Gradian Health Systems®

Universal Anaesthesia Machine®

Maintenance Manual

Printed in the United States of America.

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NOTE: For the latest UAM specifications and technical materials please visit us online at:
http://www.gradianhealth.org/our-products/uam/

GENERAL DESCRIPTION OF THE UNIVERSAL ANAESTHESIA MACHINE®

The UAM® combines elements from both continuous flow and draw-over designs to provide a workstation that delivers controlled anaesthesia in all hospital settings.

The breathing system is a low pressure (limited to 5 cm H2O) continuous flow system that defaults to a demand-flow (draw-over) system when the supply fails. There are three one-way valves and a balloon operated inflating valve which provide this uniquely versatile method of anaesthesia delivery.

Oxygen can be provided from a variety of sources, and if none of those sources is available the machine will automatically draw in room air without the need for the user to change settings. The vaporizer provides calibrated delivery of anesthetic agent and the manual bellows ensures that safe assisted respiration can continue without requiring a high pressure gas source.

The system has been designed to accept standard anaesthesia accessories such as the breathing circuit, oxygen sensor, and standard connectors for the oxygen and nitrous oxide supplies. The UAM is also designed for simple field service. Most components can be removed with standard tools and local technicians can install replacement parts without removing the UAM from the hospital.

The UAM carries the CE Mark, having passed EU regulatory inspections. It is manufactured in an ISO-certified factory in England. It is used in a wide variety of hospitals, from internationally recognized academic centers to resource-constrained district hospitals.

The Universal Anaesthesia Machine ensures that an adequate supply of oxygen and anaesthesia is always available to meet patient demand, no matter what the environment.

The UAM provides several ways to deliver oxygen, including connections for cylinder and pipeline. Most importantly, the machine produces its own oxygen using an integrated concentrator that converts room air into 95% oxygen. Air is drawn into the UAM and is purified by 2 different filters. Ambient air is made up of 78% nitrogen, 21% oxygen and 1% other gases. The electrically powered oxygen concentrator in the UAM removes nitrogen from room air, creating a mixture that is 95% oxygen and 5% other gases.

The compressed air passes into a canister filled with a powdered material called Zeolite. Nitrogen sticks to the Zeolite, while oxygen and other gases flow through it to a reservoir tank. The UAM produces up to 10 liters per minute of up to 95% oxygen. The oxygen then travels through the rotameter bank into the back bar and reservoir bag.

GAS FLOW IN THE PATIENT SYSTEM

The flow dials control the amount of oxygen entering the back bar and available for the patient. The spinning bobbin in each rotameter shows the flow rate in liters per minute.

The back bar provides the following functions:

1. The reservoir bag stores up to 2 liters of oxygen.
2. The pressure relief valve limits pressure in the back bar to 5 centimeters of water, protecting the patient from harm.
3. The air inlet valve allows room air to be drawn in whenever the supply of oxygen is less than the demand, as expressed by the patient's minute volume.

The low-resistance draw-over vaporizer adds volatile agent to the carrier gas passing through it. Volatile agent is added by using the selector wheel to achieve the desired percentage. The resulting anesthetic supply gas is comprised of oxygen, volatile agent and a variable amount of room air. The anesthetic supply gas flows from the back bar at low pressure to the breathing block and the bellows.

An oxygen analyzer measures the oxygen concentration of the supply gas passing to the patient. The reading is displayed on the analyzer screen.

As the supply gas flows past the sampling point for the consumable oxygen sensor, it passes the first one-way valve, then enters the bellows chamber. Depending on the configuration, the second one-way valve is immediately after the bellows in the breathing block, or on the inspiratory Y-piece connection.

During spontaneous breathing both non-return valves open for inspiration and close during expiration. The bellows will not fill with exhaled gas.

The bellows is used for intermittent positive pressure ventilation, also known as IPPV or controlled ventilation. When the bellows is raised, supply gas flows through the first non-return valve into the bellows. The second non-return valve remains closed.

As the bellows are pushed down, the supply gas flows out through the second non-return valve into the inspiratory limb. The first non-return valve is closed.

Another pressure relief valve ensures that excessive manual force on the bellows cannot cause harm to the patient.

The UAM uses a conventional Y-piece patient connection. Exhaled gas returns to the UAM via the expiratory limb of the Y-piece and then passes by a third one-way valve and the Fenton balloon to the scavenger port. The balloon acts as an inflating valve which enables controlled ventilation of the lungs, the third valve prevents back-flow during spontaneous breathing.

UAM CONFIGURATIONS

IF YOUR UAM DOES NOT LOOK LIKE PICTURES PRESENTED ELSEWHERE, DO NOT BE ALARMED. The UAM has two different designs depending on when it was manufactured: Rev A (for UAMs manufactured before October 2018) and Rev B for UAMs manufactured after that date. UAMs with a serial number prior to 21501-001 are Rev A. Serials numbers after this are Rev B. The order and exact location of select components depends on the design. Your institution may or may not have also purchased a UAMV and/or a patient vital sign monitor, which sit on top of the UAM.

Rev A
Before Oct. 2018

Rev B
After Oct. 2018

Photos and Diagrams specific to one configuration will be highlighted with a grey border (Rev A: manufactured before October 2018) or orange border (Rev B: manufactured after October 2018) Photos and diagrams that lack borders apply to both UAM designs.

SPECIFICATIONS

PHYSICAL AND ELECTRICAL

- Workstation: 146cm x 53cm x 69cm, 130kg; aluminum frame, vertical mounting side rails on both sides, nylon internal tubing
- Top shelf: 54 cm (W) x 37 cm (D), maximum load 35 kg with even load distribution; Epoxy powder coated pressed aluminum; monitor brackets bolt items to the top of the top shelf
- Drawer: 10cm x 29cm x 32cm in A, 11cm x 29cm x 24cm in B; 35kg weight limit, stainless steel, removable for cleaning.
- Work surface: Stainless Steel, 46 cm (W) x 31 cm (D) x 88 cm (H) above ground (removable) in A, 46 cm (W) x 26 cm (D) x 88 cm (H) in B
- Mains power supply: 220V, 50-60Hz
- Power: 500 Watts/220v = 2.27 amps
- Oxygen analyzer power: CE-marked, fused and medical grade. Mains powered with battery backup for ten hours of use.
- Automatic over/under voltage mains power isolator protects oxygen concentrator, and sockets for monitor and accessories
- 3.5" TFT touch screen for oxygen percentage display and alarm setting
- Membrane switch for oxygen analyzer power
- Casters: 150 mm diameter single wheel antistatic casters, front lockable casters

OXYGEN SUPPLY AND MONITORING

- Oxygen concentrator flow rate: 0.1 to 10.0 liters per minute
- Maximum oxygen concentration: 95%
  NOTE: The oxygen concentration may vary according to ambient humidity and maintenance of the air filter
- Alternative sources: cylinder yoke, pipeline, or other external flow regulated portable oxygen source
- Automatic room air intake when patient minute volume exceeds supply gas flow
- Accuracy of glass rotameter for O_2: +/- 2.5% when using 100% O_2
- Integrated inspiratory oxygen analysis uses a MOX-3 oxygen sensor
- Calibration for room air (21%) and 100% oxygen
- Pressure sensitive apnea or high flow alarm
- Adjustable minimum and maximum oxygen alarm settings
- Up to ten hour analyzer battery backup, trickle recharge from mains power
- Membrane keypad and touch screen

OPTIONAL USE OF NITROUS OXIDE

- Sources: pipeline or cylinder
- Hypoxic cut-off: A solenoid automatically shuts off nitrous oxide delivery if supply gas O_2 level falls below a minimum of 25%
- Flow of N_2O stops if electrical power fails
- Sight and touch differentiated flow control dial per ISO standards
- Accuracy of glass rotameter for N_2O: +/- 2.5%

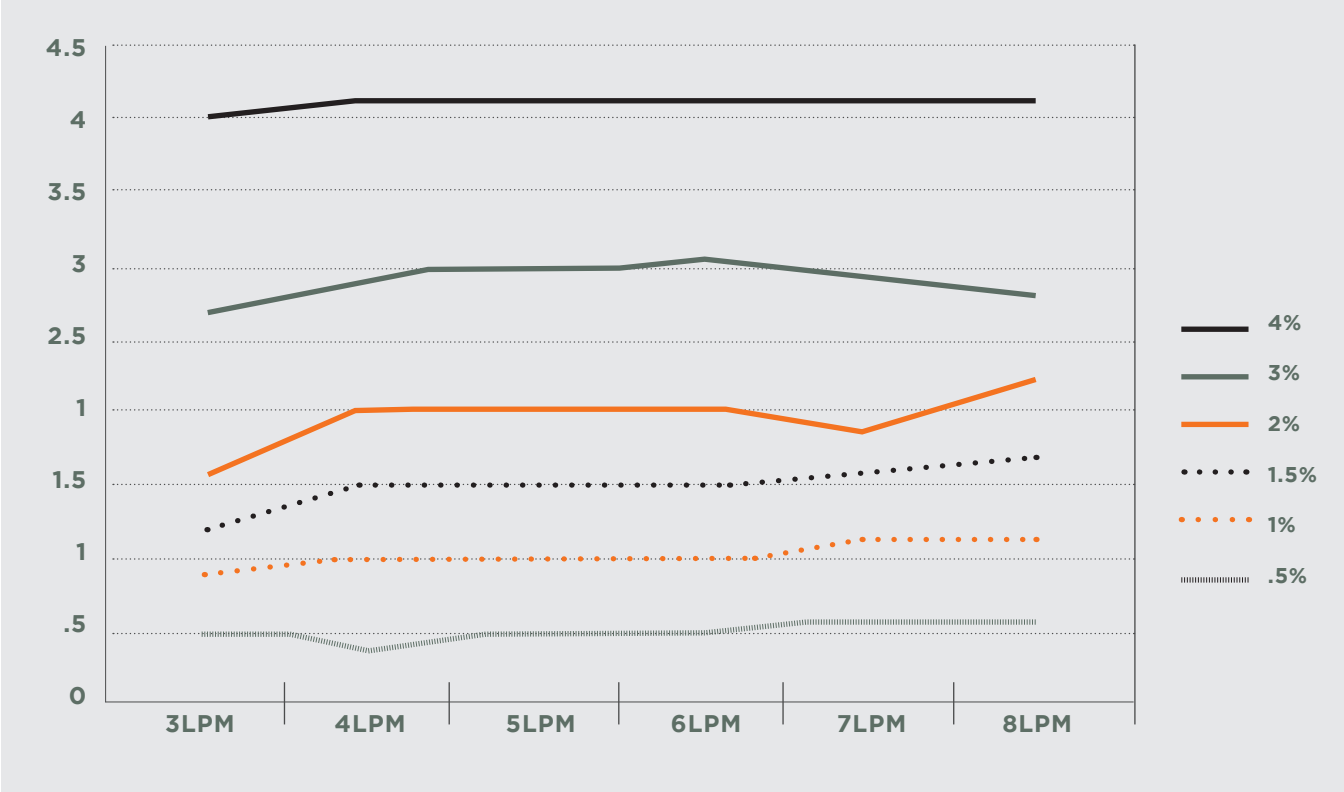
VENTILATION

- Manual bellows for adult and pediatric use made from durable, long-lasting silicone rubber
- 1600cc capacity
- Inspiratory pressure relief of 55 cmH_2O for pressure created during mechanical ventilation
- Aluminum bellows block
- Silicone balloon inflating valve at the expiratory port
- 15mm female/22mm male ISO standard taper connection for breathing circuit, 30mm male ISO standard taper connection for AGSS scavenging equipment

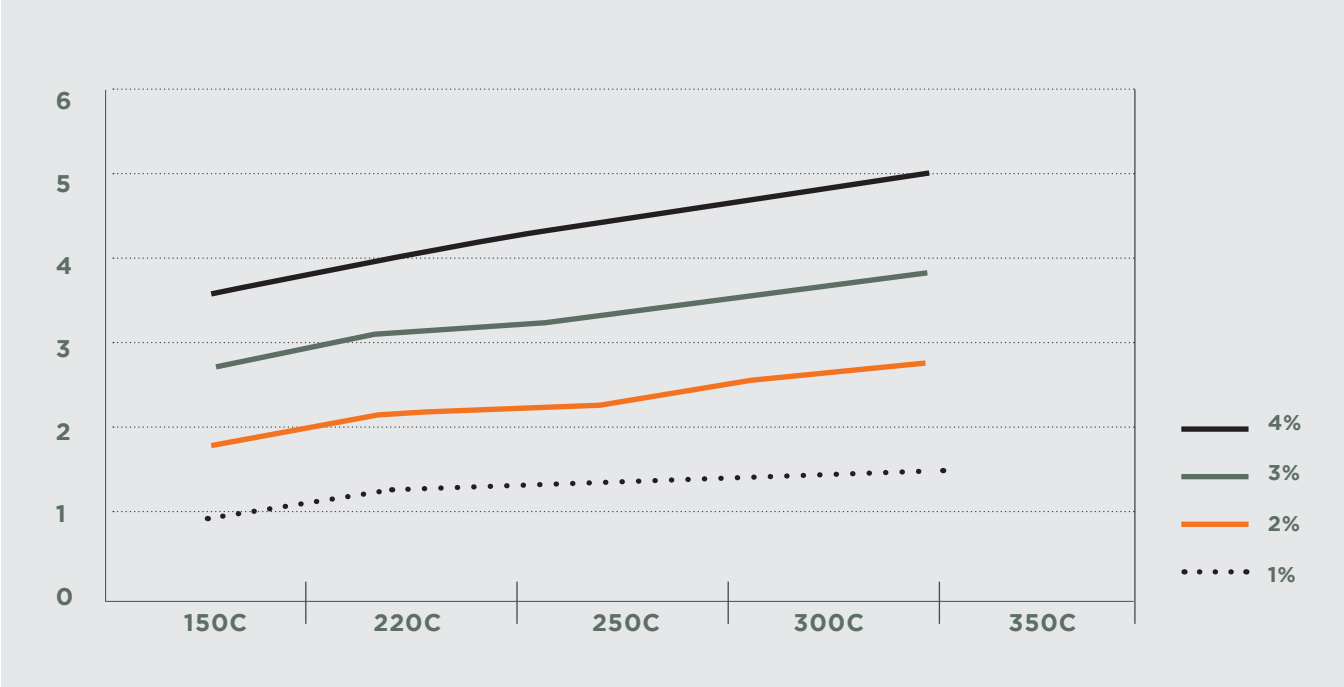
VAPORIZERS

- Stainless steel and plated brass construction
- Draw over flow type
- Pour filler type.
- Separate units for isoflurane, sevoflurane, and halothane per ISO standards
- Agent delivery range: 0.5% to 4%
- 120ml capacity

