until an electric current creates a magnetic field to force the plunger up and open or close the valve.

They are used to control the flow of air into and out of the molecular sieve beds. Feed valves direct and regulate the flow of ambient air from the compressor to the sieve beds, while waste valves direct and regulate the exhaustion of nitrogen out of the sieve beds.

Equalization valve/Tube

It directs some of the oxygen produced in one sieve to the other in every cycle. The equalization valve plays two critical roles in the Pressure Swing Adsorption process:

It facilitates pressurization and nitrogen purging of the sieve under depressurizing cycle thus, reducing energy requirements and increasing efficiency.

Cabinet fan

The cabinet fan pulls ambient air into the unit and circulates air throughout insides of concentrator, cooling internal components. Cabinet fans can either be AC or DC powered. DC powered cabinets fans have a stepdown transformer attached to it. They also have orientation of rotation, always verify with fan information.

Pressure regulator

Controls the oxygen pressure as it leaves the product tank. This is typically set by the manufacturer to 20 psi (138 kPa, 1.4 bar).

Check valve

Prevents backflow of oxygen after air has been processed through the sieve beds.

Intake muffler

Minimizes noise from compressor suction as air enters compressor.

Exhaust muffler

Minimizes noise of nitrogen-rich air exhaust and discharges this air from concentrator.

Product tank

Reservoir where oxygen is kept before proceeding to the outlet ports. This tank stores a small amount of oxygen that is released when the device is turned off or power is lost.

Pressure relief valve

it is embedded onto the compressor. It protects the compressor from high pressure build up. It releases pressure when it exceeds the design capacity of the machine. This usually happens when there is air blockage within the system.

Oxygen output ports

Product output ports: these ports may have free flowing oxygen or require a Christmas tree adapter to be connected to allow flow. Provides a receptacle for connecting other accessories like nebulizers, flow splitters, bCPAP etc…

Fine particle intake filter

Internal to the machine, either composed of filter paper or thick white felt filter. Filters particles from air to protect the compressor.

Gross particle intake filter

External to the machine, very porous and only intended to filter out large particles.

Product filter

Filters fine particles from product oxygen stream prior to administration to patient. Unlike other filters, intended for use of unit lifetime.

Hour meter

Records the device's cumulative running time.

Reset button

Circuit breaker; resets the unit after electrical overload shutdown.

Alarm battery

Provides power to audible alarm speaker to ensure alarms sound during a power outage.

Alarms

Alarms may be audible, visual or both. LED indicators illuminate to indicate oxygen level, system failure and power failure. Some oxygen concentrators have specific error codes on the display that designate each failure; refer to the model-specific user and service manual for more information.

Flowmeter and regulator knobs

Controls and displays the oxygen delivery rate to the patient(s) in L/min.

3 Setting Up

These instructions are helpful for a biomedical engineer or technician both in user training and in assessing the appropriate functionality of the device.

1. Plug oxygen concentrator's power cable into the oxygen concentrator **(Figure 3.1a)** and into the wall and turn on power at socket. Turn on concentrator **(Figure 3.1b)**.
2. Set flow to desired rate. If machine has not been turned on, allow to run for five minutes or until O_2 indicator light **(Figure 3.2)** shows that concentrator is providing appropriate concentration of oxygen for treatment. Check that no alarms sound on the machine.
3. Perform hand washing protocols. Connect appropriately sized nasal prongs to oxygen port on machine **(Figure 3.3)** or to humidifier (if using).
4. Test that oxygen flow has begun by placing your finger near the nasal prongs, ensuring that flow commences. This can also be tested by submerging the nasal prongs in clean water and checking for bubbles **(Figure 3.4)**, also known as the "Bubble Test." [3]

Figure 3.1 (a) Plug in the oxygen concentrator.

Figure 3.1 (b) Turn on the oxygen concentrator.

