**FACT SHEET ON THE CONTINUOUS POSITIVE AIRWAY PRESSURE (CPAP)**

CPAP is an acronym for Continuous Positive Airway Pressure, which describes the therapeutic action that the technique provides to alleviate respiratory distress to a specific class of patient suffering from hypoxia. The patient is provided with a nearly continuous flow and mild overpressure of respiratory gas (air/oxygen mix) that has a specified oxygen concentration (fraction of inspired oxygen, $FiO_2$). The overpressure assists in the inflation and recruitment of the lung alveoli, and the supplemental oxygen mitigates effects of residual lung malfunction.

**Key aspects of CPAP therapy are:**

a) It is non-invasive: The respiratory gas is provided to the patient by a mask or hood, not via intubation. The implication is that specialist clinical skills are not required for its application, as would be the case for invasive ventilation techniques. However, a doctor would still be required to adjust the device parameters to suit the needs and comfort of the patient.

b) The patients are conscious and cooperative during the therapy, and capable of spontaneous breath. There is no need for the device to provide synchronous or mandated breathing cycles.

c) It is an open-loop system: there is no requirement for complex control systems that vary the therapy parameters automatically. It is assumed that the patient's blood oxygen concentration will be monitored independently using a pulse oximeter or similar device.

In summary, CPAP is limited scope therapy requiring a relatively simple device and a simple standard operating procedure.

**Implementation**

A specialist CPAP system consists of two components: a respiratory gas supply and a patient circuit. These two items are described below:

- *Respiratory gas supply*

The respiratory gas supply provides a constant flow of an air/oxygen mixture. Two essential controls for the gas supply are:

a) The capability to control the fraction of inspired oxygen ($FiO_2$). It is not essential that the device has a calibrated means to determine the $FiO_2$ being supplied to the patient because the patient's blood oxygen saturation is monitored with an oximeter. The $FiO_2$ control is adjusted to obtain the required patient oxygen saturation level.

b) The gas supply flow must be variable in a range that produces sufficient flow for the patient circuit to operate effectively and safely. The flow volume must be set to match the patient's breathing effort, and must be sufficient to ensure that the set positive end-expiration pressure (PEEP) is maintained. There is no essential requirement to have a calibrated flow indicator because observation of the patient circuit function will provide an indication of the required flow rate.

There are two types of gas supply systems: oxygen/air blenders that require both oxygen and compressed medical air supplies, and blenders that mix supplied oxygen with entrained ambient air. Both gas supply options require a reliable supply of medical oxygen (~400 kPa), either provided by a standard hospital wall supply socket or an oxygen bottle with an appropriate pressure regulator and SANS 1409 terminal. If applicable, medical air supply (~400 kPa) is via a SANS 1409 terminal.

Oxygen consumption is a function of the flow rate of the gas supplied to the patient circuit and the $FiO_2$ set point. The oxygen demand for the majority of patients will be about 20 lpm, although the gas supply devices are capable of consuming up to 60 lpm for very high flow rates and oxygen fractions. CPAP is not an appropriate long-term therapy for patients requiring these higher flows and oxygen fractions, so the use of high-flow CPAP would be a temporary intervention until the patient can be transferred to an invasive ventilator.

- *Patient circuit*

A patient circuit has the following functions:

a) Deliver the gas from the above gas supply to the patient via a hood, full-face mask, or a half-face mask, depending on the preference of the patient and/or clinician. The gas seal between the hood or mask and the patient must be such that no significant leakage occurs for the full range of therapeutic parameters and all patient breathing efforts. This is to ensure that the therapeutic PEEP is maintained, and to prevent viral contamination of the ambient environment.

b) Provide a route for exhaled respiratory gas to be vented to the ambient environment. For COVID-19 patients this exhaled gas needs to be filtered to prevent virus contamination of the ambient environment.

c) Provide a mechanism for controlling the maximum airway pressure of the patient. This function is provided by a PEEP (positive end-expiratory pressure) valve included in the exhalent circuit.

d) Protect the patient from possible hyperbaric trauma caused by accidental overpressure through the inclusion of an overpressure relief valve.

e) Protect the patient from possible asphyxia caused by an insufficient respiratory gas supply to the mask or hood through the inclusion of an anti-asphyxiation check valve. This valve will be activated during peak inspiration of a patient who is breathing heavily because it is unlikely that the gas supply will manage to satisfy the peak inspiration rate of the patient (although gas supply rate will exceed the minute volume of the patient). The anti-asphyxiation valve is not required if the gas supply device itself provides this functionality.