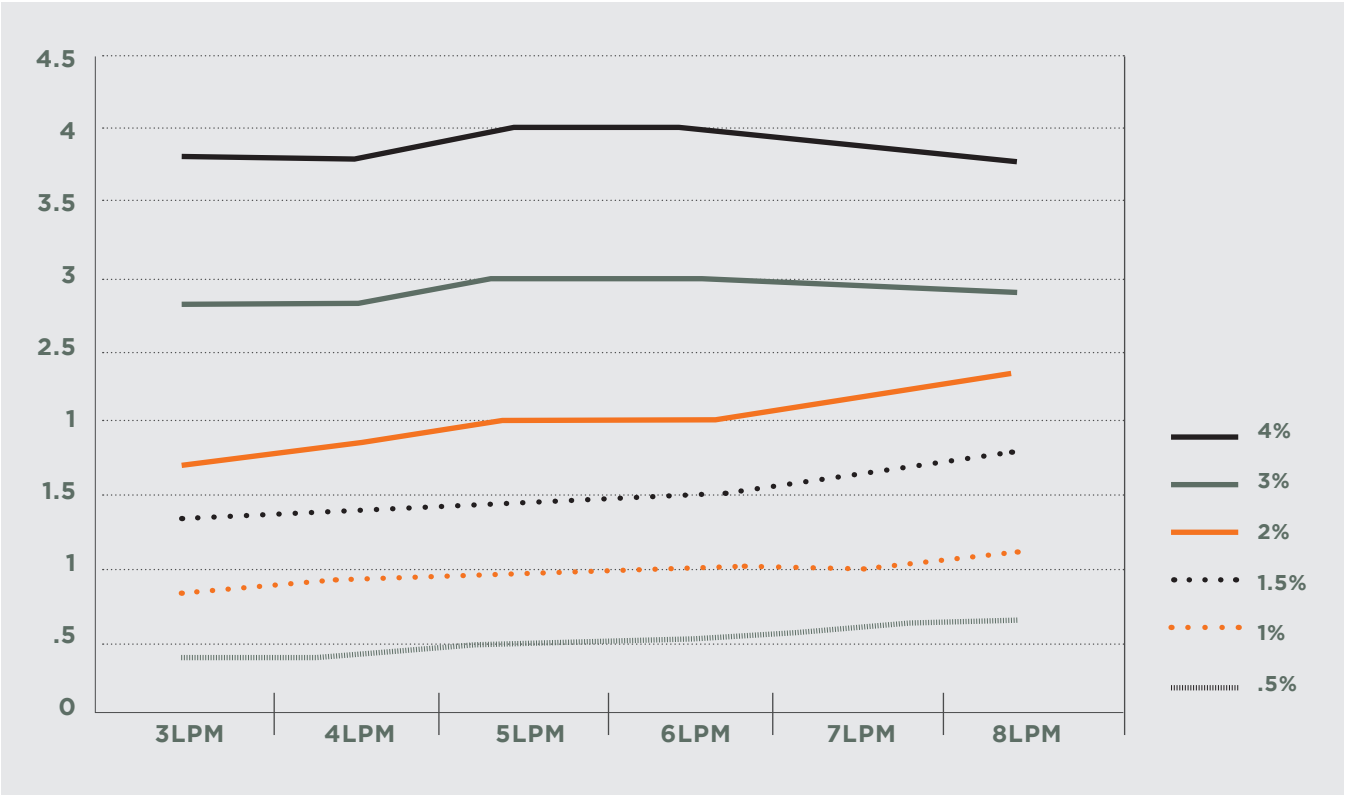
→ Performance:



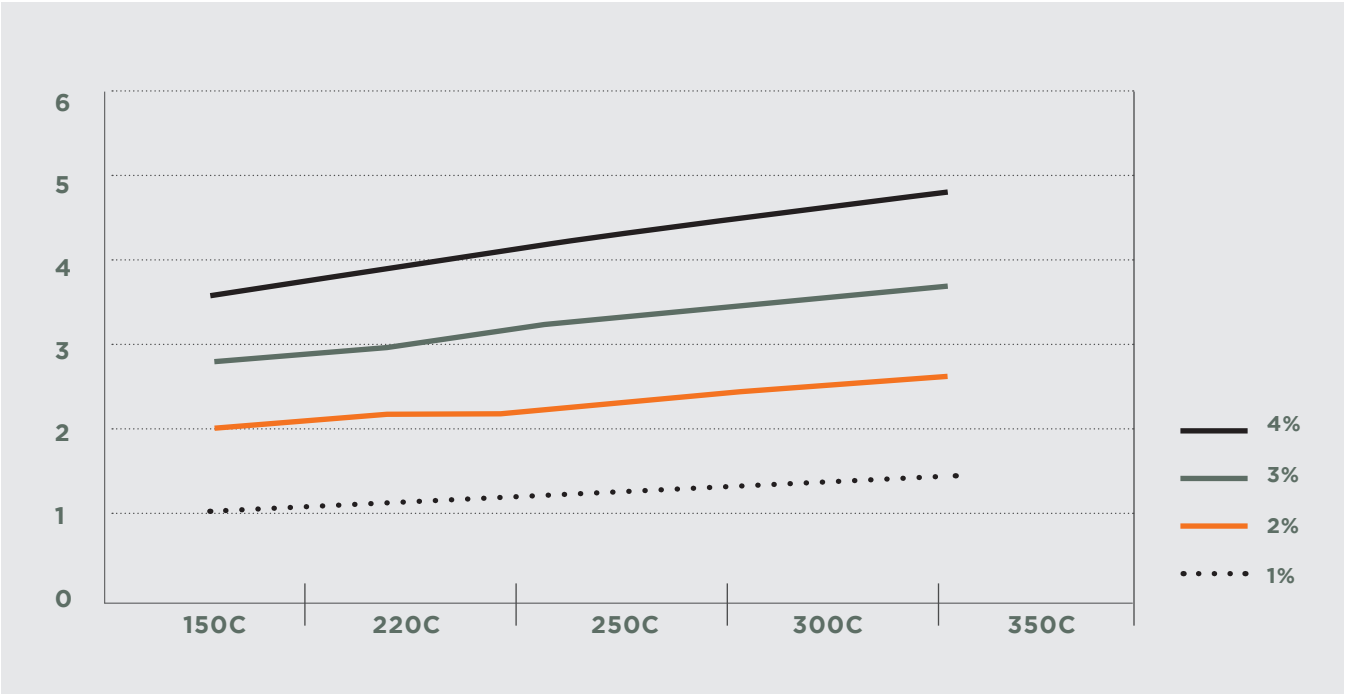
TYPICAL HALOTHANE VAPORIZER PERFORMANCE WITH FLOW



TYPICAL HALOTHANE VAPORIZER PERFORMANCE WITH TEMPERATURE



TYPICAL ISOFLURANE VAPORIZER PERFORMANCE WITH FLOW



TYPICAL ISOFLURANE VAPORIZER PERFORMANCE WITH TEMPERATURE

REAR PANEL CONNECTORS

- Mains isolator switch, 2 UK style power sockets
- Oxygen and nitrous pipeline NIST connectors and cylinder yokes
- Multi-diameter external oxygen hose connector

COMPONENTS OF THE UAM

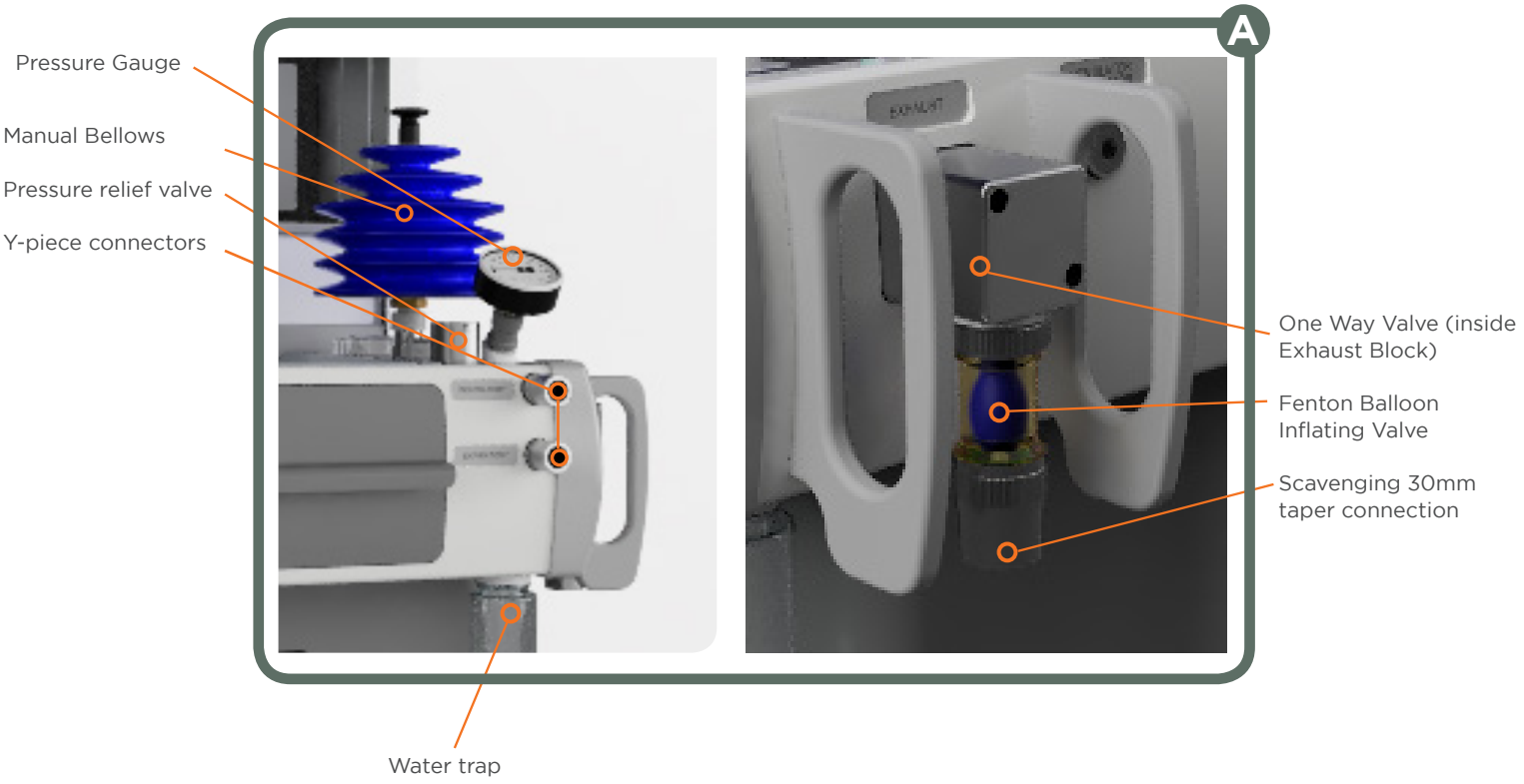
1. Oxygen analyzer and control screen
2. Oxygen and Nitrous Oxide Flowmeter Bank
3. Back bar with air inlet, pressure relief valve and 2 liter reservoir bag
4. Low resistance vaporizer
5. Oxygen concentrator on/off switch
6. Oxygen cylinder and pipeline pressure gauges
7. Nitrous Oxide cylinder and pipeline gauges