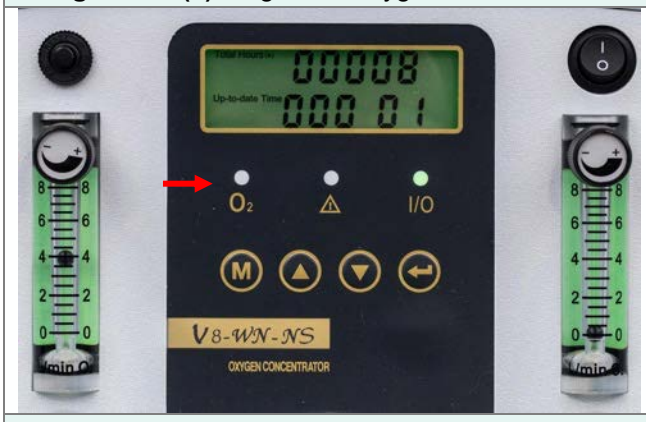


Figure 3.2 The "Low Oxygen" alarm indicates that produced concentrations are lower than 85%.

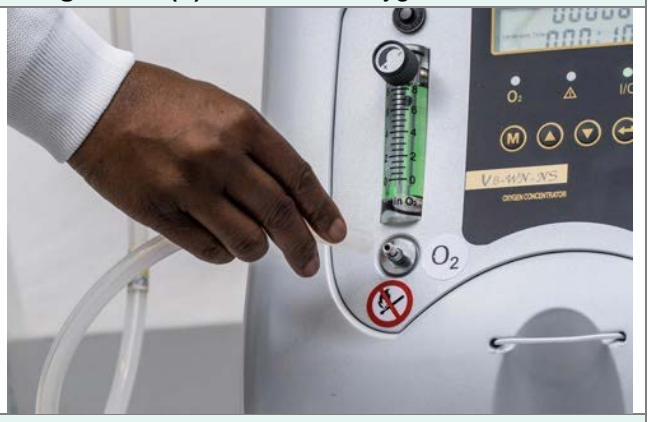


Figure 3.3 Connect correctly sized nasal prongs to oxygen port.

Figure 3.4 Submerging the nasal prongs in water should produce bubbles.

4 Infection Prevention

Any piece of equipment used in providing patient care must be handled carefully, as it may be contaminated and have the potential to spread infection.

1. Wash hands with water and soap.
2. Wear appropriate PPE before any repairs or maintenance are made to avoid any contact between used piece of equipment and skin, mucosa or clothing.
3. Clean and disinfect with 70% alcohol:
    - The housing of the oxygen concentrator
    - Patient related tubing
    - Oxygen output ports
4. Do not use personal gadgets during working to prevent cross-contamination
5. Post-maintenance decontamination of all tools and surfaces used should be done with 70% alcohol or according to manufacturer guidelines. Do not use equipment until it has fully dried following decontamination.
6. Dispose all the used materials in an appropriate container
7. Wash and disinfect your hands

5 Preventive Maintenance

Preventive maintenance is an important part of improving and maintaining the lifespan and viability of the oxygen concentrator.

Weekly

- Visually inspect device components and placement.
- Confirm that no alarms are audibly or visually activated. If concentrator has not been used in the last week, turn on and allow to run for 15 minutes.

Monthly

- Perform **Weekly** preventive maintenance tasks.
- Assess condition of the gross particle intake filter.
- Assess the condition of the fine particle intake filter. Clean or replace if needed.

- Perform power loss alarm functionality test.
- Assess concentration and output flow rate at both minimum and maximum flow rates on all oxygen outlet ports. If an analyzer is not available, observe the 'Low Oxygen' LED indicator.
- Visually assess the internal housing for dust. Blow clean if necessary.
- Check the castors for proper movement and brake functions.
- Audibly assess the concentrator for sounds outside of standard operation.
- Perform power loss alarm functionality test.

Quarterly

- Perform **Monthly** preventive maintenance tasks.
- Measure grounding integrity and casing leakage current.
- Check that all PCBs are functional and have no visible damage.

Yearly

- Perform **Quarterly** preventive maintenance tasks.
- Confirm supply of spare power supply units, sieve beds, control PCBs, solenoid valves, compressor rebuild kit, intake filters and power cables are adequate to support estimated replacement for upcoming year.