## SAVE-P CPAP/HFNO Blender

s air/oxygen blender is based on the gas mixer that is integral to the Penlon Nuffield Series 200 anaesthesia ventilator. It can be used for both Continuous Positive Airway Pressure (CPAP) and High-Flow Nasal Oxygen (HFNO) therapy in the treatment of Covid-19 patients. It is the preferred option for hospital beds that have both a wall oxygen supply and a wall medical air supply.
s device has the following features and requirements:

- The device mixes high-pressure medical air and oxygen to the required $FiO_2$ and patient circuit flow rate.
- Pressure imbalances of up to 100 kPa between the oxygen and air supplies are equalized by two differential regulators to ensure the set $FiO_2$ is independent of any supply imbalance. An audible alarm sounds if the supply pressure difference exceeds 100 kPa.
- An internal pressure regulator ensures that the patient circuit flow is independent of gas supply pressures.
- No electrical power is required.
- It is provided with colour-coded oxygen (white) and medical air (black) supply hoses fitted with standard SANS 1409 probes. The hoses link to the device via distinct DISS connectors.
- A pressure gauge indicates the patient circuit pressure (cm $H_2O$).
- The interface to the patient circuit is a standard ISO 5356 22mm-tapered male port.
- For CPAP therapy the patient circuit must include:
    - 22 mm flexible tube (~2 m length)
    - mask or hood with appropriate ports
    - 40cm $H_2O$ pressure relief valve
    - anti-asphyxia valve
    - 0-20 cm $H_2O$ PEEP valve
    - viral filter for the exhaled gas
- For HFNO therapy the output port must be connected to a standard HFNO system, including humidifier and high-flow cannula.
- The device is supplied with a stand with a triangular base fitted with three castor wheels (one locking).
- A pulse oximeter or equivalent blood oxygen saturation monitor must be available to set the flow rate and $FiO_2$ to the patients needs and provide regular monitoring.

## Specifications of a CPAP 100 blender

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| Manufacturer | SAVE-P consortium |
| Device Name | CPAP 100 |
| Overall Dimensions | 270 mm (width) x 165 mm (height) x 140 mm (depth)<br>(blender unit only, including ports and controls) |
| Weight | 4.0 kg (excluding stand and hoses) |
| Gas ports (3) | 1. High Pressure $O_2$ supply (SANS 1409)<br>2. High pressure medical air supply (SANS 1409)<br>3. Patient circuit outlet (ISO 5356 22mm) |
| $O_2$ and air supply pressure | 300-400 kPa |
| Controls (3) | 1. Gas flow on/off<br>2. Flow Rate (dial scale 15-60 lpm)<br>3. $FiO_2$ (dial scale 21-100%) |
| $FiO_2$ adjustment range | 21-100% |
| Flow to patient circuit | 15-60 lpm |


**Illustration 1:** The SAVE-P air/oxygen blender providing gas for a HFNO system. The blender outlet connects directly to a standard humidifier, which provides heated and humidified gas to the high-flow cannula.


**Illustration 2:** The SAVE-P air/oxygen blender connected to standard hospital oxygen and medical air supply ports via colour-coded hoses and providing gas to a half-face mask CPAP patient circuit via a 22 mm flexible tube.

## UCL Ventura CPAP/HFNO Blender

s air/oxygen blender is manufactured to the UCL/Mercedes design specifications. It can be used for both Continuous Positive Airway Pressure (CPAP) and High-Flow Nasal Oxygen (HFNO) therapy in the treatment of Covid-19 patients. It is the preferred option for hospital beds that have a wall oxygen supply, but no medical air supply.
s device has the following features and requirements:

- The device uses a high-velocity oxygen jet to entrain ambient air and requires only an oxygen supply for its operation (no medical compressed air or electrical power are required).
- It is provided with a standard SANS 1409 oxygen probe that plugs directly into a wall or bottle supply (no hose or support stand are required).
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- The interface to the patient circuit is a standard ISO 5356 22mm-tapered male port.
- For CPAP therapy the patient circuit must include:
    - 22 mm flexible tube (~2 m length)
    - mask or hood with appropriate ports
    - 40 cm $H_2O$ pressure relief valve
    - 0-20 cm $H_2O$ PEEP valve
    - viral filter for the exhaled gas
    - anti-asphyxia protection is provided by the entrainment port on the device
- For HFNO therapy the output port must be connected to a standard HFNO system, including humidifier and high-flow cannula.
- A pulse oximeter or equivalent blood oxygen saturation monitor must be available to set the flow rate and $FiO_2$ to the patient's needs and provide regular monitoring.

## Specifications of a UCL blender

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| Manufacturer | Various (Gabler, CSIR/Sabertek) |
| Device Name | UCL Ventura |
| Overall Dimensions | 160 mm (width) x 130 mm (height) x 50 mm (depth)<br>(blender unit only, including ports and controls) |
| Weight | 0.4 kg |
| Gas ports (2) | 1. High Pressure $O_2$ supply (SANS 1409)<br>2. Patient circuit outlet (ISO 5356 22mm) |
| $O_2$ supply pressure | 300-400 kPa |
| Controls (3) | 1. Gas flow on/off<br>2. Flow Rate (no dial scale)<br>3. $FiO_2$ (no dial scale) |
| $FiO_2$ adjustment range | 30-100% |
| Flow to patient circuit | 0-120 lpm |
| Indicators/Alarms | None |

**Illustration 3:** The UCL VENTURA air/oxygen blender providing gas for a HFNO system.
The blender outlet connects directly to a standard humidifier, which provides heated and humidified gas to the high-flow cannula.


**Illustration 4:** The UCL VENTURA air/oxygen blender plugged directly into a standard hospital oxygen supply port and providing gas to a half-face mask CPAP patient circuit via a 22 mm flexible tube