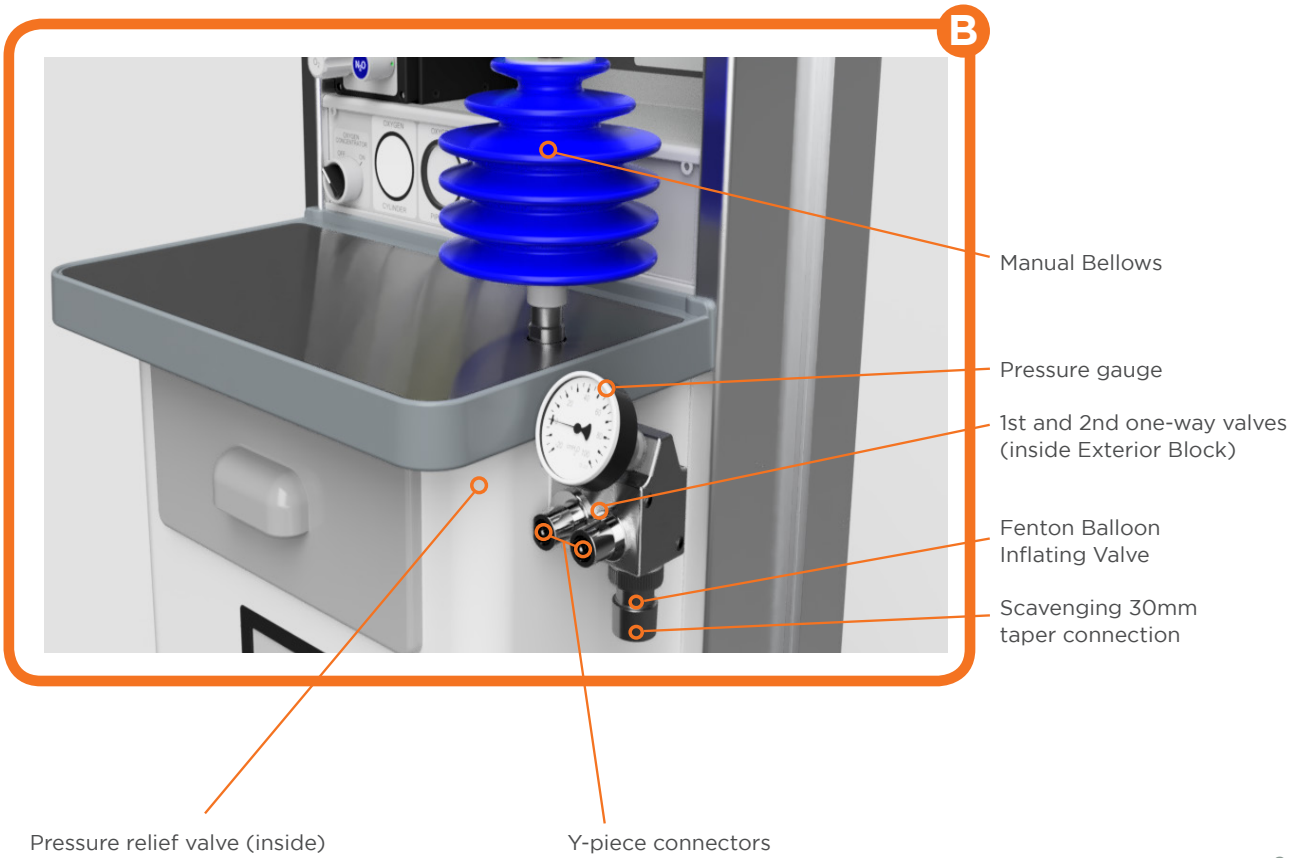
SEE INSET PAGE 9

8. Manual Bellows
9. Pressure relief valve and gauge
10. Fenton Balloon expiratory valve
11. Y-piece connectors
12. Water trap

NOTE A VS B

13. Oxygen concentrator status screen
14. Integrated oxygen concentrator
15. Castors (front lockable)

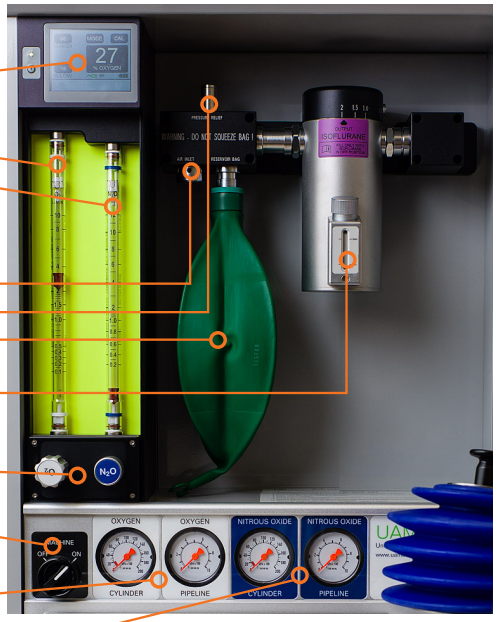

A
Pressure Gauge
Manual Bellows
Pressure relief valve
Y-piece connectors
Water trap
One Way Valve (inside Exhaust Block)
Fenton Balloon Inflating Valve
Scavenging 30mm taper connection


B
Manual Bellows
Pressure gauge
1st and 2nd one-way valves (inside Exterior Block)
Fenton Balloon Inflating Valve
Scavenging 30mm taper connection
Pressure relief valve (inside)
Y-piece connectors


B
Pin-indexed connectors for E-size oxygen and nitrous oxide cylinders
Emergency oxygen inlet
Pipeline connections for oxygen and nitrous oxide
Mains isolator (Power On/Off)
Fuses for oxygen analyzer, oxygen concentrator and outlet plugs
British-style 3 prong electric outlets plugs
EMERGENCY OXYGEN
MAINS ISOLATOR
O2 MONITOR
O2 CONCENTRATOR
SOCKET
SOCKET
DANGER
CAUTION

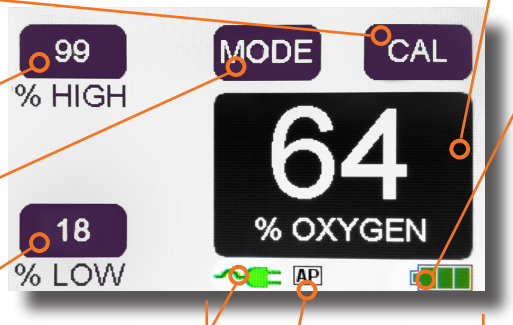

B
Consumable oxygen sensor
Ventilator taper connection

INSET



1. Oxygen analyzer and control screen
2. Flowmeter Bank: Oxygen and Nitrous Oxide Rotameters
3. Backbar
   - **a.** Air inlet valve
   - **b.** Pressure relief valve
   - **c.** Reservoir bag
4. Low resistance vaporizer
2. Flowmeter Bank: Flow dials
5. Oxygen concentrator on/off switch
6. Oxygen cylinder and pipeline pressure gauges
7. Nitrous Oxide cylinder and pipeline gauges

ANALYZER SCREEN



Calibration settings (to calibrate oxygen sensor and apnea alarm)

High oxygen percentage alarm (user adjusted)

Mode (opens screen for system settings)

Low oxygen percentage alarm (user adjusted)

Percent Oxygen (shows the oxygen percentage of the anesthetic gas measured before inspiration)

Battery charge status

Message Area

Apnea alarm on/off

Mains power indicator (machine is on mains power supply)

PREPARING THE UAM FOR USE

1. Connect pipeline hoses and cylinders.
2. Open the top rear access panel if working on UAM B. Screw in oxygen sensor and connect telephone-style cable. Some oxygen sensors come with an extra piece: this may be discarded. *(See photo on next page.)*

USING OXYGEN

The UAM accepts an E-size pin-index oxygen cylinder. The cylinder connects via a yoke and Bodok seal and the pressure is displayed on the pressure gauge on the front of the machine.

Bull-nose cylinders may be attached to the pipeline inlet using an approved 4 Bar medical regulator.

USING A PIPELINE CONNECTOR

The UAM accepts pipeline connections for oxygen. Each machine is supplied with an oxygen hose connecting to the UAM's NIST inlet. The other end is typically shipped with a BS 5682 probe, which is the British standard. Probes for other connector types can be arranged. Pipeline pressure is displayed on the gauge on the front of the machine.

USING THE EMERGENCY OXYGEN INLET

An emergency oxygen supply connection is mounted on the back of the machine. It accommodates differing tube sizes from ward-style flowmeters.

CAUTION: Oxygen from this source is not controlled by the rotameter bank on the front of the UAM. Rather, it must be controlled with an external flowmeter attached to the cylinder providing the emergency oxygen. The user can confirm that oxygen is being given by observing the oxygen analyzer.

NOTE: Use only 1 L/minute flow to conserve the oxygen in the external cylinder. This will provide 30-35% oxygen to the patient.

USING NITROUS OXIDE

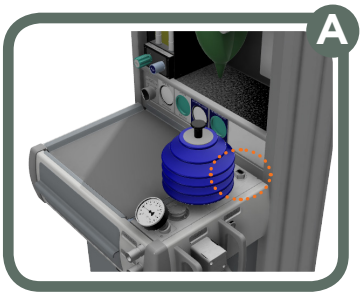
The UAM supports cylinder and pipeline sources of nitrous oxide. The flow of N_2O is controlled by the right hand side flow dial. The N_2O flow dial has a different size and shape to distinguish it from the oxygen flow dial.

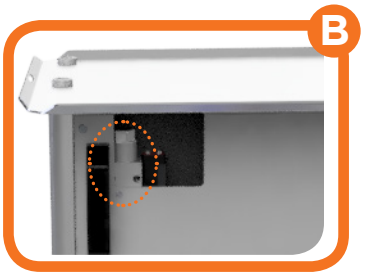
The UAM automatically cuts off nitrous oxide if the percent of oxygen in the anesthetic mix falls to 25% and below. The oxygen analyzer must be powered on and working correctly for nitrous oxide delivery to occur. An exhausted oxygen sensor or battery will shut off N_2O supply.

The cut off mechanism is electrical, unlike older style mechanical interlocks. The N_2O valve is closed in its resting position and must receive a current from the oxygen analyzer to open. Any interruption of that current, including a decrease in oxygen below 25%, will shut off the flow of nitrous oxide.

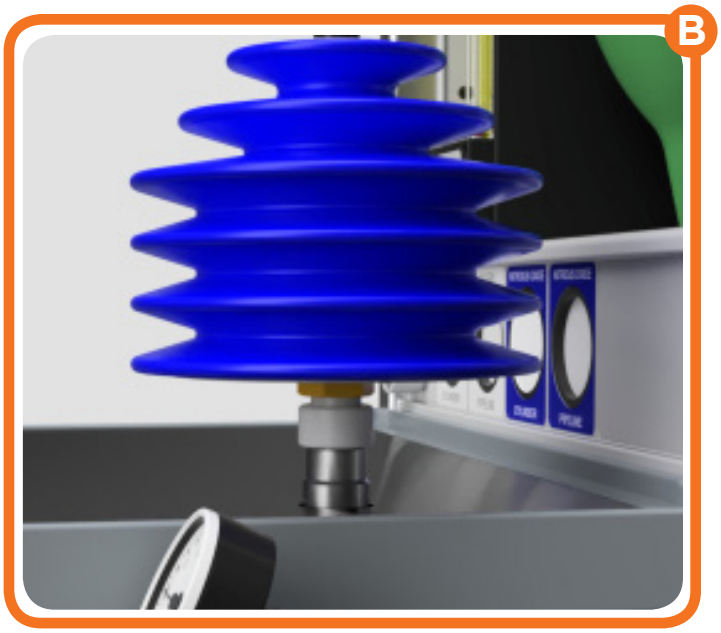
NOTE: Do not open the package of the spare oxygen sensor until it is needed. The oxygen sensor will start to deplete as soon as it comes into contact with air.

2. Screw in oxygen sensor and connect telephone-style cable. Some oxygen sensors come with an extra piece: this may be discarded.

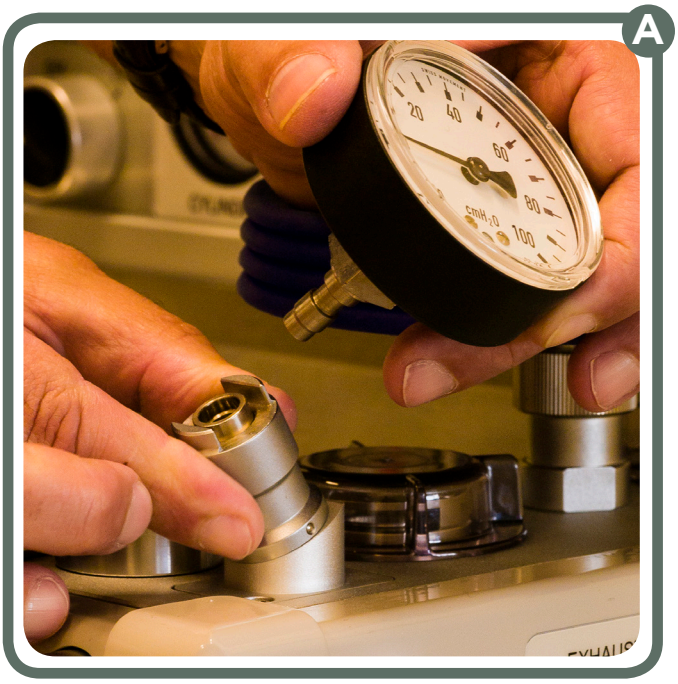


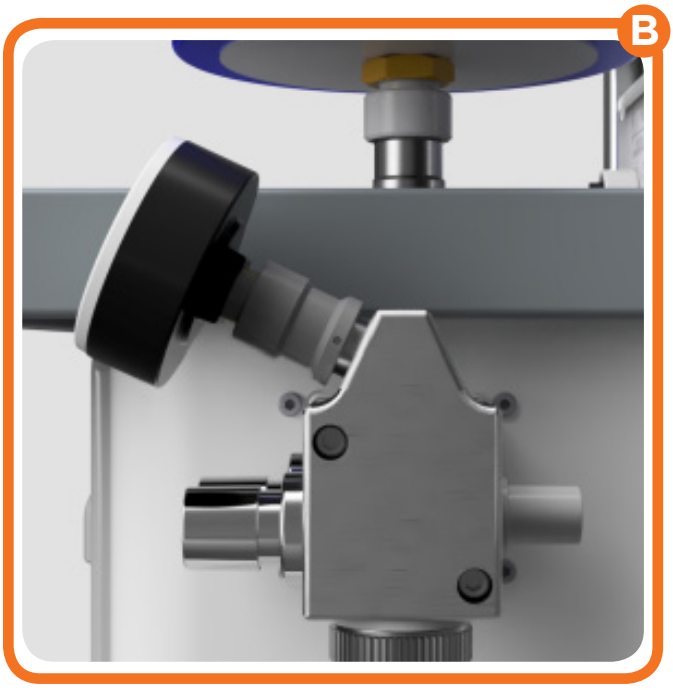


3. Attach bellows assembly to UAM by placing it on top of the connector and firmly pushing down. Then tighten knurled nut fully.