6 Testing & Calibration

The oxygen concentrator does not need special calibration, but the oxygen concentration can be tested using an oxygen analyzer which can measure and confirm oxygen purity and flow rate as well as pressure of the oxygen source.

7 Troubleshooting & Repair

Biomedical engineers and technicians are responsible for providing rapid maintenance and troubleshooting, as well as repair support for users. Ensure that the device is disconnected from the mains power before opening and handling the internal components.

PREPARE FOR REPAIR

ACCESSIBLE TOOLS	SPARE PARTS	DEVICE CHECKLIST
• Digital multimeter • Phillips screwdrivers • Allen keys • Adjustable wrench • Wire strippers • Needle nose pliers • Oxygen analyzer • Oscilloscope • Compressed air blower • Digital multimeter	• LCD • Power supply unit • Control PCB • Gross and fine particle intake filter • Solenoid valves • Starting capacitor • Compressor and rebuild kit • Crimp or zip ties	• Oxygen concentrator • Power cable • Gross particle intake filter • Oxygen tubing or nasal prongs

TROUBLESHOOTING FAILURES

For exact troubleshooting strategies, consult the service or user manual for your device. If there is an internal failure that is beyond repair, immediately decommission the device and do not use it until the issue has been resolved.

Device is not turning on:

Probable causes:

- Visually inspect device components and placement.
- Confirm that no alarms are audibly or visually activated. If concentrator has not been used in the last week, turn on and allow to run for 15 minutes.

Check:

- Power cable continuity
- Reset button/circuit breaker activation & continuity
- Power switch physical integrity & continuity
- Power entry module fuse(s) physical integrity & continuity
- Power supply unit continuity & voltage
- Control PCB physical & electrical integrity and continuity

No flow from oxygen ports:

Probable causes:

- Blocked oxygen ports
- Displaced internal tubing

Check:

- Flowmeter knobs and cracked flowmeters
- Oxygen outlet port for debris or blockages
- Internal tubing for leaks, blocks or kinks
- One way valve orientation

Low oxygen concentration light and alarm audible:

Probable causes:

- Contaminated sieve beds
- Worn compressor
- Blocked filters

Check:

- Combined flow rates, within device specs (sum ≤8L/MIN)
- External and internal filter for dust or debris
- Sieve beds for high pressure or contamination
- Compressor and compressor kit for damage or wear
- Control PCB, visually or functionally on a working device

Compressor periodically shuts down:

Probable causes:

- Malfunctioning cooling system

Check:

- Device placement, >30 cm away from wall on all sides
- Fan, visually or functionally by connecting to power source

- Control PCB, visually or functionally on a working device
- Internal tubing for blockages or kinks
- Starting capacitor, capacitance 15µF±5%
- Power supply unit, visually or functionally using a working PCB

Loud popping sound from device:

Probable causes:

- High pressure build-up from the system

Check:

- Flow restrictions in all airways/tubing/exhaust ports
- System operating pressure (12-30psi)
- Control PCB, visually or functionally on a working device
- Sieve beds for high pressure or contamination
- Solenoid valves' resistance, 150Ω±10%
- Internal wiring for shorting/ground/wire cuts/continuity
- Compressor pressure relief valve, physical condition

Device flowmeter beads fluctuating more than 0.2 L/MIN:

Probable causes:

- Low pressure in the system

Check:

- Leakages in the system
- Compressor and compressor kit for damage or wear
- Control PCB, visually or functionally on a working device
- Solenoid valves' resistance
- Air intake system and resonator for restrictions
- Flowmeter, cracks and leakage

Circuit breaker trips repeatedly when power switch is in the ON position:

Probable causes:

- Power circuitry malfunction

Check:

- Control PCB, visually or functionally on a working device
- Starting capacitor
- Compressor
- Internal wiring for shorting/ ground/ wire cuts/ continuity

Compressor does not start:

Probable causes:

- Overheated or cold compressor

Check:

- Device temperature, allow to cool down before retesting
- Starting capacitor
- Control PCB, visually or functionally on a working device
- Internal wiring for shorting/ground/wire cuts/continuity
- Seized bearings or field winding resistance

White dust coming from device:

Probable causes:

- Degraded sieve beds filter which causes zeolite to escape into concentrator

Check:

- Internal condition of the concentrator
- Blow clean
- Disassemble and clean all internal components including exhaust assembly, tubings
- Replace sieve beds and compressor kits

REPAIR

Where technically possible and not likely to obstruct clinical care, repairs may be made within the newborn care ward. Use discretion to determine if this is appropriate or if the device should be removed to the biomedical workshop for more testing or repair.