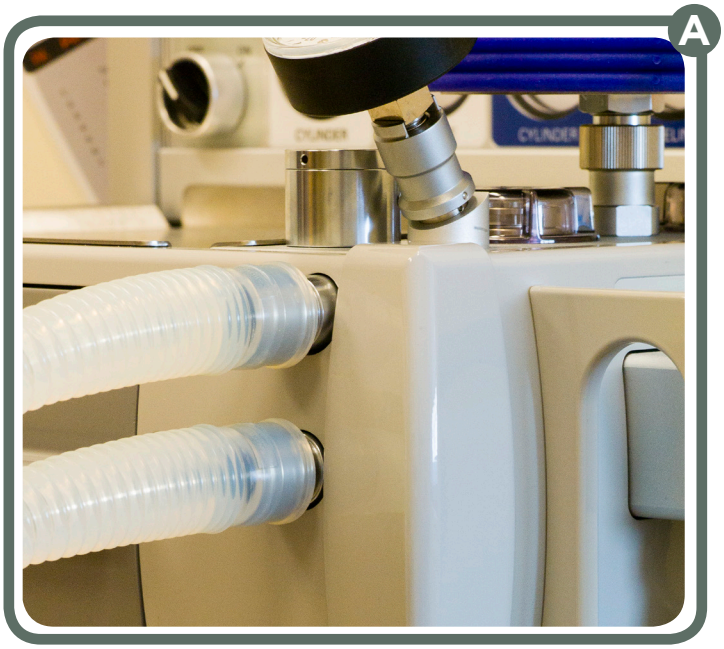
4. Attach airway pressure gauge by pushing down collar and inserting gauge into the port. Press firmly until collar springs up.





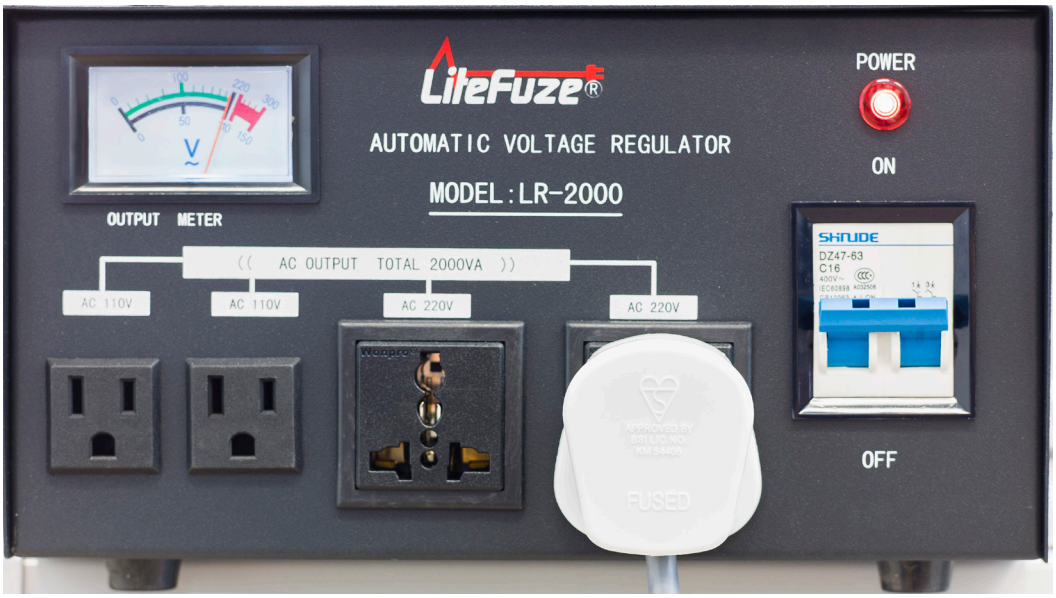
5. Attach green reservoir bag to back bar as shown in photo.

6. Attach patient circuit to inspiratory and expiratory ports.



7. Attach green plastic 30M-30F connector to the scavenging hose by inserting the male side into the hose. The female side attaches to the one-way expiratory port underneath the Fenton balloon.
8. Connect 30mm hose to scavenging port, or attach standard scavenging device.
9. Operate the bellows, check that it fills freely with air from the air inlet and observe the Fenton balloon moves freely in it's housing when the bellows is moved. Occlude the Y-piece and check airway pressure reaches 45-55 cmH_2O.
10. Connect and turn on mains power by pressing the green switch on the back of the UAM. Wait about 10 seconds for the internal supply to come on, and then check the screen to see if the oxygen analyzer shows green. This indicates the mains supply is working correctly.

NOTE: GRADIAN HEALTH SYSTEMS STRONGLY RECOMMENDS CONNECTING THE UAM TO A 2000-WATT VOLTAGE STABILIZER.



11. Calibrate oxygen analyzer using 100% O_2 from cylinder or pipeline if available. NOTE: If cylinder or pipeline do not deliver 100% O_2, only calibrate on room air as described below in **11c.**

- **a.** Using 100% cylinder/pipeline oxygen, set oxygen flowmeter to 6 L/minute and wait for maximum reading on monitor.
- **b.** Press CAL, then O_2, then GO. When the calibration is finished, press EXIT twice.
- **c.** Turn off the oxygen. Draw room air through the system with the bellows until the reading reaches its lowest value.
- **d.** Press CAL, then AIR, then GO. When the calibration is finished, press EXIT twice.

12. Calibrate apnea alarm pressure transducer as follows:

- **a.** Make sure flow dials are set to zero flow and reservoir bag is empty
- **b.** Press CAL, then PRESSURE: CAL, then GO. When the calibration is finished, press EXIT twice.

13. Turn on oxygen concentrator using the selector switch on the front of the machine. Set the oxygen output to 6 L/minute and ensure that oxygen reaches at least 90 to 95% output after a few minutes.

14. If using nitrous oxide, check the function of the Nitrous Oxide cut off at 25% oxygen concentration as follows:

- **a.** Set oxygen flow to 6 L/minute.
- **b.** Set Nitrous Oxide flow to 4 L/minute.
- **c.** Gradually reduce the oxygen flow to decrease the delivered O_2 to 25% and lower—nitrous oxide flow should cut off.

15. Fill the vaporizer to maximum with correct anesthetic agent. See the directions in the User Manual. **WARNING:** Do not overfill the vaporizer. Do not spill agent on to the UAM, especially on to the oxygen sensor. UAM Configuration **A** has the oxygen sensor in front. Cover the sensor with a protective cloth when filling the vaporizer on UAMs with this configuration. Refer to the fill level window.

16. Place all manuals and training materials in drawer and secure a location for extras, such as the additional oxygen sensor, spare balloons, and so forth.

NOTE: High levels of relative humidity in the environment will affect the performance of the UAM. It is recommended that the UAM be used in areas where the humidity can be controlled. After operating the UAM in humid environments water drainage should be observed underneath the machine once the concentrator is turned off and has depressurized.

IF YOU HAVE PURCHASED THE PATIENT VITAL SIGNS MONITOR:

1. Unpack monitor and insert the battery. The battery is in a white box inside the foam protectors holding the monitor securely in the cardboard box.
2. Mounting the monitor: Please refer to the mounting instructions for the particular model of monitor obtained.
3. Connect patient cables to monitor – NIBP, SPO2, TEMP and ECG
4. Connect mains lead from monitor to one of the three prong sockets on the back of the UAM.
5. Allow patient monitor and analyzer screen batteries to charge for 24 hours.

RECOMMENDED UAM MAINTENANCE SCHEDULE

FREQUENCY	ACTION
Daily or prior to use (user)	**Perform operational check (see UAM User Manual and Checklist on the UAM)**
Every 3 months	**Perform full function test**
Every 6 months	**Perform full function test** **Check air filter- clean or replace if needed**
Every 12 months	**Perform full function test** **Check air filter- clean or replace if needed** **Replace oxygen sensor** **Replace oxygen concentrator loss of power battery (9V)** **Remove and inspect Fenton balloon**
Every 3 years	**Replace oxygen analyzer battery**
Every 5 years	**Contact Gradian Health Systems for a complete maintenance check** **service@gradianhealth.org | +1.212.537.0340**

FULL FUNCTION TEST (SEE CHECKLIST IN APPENDIX IV)

SYSTEM CHECKS

1. Check that no unauthorized modifications have been made to the UAM. Check that the Ayre's T-piece is present and spares as originally supplied are present. Check oxygen tubing for venturi (Hudson type) mask is available.
2. UAM frame – check for any loose screws or panels and tighten as required. Check wheels.
3. Check mains cable and gas supply tube condition and repair as required.
4. Connect mains supply, turn on mains isolator switch (note that there will be a delay of around 10 seconds while the mains filter starts) and check that the oxygen analyzer and patient monitor (if fitted) yellow charging LED's are visible.
5. Turn off the machine mains isolator and ensure that the Mains Power Indicator goes red – this indicates mains failure.
6. Check that the battery indicator icon shows three green segments and that it discharges with mains off and recharges with mains on. NOTE: Battery must be replaced every three years or sooner if battery life is low.
7. Check that the cylinder yoke seals are fitted and replace if damaged or missing.
8. Connect the cylinders to the yokes and ensure that the cylinder pressure is indicated on the correct pressure gauge (nitrous oxide and oxygen) when turned on individually.
9. Connect the machine pipeline hoses to the supply outlets (wall outlet or bullnose cylinder regulator) and ensure that pipeline pressure is indicated on the correct pressure gauge (nitrous oxide and oxygen) when connected and turned on individually.
10. Turn on the oxygen and the nitrous oxide flow dials using each gas supply (concentrator, cylinder and pipeline) and ensure that the maximum flow of 10 L/minute is achieved for each gas.
11. Close the flow dials and ensure that the flow stops.
12. Check that the emergency oxygen inlet functions by observing an increase of oxygen % on the analyzer.

OXYGEN CALIBRATION, SAFETY AND QUAVLITY CHECKS

13. Turn on the analyzer screen and ensure that the vaporizer is off. Turn on the oxygen cylinder or pipeline to provide 100% oxygen, turn on a 6 liter/minute flow and wait for the oxygen sensor to stabilize, then press CAL – O2 – GO and wait for the calibration to finish, then go back to the main display by pressing EXIT twice. If the oxygen sensor fails to calibrate or an oxygen sensor exhausted alarm is present, replace the oxygen sensor.

NOTE: For the most accurate performance over the entire range of possible oxygen concentrations, the oxygen sensor must be calibrated with both 100 % oxygen and 21% oxygen (room air). If 100% oxygen is not available then the it should at least be calibrated with 21% oxygen. If the sensor has not been calibrated at 100% oxygen then the monitor will display 104% at higher oxygen concentrations. Calibrating the cell at 100% oxygen can clear this condition.

NOTE: The oxygen sensor will need to be replaced approximately every 12 months. An alarm will indicate when the oxygen sensor is exhausted.

14. With the oxygen turned off cycle the bellows to draw in air, wait for the oxygen sensor to stabilize, then press CAL – AIR – GO and wait, then press EXIT to go to the main display. If the sensor fails to calibrate or an oxygen sensor exhausted alarm is present replace the oxygen sensor.
15. Check that the high and low oxygen percentage alarms can be adjusted and that they function; this is achieved by turning up the oxygen supply to exceed the high alarm or increasing the entrained air to fall below the lower alarm.
16. Increase the nitrous oxide flow and ensure that it cuts off when the oxygen concentration is 25% or lower.
17. Disconnect the oxygen sensor (mounted by the bellows in Configuration **A**, behind the rear top access panel in Configuration **B**) – ensure that the disconnect alarm sounds and that nitrous oxide (if fitted) turns off.
18. Set a 6 L/minute flow from the oxygen concentrator and ensure that the output stabilizes at 90% – 96% oxygen concentration. increase the flow rate to 10 L/minute and ensure that the output remains at 90% or better. If the output concentration is low check the filter condition and replace it if required.

BREATHING SYSTEM CHECKS

19. Turn on the oxygen flow with patient Y-Piece blocked and ensure that the reservoir bag fills and excess gas escapes through the pressure relief valve and that maximum circuit pressure is around 5 cmH_20. Confirm that the apnea alarm sounds with a full bellows after 30 seconds and that it repeats every 30 seconds.
20. Turn off the flowmeter and cycle the bellows and ensure that air is drawn in through the under pressure valve – this is indicated by a slight fluttering of the reservoir bag when it is empty.
21. Check condition of reservoir bag.
22. Check that the bellows assembly is securely connected to the machine and is undamaged, check for splits in the bellows or displacement of the end plates, loosen and re-clamp centrally if required.

23. Cycle the bellows assembly with the inspiratory port blocked and ensure that 55 cmH_2O can be achieved when the bellows is pushed down for inspiration.
24. Check the patient system water trap is correctly screwed in place without leaks on Configuration **A** UAMs. Configuration **B** UAMs do not use a patient system water trap.
25. Check the correct function of the Fenton balloon. Attach the Y-piece patient connection and occlude the distal end. Operate the bellows and observe the free movement of the balloon in its tube. Apply sustained pressure on the bellows and check the pressure rises to at least 45 cm H_2O. If patient system pressure is not achieved, unscrew the balloon cover, remove balloon and perform checks (see page 22).
26. Cycle the bellows and ensure that the pressure relieves at 55 cmH_2O.

NOTE: The above verification can only be performed if the oxygen sensor has been calibrated with 100% oxygen.

VAPORIZER CHECKS

27. Check that the vaporizer is full, fully turned off and that it indicates the level of liquid.
28. Turn on the concentrator and set an oxygen flow of 6 L/minute and wait until the output has stabilized. Set the vaporizer output to 3%. Verify that after 2 minutes that the oxygen concentration has dropped by 3%.

NOTE: This is a very basic test and can only indicate approximate output. The vaporizer output is affected by temperature, flow, and time. Ideally, the above test should be conducted at an ambient temperature of 22 degrees Celsius.

RESIDUAL FLOW CHECK

29. Turn on the concentrator and allow it to run for at least 5 minutes with the oxygen flow dial fully closed. Turn the concentrator off and set the oxygen flow to 200 ml/min. You should observe this level of flow for at least 5 minutes. If this test fails this could indicate a leak anywhere between the oxygen concentrator reservoir tank and the rotameter.
30. Ensure that the service record (see appendix IV) is completed and filed. Attach a label (see appendix V) with your initials and the date to let the users know that the UAM has received periodic maintenance and testing.

MAINTENANCE PROCEDURES

CLEANING OR REPLACING THE PRIMARY AIR FILTER

Materials and tools required:

- → 3mm hex key
- → M5 crescent wrench (also known as a spanner, or flare nut wrench)

The oxygen concentrator includes a replaceable filter that cleans the room air before entering the oxygen concentrator. Keeping it clean will extend the life of the concentrator.

To remove the filter:

1. Turn off the UAM and disconnect it from the mains power supply.
2. At the lower back panel, loosen the six hex screws closest to the sides of the panel, three on each side, using a 3mm hex wrench.
3. Carefully tilt the rear panel back from the top, taking care not to disconnect the wires attached to it.
4. Detach the two hoses leading to the air filter. Press the orange collar to release the hose. Do not pull on the hose without depressing the collar.
5. Remove the cover plate that holds the filter in place by removing the center M5 nut.
6. Filters may be cleaned by shaking or vacuuming. If the filter is too dirty to clean, replace it with a new one.
7. Install the new filter and replace the cover plate.
8. Replace the back panel, connect the mains power supply, and turn the UAM on.

NOTE: Replacement filters can be ordered from Gradian but they may be less expensive and quicker to obtain from local automotive parts suppliers.

Filter Details:

Type: AG285
Applications: Used in automobiles made by Ford, Audi, Volkswagen, Citroen, Seat, Skoda and Saab.
Replacement options:

Factory Number	
FRAM	CA4739
GMC	93152533
MEYLE	7126080390
MONARK	30780031
PUROLATOR	AF3561
TEHO	2247

Dimensions:
Outer Diameter: 241 mm
Inner Diameter: 185 mm
Height: 50 mm

REPLACING THE OXYGEN SENSOR

Materials and tools required:

- → New sensor
- → 3 mm hex key, if replacing on a Configuration **B** UAM

Replace the oxygen sensor every 12 months, or when an alarm message on the oxygen sensor indicates that the sensor has failed to calibrate.

Always keep a spare sensor and store it unopened in its sealed pouch. The sensor begins to decay when you open the packaging and expose it to air.

To replace the oxygen sensor:

1. Open the top rear access panel if working on a Configuration **B** UAM using the hex key.
2. Disconnect the oxygen sensor cable.
3. Turn the existing sensor anticlockwise to disconnect it.
4. Remove the new sensor from its container and remove the extension piece covering the bottom of the sensor.
5. Place the sensor in position, and turn it clockwise to screw it into place. Do not over tighten.

NOTE: Take care to engage the thread correctly, and ensure that the replacement cell is fitted with a suitable O-ring to prevent leaks from the breathing system. Replacement sensors include a new O-ring.

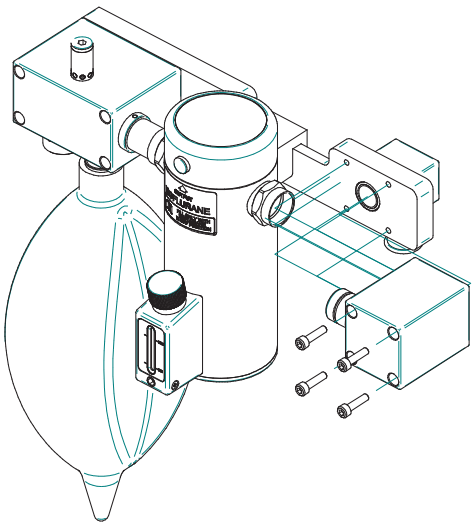
6. Connect the oxygen sensor cable and close the access panel on Configuration **B** machines.
7. Recalibrate the oxygen sensor.

REMOVING AND REPLACING THE DRAW-OVER VAPORIZER

Materials and tools required:

- → 4mm hex key
- → A pencil (recommended)

1. Ensure that the UAM is turned off.
2. With a fine tipped pencil draw a line on the back bar along the right edge of the right hand block. This will help align the block when re-assembling.
3. Use a 4mm hex key to turn the right hand block's 4 screws anticlockwise.



4. Slide the block off the vaporizer.
5. Slide the vaporizer to the right to remove it from the back bar.
6. Lift the vaporizer off the back bar.
7. To replace the draw over vaporizer: repeat the above steps in reverse order using the pencil mark as a guide to align the right hand block.

NOTE: Ensure that the O-ring in the back of the right hand block is in position during reassembly.

CLEANING THE HALOTHANE VAPORIZER

Materials and tools required:

→ Metal bowl or container

Drain Halothane vaporizers every 3 months to prevent thymol build up. Excess thymol can damage the selector wheel mechanism over time.

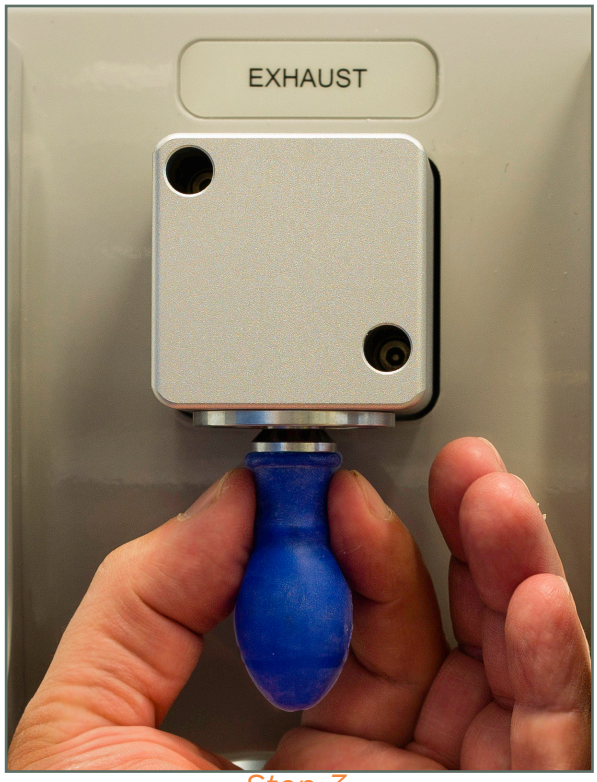
1. Unscrew the filler cap on the front of the vaporizer.
2. Place a metal bowl or container underneath the vaporizer. Halothane is corrosive and can damage the UAM if spilled.
3. Using the filler cap, insert the key on the bottom of the cap into the receptacle just below the window on the front of the vaporizer.
4. Turn the filler cap anticlockwise to open the drain underneath the window.
5. When finished, turn the filler cap clockwise until the drain if fully closed. Do not over tighten.
6. Re-fill the vaporizer with halothane.
7. Dispose of the old anesthetic agent using your hospital's procedures for disposing of medical waste.

REPLACING THE FENTON BALLOON

Materials and tools required:

→ New Balloon

1. Unscrew the balloon chamber unit, located on the exhaust block on Configuration **A** UAMs, and on the exterior breathing block on Configuration **B**. The unit is one, opaque, piece on Configuration **B**, and on Configuration **A** it includes the top aluminum ring, the housing (clear plastic) and the scavenging taper attached to the bottom. Turn using the top ring to make sure that it comes off as one piece. Make sure that the O-ring above does not fall down.
2. With fingers on the neck of the balloon, carefully peel off the balloon from its mounting.
3. With a small amount of moisture on the neck, slide the new balloon on to its mounting and move it up so that the top ring locates in the groove on the mounting. Shown on a Configuration **A** UAM in photos below.
4. Replace the tube assembly unit, taking care not to catch the balloon in the screw threads. Use a rotating action to make sure the balloon is free inside the tube before locating the screw threads.



Step 3

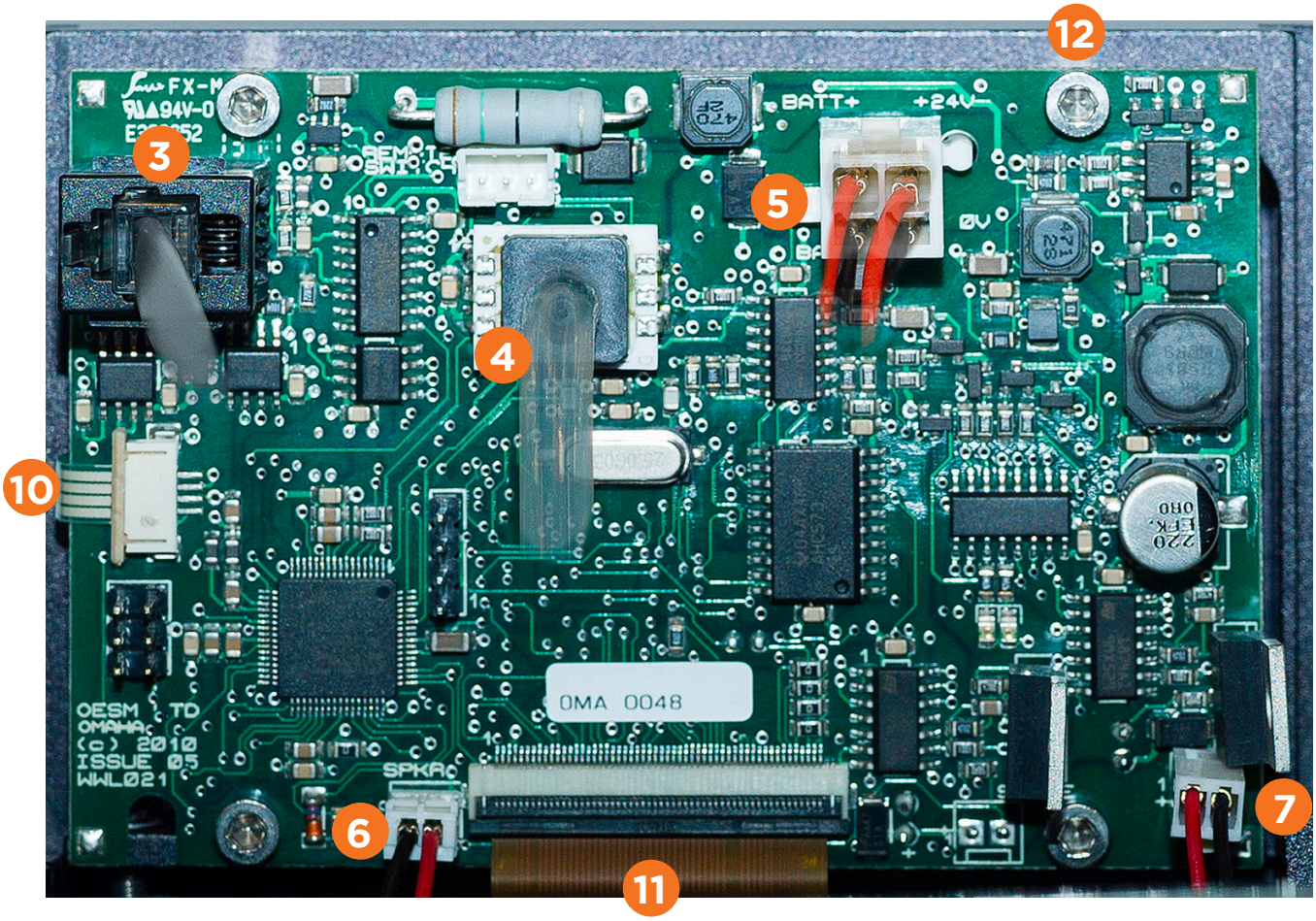
Step 4

REPLACING THE ANALYZER SCREEN CIRCUIT BOARD

Materials and tools required:

- → 4 mm hex key
- → 2.5 mm hex key
- → Long nose pliers

1. Switch off mains power.
2. Remove the six top shelf retaining screws and washers using a 4 mm hex key and lift off the monitor shelf.
3. Disconnect the oxygen sensor cable – note that the clip must be squeezed in to disconnect.
4. Pull off the silicone tube from the pressure transducer – do not put any stress on the transducer – support the body and use a slight twisting action.
5. Disconnect the 4 way power supply connector – note that the clip must be squeezed in to disconnect.
6. Disconnect the speaker connector – pull connector body out with long nose pliers – do not pull on cable.
7. Disconnect the solenoid connector – pull connector body out with long nose pliers – do not pull on cable.
8. Remove the two screen securing screws using a 2.5 mm hex key.
9. Slide screen up to remove from rotameter bank.
10. Pull touch screen connector clamp to disconnect the ribbon cable.
11. Disconnect screen display cable by flipping up the clamp using a thumbnail.
12. Remove the 4 printed circuit board securing screws using a 2.5 mm hex key.
13. Reverse sequence using new board.