Testing & checking of oxygen concentration

You can test the purity of oxygen using an oxygen analyzer. The device LED indicator visually indicates the oxygen concentration level (typically, RED for low concentration and GREEN for normal concentration). Perform this check during installation, preventive maintenance (PPM), and after any major repairs or part replacements. Ensure that the oxygen concentration exceeds 82%.
Follow the procedure:

1. Run the device for a maximum of 5 minutes
2. Adjust the flow rate to the maximum level
3. Connect oxygen analyzer directly to the O2 port
4. Wait for the reading to stabilize
5. Record reading, if below 82%, the device is faulty, refer to the troubleshooting section for guidelines. If above 82%, the device is functional.

Testing pressures

The operating and output pressures can be measured by use of pressure gauge. This can be done as follows:
Operating pressure:

1. Open the device to access the pressure testing port
2. Run the device
3. Connect pressure gauge to the testing port
4. Record the minimum and maximum reading, refer to the manufacturer manual for specific operating pressure ranges.
5. If above the maximum or below the minimum expected reading, refer to the troubleshooting section

Output pressure:

1. Run the device for a maximum of 5 minutes
2. Adjust the flow rate to the maximum level
3. Connect the pressure gauge to the O2 outlet port
4. Wait for the reading to stabilize
5. Record reading, refer to the manufacturer manual for specific pressure
6. If below or above normal reading, refer to the troubleshooting section

Some oxygen analyzers can also be used to measure output pressure. For this purpose, connect the analyzer and close the outlet port on the analyzer.

Replacing the power supply unit or module

Testing Power Supply Unit

1. Open the device to access the power supply unit
2. Visually inspect the PSU electronic components for burnt marks, corrosion and physical damage.
3. Power the device
4. Locate the input and output terminals of the power supply unit
5. Using a digital multimeter, measure the input VAC voltage. Should be equal to mains AC
6. Using the multimeter, measure the PSU DC output voltage (Refer to the manufacturers manual for the specific output Voltage)

If any of the readings deviates from the expected values, replace the PSU or replace any serviceable individual components on the board.

The procedure should be completed with caution, as the power to the device must be switched on to accurately measure the voltages.

Testing the Power Switch

1. Disconnect the device from power supply
2. Remove the power entry module to access the terminals
3. Using a digital multimeter test the continuity of the of the terminals

Testing & replacing control PCB and associated components

In most cases, if one element of the control PCB has malfunctioned, the entire control PCB should be replaced. Visually assess the PCB for burnt or damaged components. Internal wiring continuity leading from the power supply to the control PCB and from the control PCB to the other components may also be assessed for replacement.

Testing & replacing internal tubing components

Leaks may contribute to both low operating pressure and accelerated failure of molecular sieve beds. Internal tubing can be assessed for leaks by running oil-free, mild or diluted soapy water or leak-testing foam along the suspected tubing, pipes and fittings during operation and checking for bubbles or movement of the liquid.

Internal tubing may have springs in place to protect from kinks or bends. When replacing tubing, remember to remove the springs and replace in the new tubing.

Assessing, cleaning & replacing intake filters

Frequency of maintenance increases in hot, humid and/or dusty operating environments. As the gross **(Figure 7.1)** and fine **(Figure 7.2)** particle intake filters become clogged with dust or other debris, intake airflow to the compressor becomes constricted and decreases the efficacy of the PSA process. Intake filters should be assessed and cleaned regularly whilst wearing appropriate PPE (including gloves, a face mask and safety glasses, if available). The fine particle intake filter should be replaced based on the condition and as per manufacturer's recommendations.

Figure 7.1 Gross particle intake filter.

Figure 7.2 Fine particle intake filter.