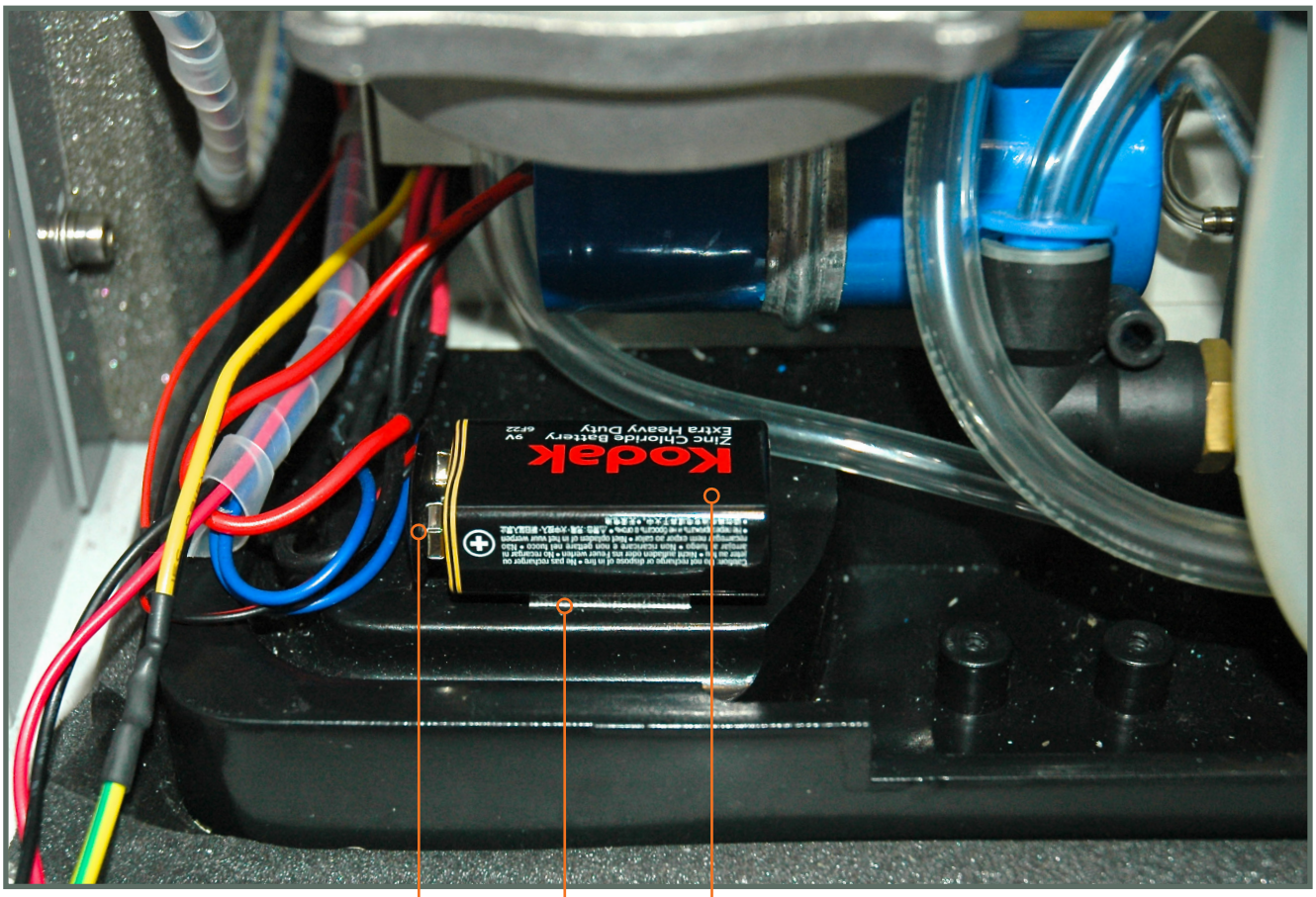


REPLACING THE CONCENTRATOR LOSS OF POWER ALARM BATTERY

Materials and tools required:

- → 3 mm hex key
- → 9 volt battery

1. Turn off the UAM and disconnect it from the mains power supply.
2. If working on a Configuration **A** UAM, loosen the hex screws on the back lower panel. On a Configuration **B** UAM, loosen the hex screw and swing open the top rear access panel to reach the alarm battery.
3. If removing the lower panel, lift and place it so that it rests on the left side of the UAM making sure not to pull on the cables. If opening the access panel, rotate aside.
4. At the back left side of the concentrator, or to the right inside the access panel, disconnect the battery
5. Install a new 9 volt battery. Reuse the Velcro strip from the old battery.
6. Replace the lower panel or reattach the access panel with fasteners.



BATTERY CONNECTOR VELCRO 9V BATTERY

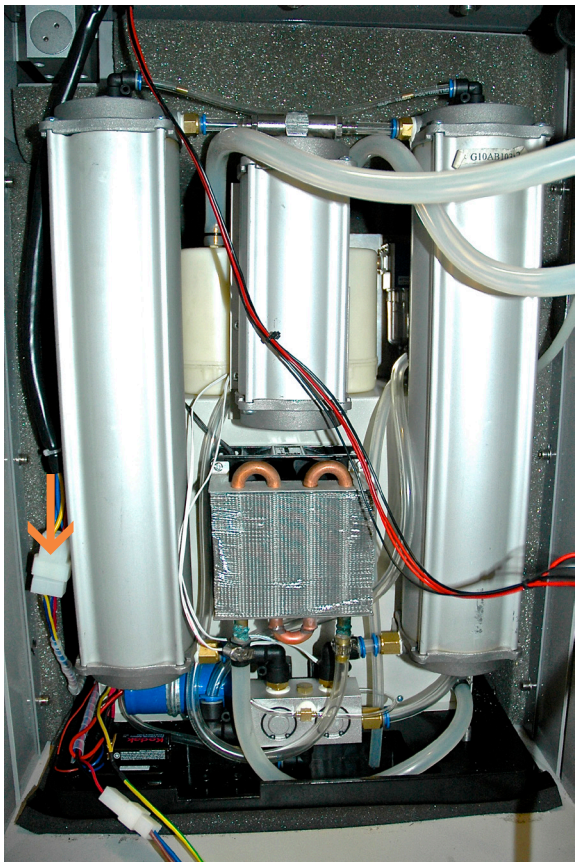
REMOVING THE CONCENTRATOR

Materials and tools required:

- → 6 mm hex key
- → 2.5 mm hex key
- → M5 flare nut wrench
- → Long flat screw driver or other long and flat metal tool

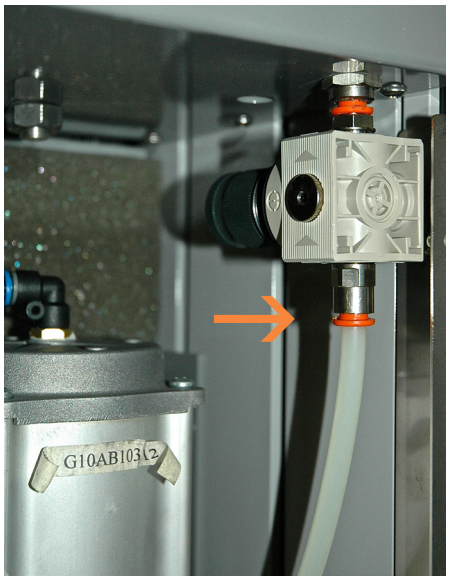
1. Engage the brakes on both of the UAM's front castors.
2. Remove the six edge screws from the lower rear panel.
3. Tilt the panel back and remove both hoses from the air filter by carefully pushing the orange plastic collars towards the filter and pulling the hoses away.
4. Rest the panel against the left side of the UAM being careful not to stress the cables connected to the panel.
5. With the nut wrench unscrew the nut on the ground post terminal on the bottom right of the panel to remove the ground wire connecting the panel to the concentrator.
6. Disconnect the concentrator power switch cable (4 wires: 2 blue, 1 yellow, 1 red).

Step 5



Step 6

7. Disconnect the white nylon tube going from the concentrator to the bottom of the regulator by carefully pushing up the orange plastic collar and pulling the tube down.
8. Remove the (4) 6mm hex screws surrounding the rectangular opening underneath the UAM.
9. Push the top of the concentrator module tilting it towards the front of the UAM and with a very large flat screwdriver or another hard flat tool separate the bottom of the concentrator from the bottom surface of the UAM's interior.
10. Once the concentrator is separated from the base, lift it and pull it towards you and letting it rest on the back edge of the bottom surface of the UAM being careful not to pull on the concentrator monitor and LED indicator panel cables.
11. Disconnect the concentrator monitor cable and LED indicator panel cable.
12. Lift and lower the concentrator module to the floor right behind the UAM.



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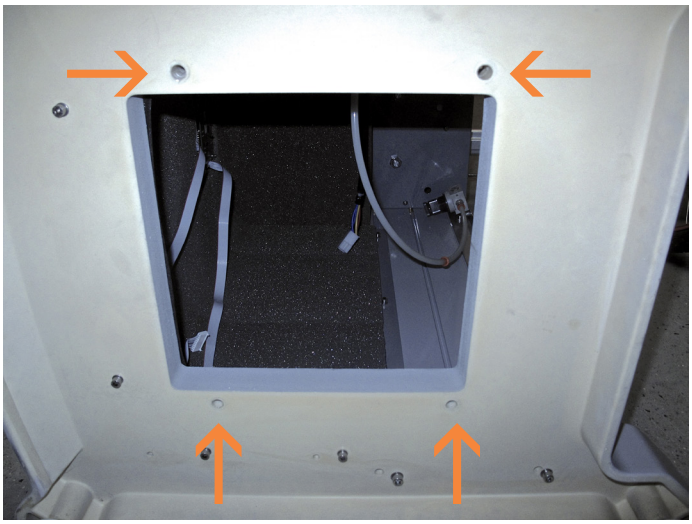
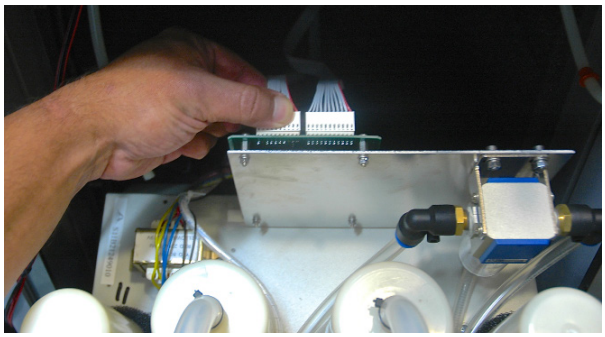


Step 8

Step 9



Step 11

INSTALLING THE CONCENTRATOR

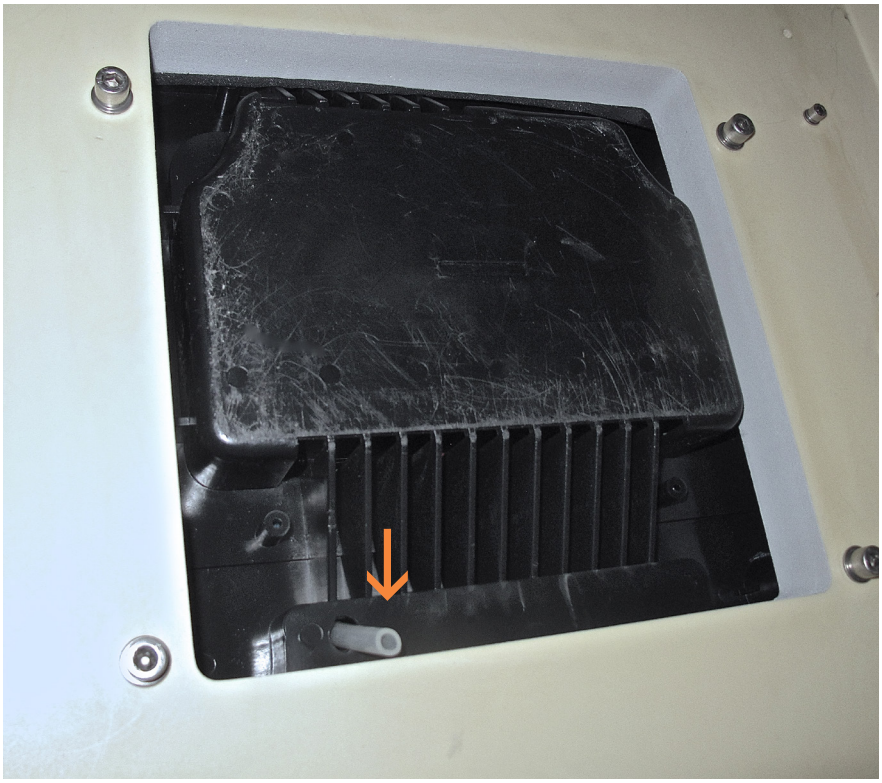
Materials and tools required:

- → 6 mm hex key
- → 3 mm hex key
- → M5 crescent wrench

1. Lift up and balance the concentrator on the rim of the base.
2. Reconnect the concentrator monitor cable and the LED indicator panel cable.
3. The drain hose from the water trap must be pushed through the hole in the bottom of the concentrator.
4. Push the concentrator into the housing, making sure that the drain hose does not get trapped between the bottom of the concentrator and the rim of the housing.
5. Make sure that the oxygen outlet tube from the oxygen reservoir is not kinked. Also make sure that the water trap is not damaged or dislodged by the top housing or by the foam on the right hand side of the housing. Realign it if necessary after it is inside.
6. When the concentrator is placed approximately in its final position, align the rear right hand holes for the 6 mm hex screw with a short screwdriver and loosely screw it in a few turns.
7. Align the rear left hand holes and loosely screw the second hex screw here. Then locate the remaining two front hex screws and tighten all screws.
8. Connect the oxygen supply hose to the bottom of the pressure regulator making sure that it is not kinked.
9. Connect the concentrator power switch cable (4 wires: 2 blue, 1 yellow, 1 red).
10. Make sure that the battery wires are connected firmly to the battery on the rear panel (black to black, red to red)
11. Insert the two air inlet hoses into the air filter and lift up the rear panel ensuring that the hoses bend downwards between the zeolite cylinders and do not kink when closing the rear panel.
12. Attach the rear panel to the housing with the 6 screws.

NOTE: When finished assembling verify that the drain hose is protruding from the orifice as picture below.

13. Test the oxygen concentration and flow of the concentrator and test that the control screen works on battery and that the battery charges.



Step 4

REPLACING THE ANALYZER SCREEN BATTERY

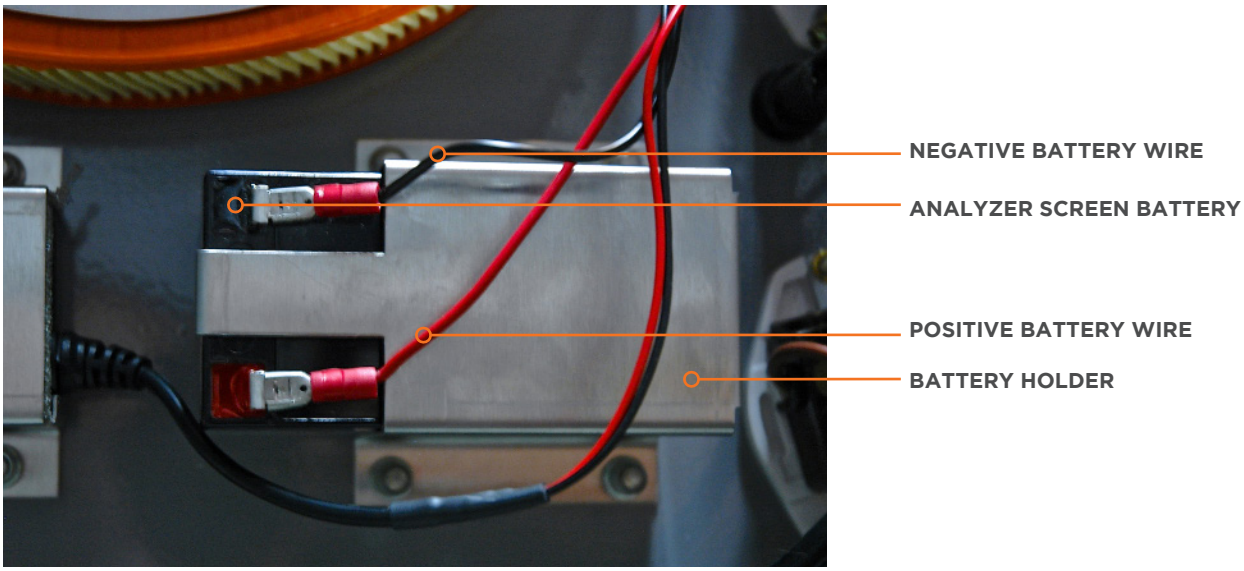
Materials and tools required:

- → 2.5 mm hex key
- → 3.0 mm hex key
- → Long nose pliers

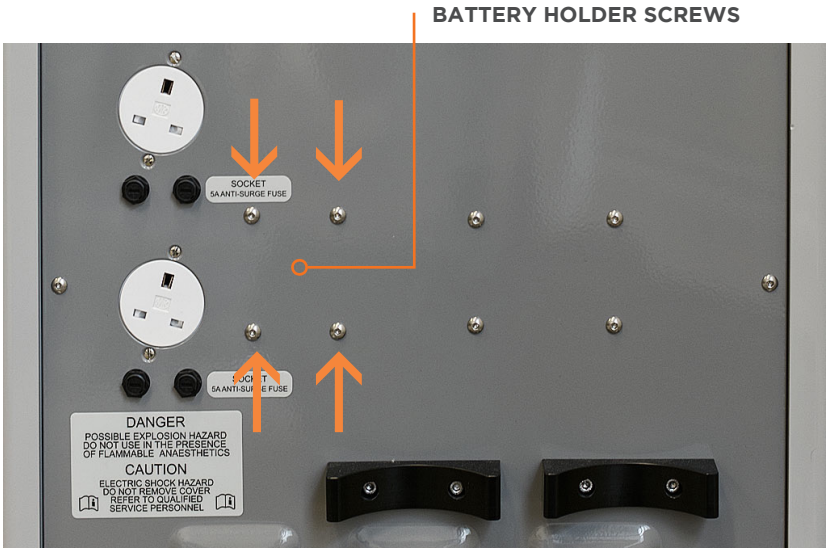
1. Remove the six screws from the edges of the lower rear panel with the 3mm hex key.
2. Tilt the panel back and remove both tubes from the primary air filter.
3. Rest the panel against the left side of the UAM being careful not to stress the cables connected to the panel.
4. With the long nose pliers disconnect the positive and negative battery wires.
5. Remove the four screws on the back of the panel that attach the battery holder.
6. Remove battery and replace with a new one

NOTE: Replacement batteries can be ordered from Gradian but they may be less expensive and quicker to obtain from a local battery supplier. Battery details: YUASA NP1.2-12 12V 1.2 AH sealed lead acid battery.

7. Assemble by following the above steps in reverse.



Step 4



Step 5

REMOVING, INSPECTING AND CLEANING THE PRESSURE RELIEF VALVE

Materials and tools required:

- 5mm hex key
- A 15 mm crescent wrench
- Medical grade cotton swabs
- Isopropyl alcohol (also know as rubbing alcohol or surgical spirit- typically 70% isopropyl and 30% distilled water)
- A small bowl

On occasion the 5 cmH_2O pressure relief valve located on the top of the back bar may not perform optimally due to accumulation of dust and other contaminants such as liquids. If you notice that the valve is not opening at 5 cmH_2O then you will need to remove, inspect, and clean it.

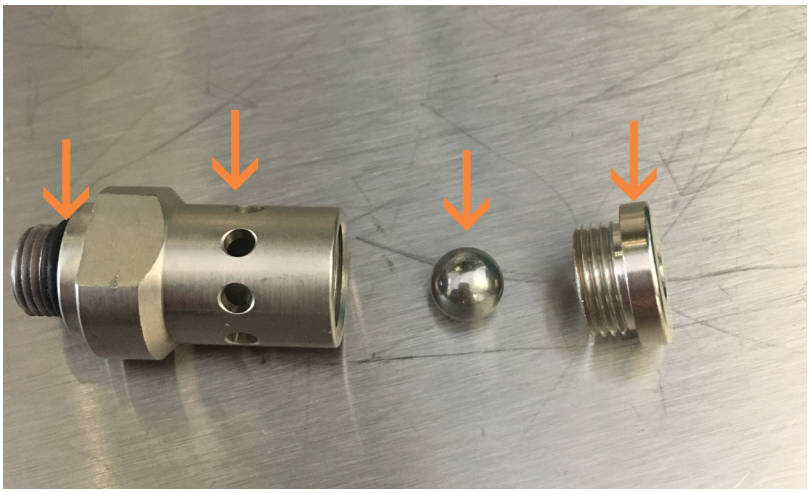
REMOVING THE PRESSURE RELIEF VALVE:

1. Turn off the UAM.
2. Using a 5mm hex key, loosen the plug on the top of the pressure relief valve and remove it.

NOTE: It may be possible that when removing the plug, the body of the pressure relief valve may loosen up from the back bar. This is not a problem and in fact may allow you to do the next step by hand.

3. With the crescent wrench, grab the flats on the body of the pressure relief valve and turn it anticlockwise to loosen it up and free it from the back bar.

4. Once removed make sure that you see the following parts (shown right to left): the relief valve plug, the stainless steel ball, the relief valve body, and the O-ring attached to the valve's body.



INSPECTING AND CLEANING THE PRESSURE RELIEF VALVE:

5. Inspect all of the parts to ensure that there are no stains, debris, moisture or rust. Inspect the condition of the O-ring and make sure it is not cracked or deformed.
6. To clean, place all the parts in a small bowl with isopropyl alcohol and let them soak for a few minutes.

7. Wipe each part with a medical grade cotton swab ensuring that there are no visible stains or debris.

8. Once cleaned, completely dry all of the parts.

REPLACING THE CLEANED PRESSURE RELIEF VALVE:

9. Place the stainless steel ball into the body of the valve and screw the plug onto the body by hand.

10. With the 5mm hex key screw in the assembled pressure relief valve into the back bar until tight, making sure not to exert too much force.

11. Test the operation of the pressure relief valve ensuring that it relieves pressure at 5 cmH_2O.

12. If the pressure relief valve does not function correctly, replace it with a new one.

PROBLEM-SOLVING

PROBLEM	POSSIBLE CAUSES/SOLUTIONS
Both the Oxygen concentrator and the control screen do not turn on	→ Check that both mains isolator switch and O_2 concentrator are switched on. → General supply voltage instability, power surges/low voltage/spikes. Use voltage stabilizer → Faulty socket outlet, general power cut → Malfunctioning mains isolator switch → Malfunctioning voltage switcher → Broken mains plug or cable → Malfunctioning voltage stabilizer, if fitted between UAM and wall socket.
UAM shuts down and re-starts.	→ General supply voltage instability, power surges/low voltage/spikes. Use voltage stabilizer → Fault in local wiring or other device in or near the operating theater. Check other electrical devices in the operating theater such as air conditioner, sterilizer, theater lights. Switch off all devices except UAM and switch on other devices at intervals, one by one.
Oxygen concentrator does not turn on or a noticeable hot smell	→ Blown 5A fuse → Malfunctioning front switch → Malfunctioning mains isolator switch → Malfunctioning voltage switcher → Malfunctioning oxygen concentrator circuit board → Compressor failure
Analyzer screen does not turn on	→ Blown 24V Power Supply Unit fuse (500mA) → Defective 24V Power Supply Unit → Circuit board failure
Oxygen analyzer displays 104% at higher oxygen concentrations	→ Oxygen sensor needs to be calibrated with 100% oxygen
Oxygen sensor will not calibrate or monitor readings are erratic	→ Oxygen sensor is exhausted and needs to be replaced → Sensor cable is disconnected or broken
Audible alarms not working	→ Disconnected speaker connector → Malfunctioning speaker → Malfunctioning analyzer screen circuit board
Analyzer screen shuts off when mains power is lost	→ Battery needs recharging or is disconnected → Battery has lost its capacity to charge and should be replaced
N_2O does not cut-off when oxygen percentage is less than 25%	→ Malfunctioning cut-off solenoid valve → Malfunctioning analyzer screen circuit board
Apnea alarm does not activate	→ Mute option is selected → Pressure transducer needs to be calibrated → Malfunctioning analyzer screen circuit board
Oxygen concentrator output measures less than 90%	→ Oxygen sensor needs to be calibrated to both 100% and 21% oxygen → Malfunctioning water trap in oxygen concentrator is allowing moisture to saturate the material in the zeolite cylinders. Clean or replace. → Air filter is dirty and obstructing air flow. Clean or replace. → Air compressor is malfunctioning → Switching valve is malfunctioning
Oxygen concentrator output does not reach 10 liters/minute and/or flow fluctuates	→ Concentrator output regulator needs to be adjusted
Concentrator alarm does not activate when power is lost	→ 9-volt alarm battery is discharged and should be replaced.
Breathing system pressure too high	→ Pressure relief valve not opening. Remove and clean. → Balloon valve malfunctioning. Remove and clean or replace.