Cleaning the gross particle intake filter

1. Pull gross particle intake filter gently from the back of the oxygen concentrator. Replace with spare.
2. Put the filter in warm, soapy water and swirl gently to remove debris.
3. Remove from soapy water and rinse with clean water. Place in shaded area until completely dry. Store as spare filter until next cleaning is required.

Cleaning the fine particle intake filter

1. Open the oxygen concentrator housing. The fine particle intake filter is internal to the device, although the exact position varies by oxygen concentrator model.
2. Remove the fine particle intake filter. Replace with spare filter **(Figures 7.3 – 7.5)**.
3. Take the filter to an outside or well-ventilated area. Hold the filter firmly a distance away from and downwind of any individuals. Use air blower or compressed air to blow dirt and debris off the filter. If compressed air is not available, a pen or pencil may also be used to firmly strike the internal filter **(Figures 7.6, 7.7)**.
4. Dust clouds will rise off the filter. Continue striking or blowing compressed air until dust no longer comes off and the colour has visibly lightened.
5. Assess the condition of the fine particle intake filter. If the filter is not damaged, store as spare filter until next cleaning is required.

Figure 7.3 Remove the fine particle intake filter from the concentrator.

Figure 7.4 Unscrew & separate the 2 parts of the plastic housing for the filter paper cylinder.

Figure 7.5 Remove the filter paper cylinder from the assembly.

Figure 7.6 Wearing PPE and using compressed air, clean all components of the fine particle intake filter separately.

Figure 7.7 Dust should blow off the filter paper.

Testing & replacing sieve beds

Clogged or faulty sieve beds usually cause low oxygen concentration and high pressure. The functionality and condition of the sieve beds can be tested by connecting it to another functioning device. The sieve beds are faulty if the functioning device is replicating the same technical issues as the original one.

Sieve beds should be replaced in pairs. While replacing, sieve bed spares should be temporarily sealed with tape until installation is complete to prevent contamination of the molecular sieve from the moisture in the ambient air. After installation of the spare sieve beds, careful leak testing should be conducted to ensure that there are no small leaks that may contaminate the newly installed sieve beds **(Figures 7.8 – 7.11).**

Figure 7.8 Unscrew sieve beds for replacement.

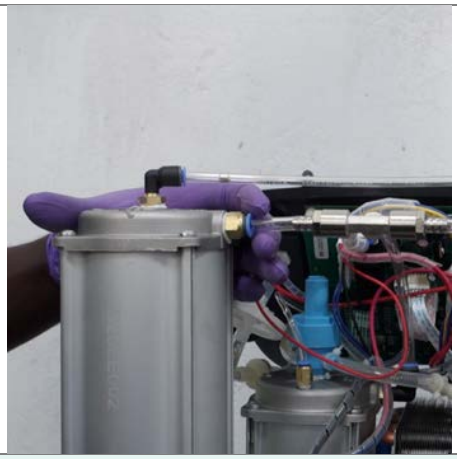


Figure 7.9 Remove attached tubing from the sieve beds by pressing the blue holding piece towards the sieve beds and pulling the tubing simultaneously.

Figure 7.10 Remove sieve bed tubing from the feed & waste solenoid valves.

Figure 7.11 Replace the sieve beds in pairs, following grooves along sieve bed housing to snap into place.

Testing & replacing the compressor and its components

Compressor output depends upon the model of the compressor, stroke size, bore size, and cup seal condition. The cup seals form the seal between the piston and the cylinder wall. As the cup seals wear, the compressor's output begins to gradually decrease. This reduction in compressor output results in less air for the sieve beds and decreases the production of oxygen. The condition of the compressor's cup seals, bearings, and other components can also result in a noticeably louder running sound.

Compressor units may be serviced by replacing internal cup seals and bearings using a compressor rebuild kit. **(Figures 7.12 – 7.19)** If rebuilding the compressor using a rebuild kit is not sufficient to repair the compressor, the entire compressor unit may also be replaced.

Alert 7.1 Assembling and reassembling compressor

When reassembling the compressor after replacing the compressor kit, assemble the compressor sleeve, plates and cups before reattaching. It is important that the compressor plates and cups have adequate purchase in the compressor sleeves; if this is not done in the first attempt, push the compressor plate and cup through the sleeve and try again. Always nest the plate within the cup before pushing into the compressor sleeve.

Compressor segments are directional. Always label the sides of the compressor with permanent ink to ensure the correct pieces are installed for the correct side.

Figure 7.12 Slide panel up to access compressor.

Figure 7.13 Mark sides of the compressor.

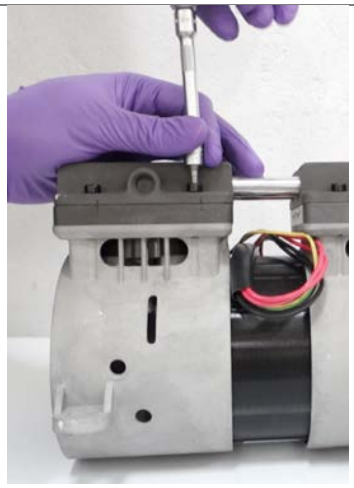


Figure 7.14 Use a ratchet to remove the bolts securing compressor head.

Figure 7.15 Lift off compressor head & assess head gaskets for damage.

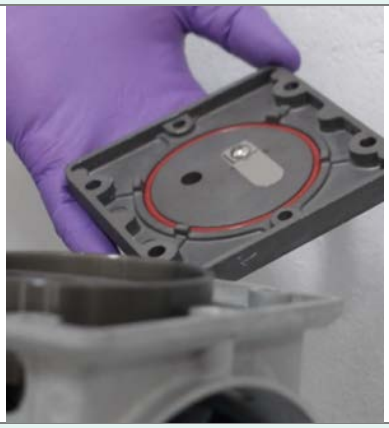


Figure 7.16 Turn over valve plate and assess o-rings and reeds for damage. Replace if necessary.

Figure 7.17 Remove compressor sleeves & assess for visible damage. Clean interior with alcohol & cotton swab.

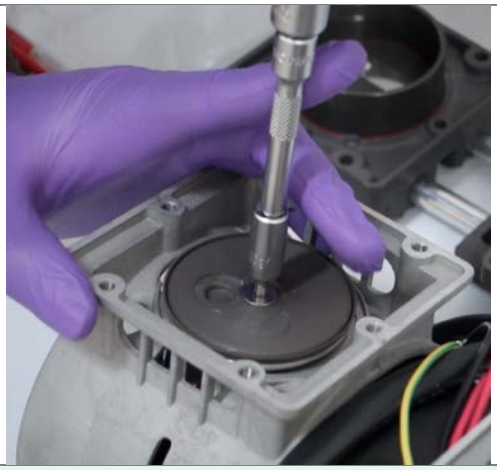


Figure 7.18 Remove the screw holding the compressor piston plate & cup in place. **Do this slowly to prevent stripping the screw.**

Figure 7.19 Check the compressor piston plates and cups for damage. Replace as needed.

The compressor relief valve and starting capacitor may also need replacement. These parts should be interchangeable with components of equivalent specifications, which can usually be determined from the component housing or device service manual.

Testing & replacing solenoid valves

Solenoid valves may be tested using a multimeter or by checking the magnetisation of the coils during operation. Valve coil resistance specifications for feed, waste and equalisation valves should be available from the manufacturer or service manual for a specific model. Coil specifications may vary within a model or between AC ratings.

Magnetisation can be tested by holding the metal tip of a magnetized screwdriver over the exposed top of the valve stem in the centre of the coil. When the coil becomes energized (magnetized) the tip of the screwdriver should be pulled down onto valve stem, indicating the valve coil is functional.

Solenoid valves may be serviced by replacing the internal coil or the entire solenoid valve assembly. The internal coil is directional and must be replaced in the same orientation as it was removed.

Assessing & replacing the fan

Most fan-related failures are due to physical damage to the fan itself or electrical damage to the fan PCB. The fan can be visually assessed for repair and replacement. The most common electrical damage to the fan PCB is the burnout of the fan transformer, which can be visually or electrically assessed. As in most PCB-based repairs, if one element of the PCB has been damaged, the entire PCB should be replaced.

Testing & replacing the thermal switch

The thermal switch shuts down the compressor when it exceeds a high temperature threshold. The oxygen concentrator may keep running the fan to allow for more rapid cooling, but it will not be able to fully turn on until cooler temperatures are reached within the concentrator. The thermal switch may become faulty over time due to poor power quality or consistently high running temperatures. A faulty thermal switch will prevent the compressor from running even during standard operating temperatures. Test the electrical integrity of the thermal switch using a multimeter; replace if required.

Assessing, repairing & replacing the flowmeter

The flowmeter may develop cracks and the knob may be break off. Crack and leakage test can be done as follows:

1. Run the device
2. Apply form to suspected leakage area. There is leakage if the form bubbles out

3 Alternatively, adjust the flowmeter to the maximum level and close the O2 outlet port. There is leakage if the bead doesn't drop all the way down.

4 Replace with a working flowmeter if faulty

Analyzing device electrical safety

A qualitative measurement of electrical can be taken using an electrical safety analyser to observe compliance of electrical safety requirements on the device. The measurements taken are:

- Leakage current
- Grounding integrity
- Resistance
- Voltage

8 Decommissioning & Disposal

DECOMMISSIONING

Assuming appropriate use and consistent maintenance, an oxygen concentrator may last up to 5 years or as per manufacturer's recommendations. Generally, it is more fiscally responsible to repair oxygen concentrators, when necessary, although there are some low-cost models that may be cheaper to replace rather than repair.

Consider **decommissioning the device** for the following reasons:

- High-maintenance cost
- Device is technically or clinically obsolete
- Unavailability of spare parts
- After-sales support is no longer available
- Manufacturer recommendations
- Serious concerns about unreliability
- Catastrophic events, such as accidents that may compromise the safety and functionality of the device
- Infrastructure incompatibility
- Regulatory withdrawal of the device on the market
- New or clinically effective technology
- Standardisation (limiting the number of models per device)

Always refer to the national, regional or international guidelines.

DISPOSAL

Consider the following **disposal methods** as per the national policies and guidelines:

- Repurposing for spare parts
- Trade-in
- Auctioning
- Donation
- Refurbish/ recycling
- Destroy

9 Assessment Questions

1 Label the diagrams using options form the word bank below:

• Intake resonator • Control valves • Cooling fan • Compressor • Molecular sieve beds • Oxygen monitor band • Stepdown transformer	• Bacteria filter • Thermal switch • Reservoir tank • Main control board • Pressure equalization valve • Pressure regulator

2 What symptoms does a clogged exhaust Muffler/filter share with defective control valves and contaminated sieve beds?

3 What advice would you give a health worker about proper placement of an oxygen concentrator? Give reasons.

4 Describe any major causes of low oxygen concentration and how you would rectify them.

5 A nurse complains that there is a loud popping noise coming from the machine, what does this tell you about the concentrator and what could be the problem?

6 What is the significance of pressure in the operation of an oxygen concentrator? What is the typical minimum and maximum molecular sieve bed operating pressure?

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DISCLAIMER

Biomedical Engineer/Technician Education Module: Oxygen Concentrator

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In addition, all forms, instructions, checklists, guidelines, and examples are intended as resources to be used and adapted to meet national and local health care settings' needs and requirements.

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MATERIALS SUMMARY

This series has been designed with the intent of supporting the clinical use and technical repair of technologies in newborn care units.

The Biomedical Engineer/Technician Education Modules provide educational support for each of the technologies included in the NEST360 bundle for newborn care. These materials are intended to strengthen locally developed neonatal and technical trainings in pre- and in-service settings. Of note, these materials are not intended to be comprehensive clinical guidelines or targeted towards intensive care of the newborn. They are to be used to facilitate the implementation of comprehensive newborn care, including bubble CPAP, in a resource limited setting.

The Biomedical Engineer/Technician Education Modules were developed through a combination of international standard review, international expert feedback, and multinational NEST360 expert consensus opinion. The modules form the backbone of all lectures, power points, job aids, and other supportive education materials supplied by NEST360.