MAIN PARTS

ITEM NO	DESCRIPTION
GAS SUPPLY	
1	Oxygen concentrator
1-a	Main concentrator control board
1-b	Compressor pump
1-c	O_2 concentrator switching valve
1-d	Zeolite Cylinder Set
1-e	Fan
1-f	Water Trap
2-a	O_2 cylinder pressure gauge
2-b	O_2 pipeline pressure gauge
3-a	N_2O cylinder pressure gauge
3-b	N_2O pipeline pressure gauge
4	O_2 4 meter antistatic hose assembly with BS5682 connector
5	N_2O 4 meter antistatic hose assembly with BS5682 connector
6	Primary air filter- Type: AG2865
ANAESTHESIA DELIVERY/BREATHING	
7	Glass Rotameter Shield
8	Flow dial O_2 and label
9	Flow dial N_2O and label
10	Draw over vaporizer - Isofluorane
11	Draw over vaporizer - Halothane
12	Draw over vaporizer - Sevoflurane
13	Breathing pressure gauge assembly
14	Reservoir bag
15	Silicone breathing circuit
16	Manual Bellows
17	Fenton balloon
18	Balloon Chamber and Scavenging Taper Assembly, UAM A
19	Balloon Chamber and Exhaust taper, UAM B
19-a	Whole Exhaust Assembly Replacement, UAM B
20	Extended Breathing Circuit Taper, UAM A
20-a	Inhale Patient Taper, UAM B
20-b	Exhale Patient Taper and NRV, UAM B
21	O_2 rotameter tube
22	Vaporizer back bar with 2 liter reservoir, air entrainment valve, over pressure valve, custom vaporizer connections
23	Manual Ventilator Manifold Assembly (includes 2 unidirectional valves, 55 cmH_2O pressure relief valve and exhaust valve), UAM A
24	Water trap and O seal
25	N_2O Cut Off Solenoid Assembly
MONITORING	
26	Analyzer screen unit- includes touch screen and housing
27	Analyzer screen circuit board
28	Consumable oxygen sensor
29	Speaker Unit
30	Vital signs monitor

ELECTRICAL

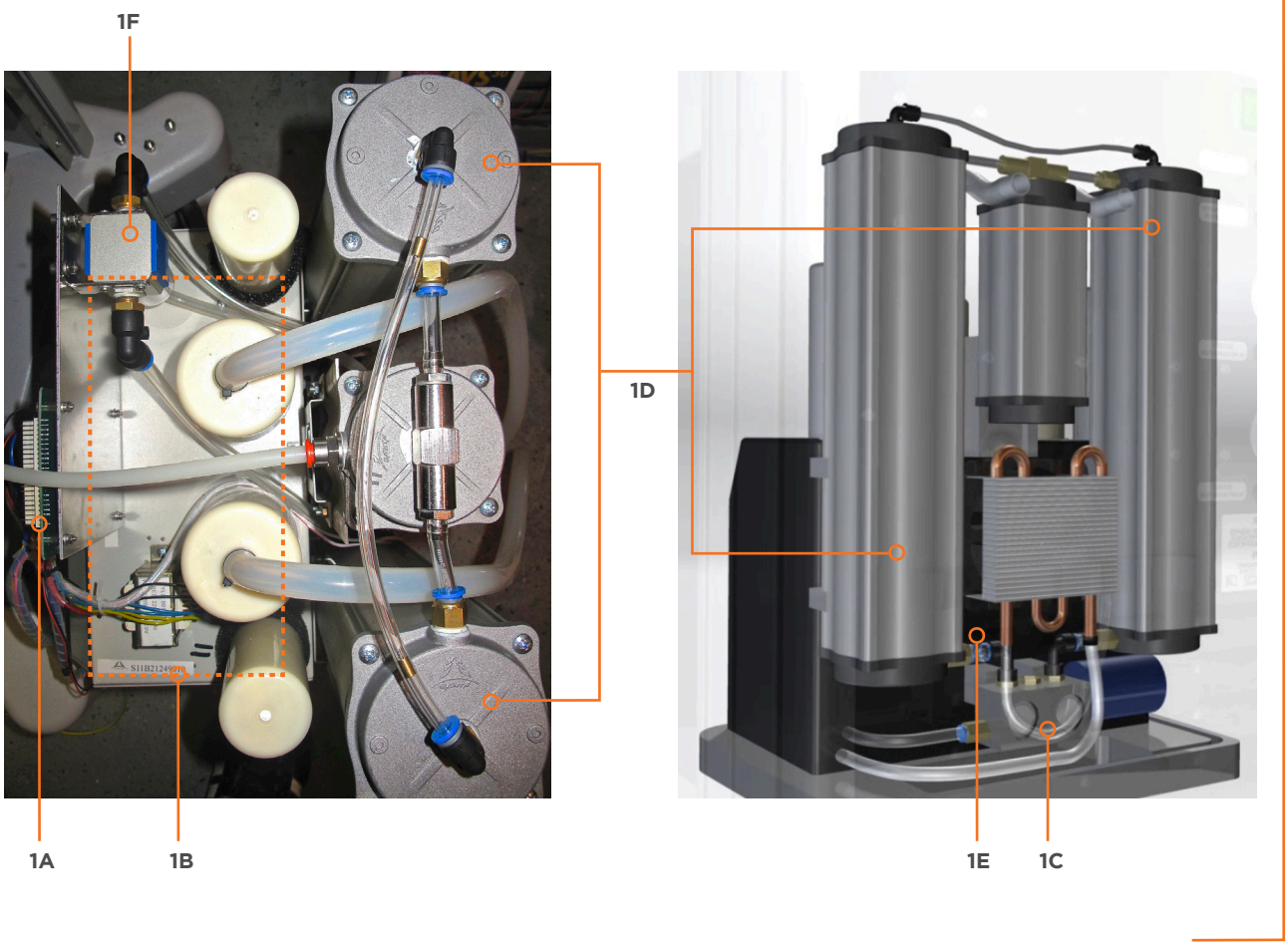
31	O_2 concentrator on/off switch
32	Fuses for O_2 concentrator and sockets - 5 amp x 5
33	Fuses for control screen - 500 mA x 5
34	Main incoming fuse - 13 amp x 5
35	Mains inlet cable with UK style plug - 4 meters
36	Electrical sockets- 13 amp UK style
37	Mains isolator rocker switch
39	Power supply for analyzer screen - 24V 15W
40	Automatic voltage switcher unit
41	Battery for analyzer screen - YUASA NP1.2-12 12V 1.2 AH sealed lead acid battery

FRAME

42	Removable stainless steel work surface, UAM A
43	Stainless steel drawer replacement, UAM A
44	Stainless steel drawer replacement, UAM B
45	Casters with brakes
46	Casters without brakes
47	Top monitor shelf, UAM A
48	Top monitor shelf, UAM B
49	Upper rear access panel, UAM B

ILLUSTRATED PARTS

REFER TO ITEM NUMBERS IN PARTS LIST

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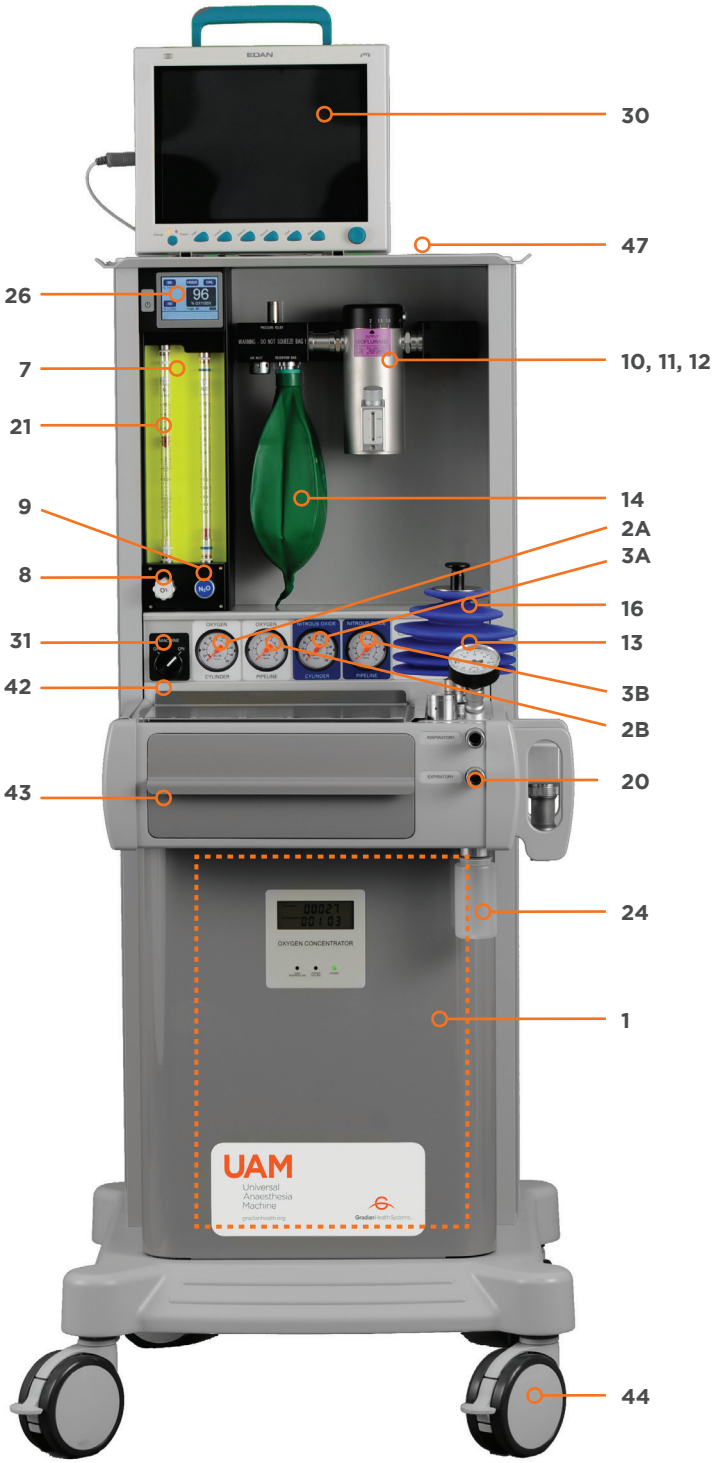
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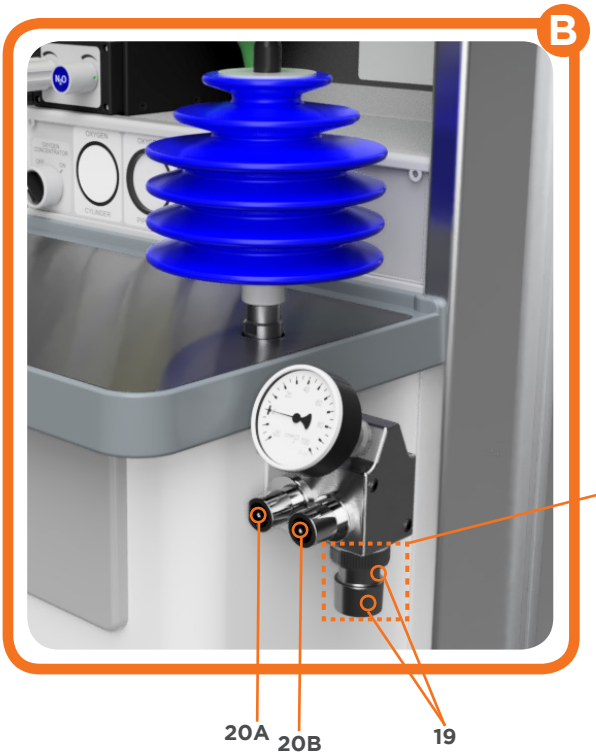
UAM
Universal
Anaesthesia
Machine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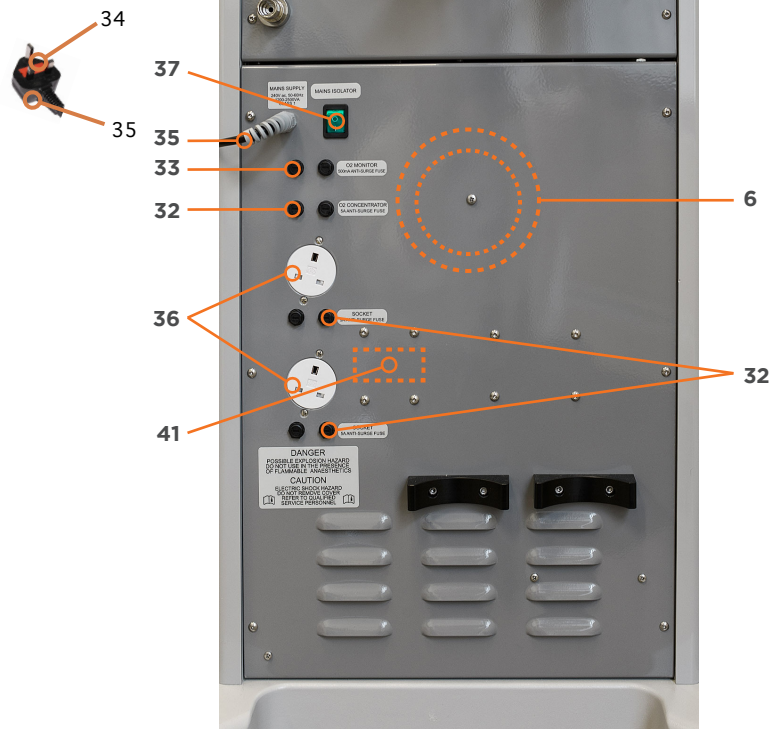
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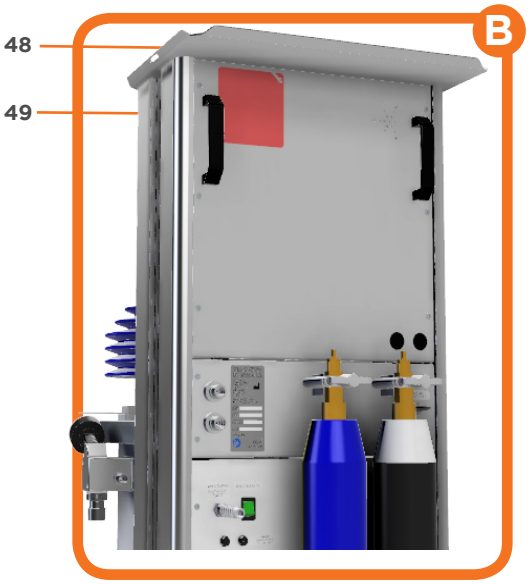
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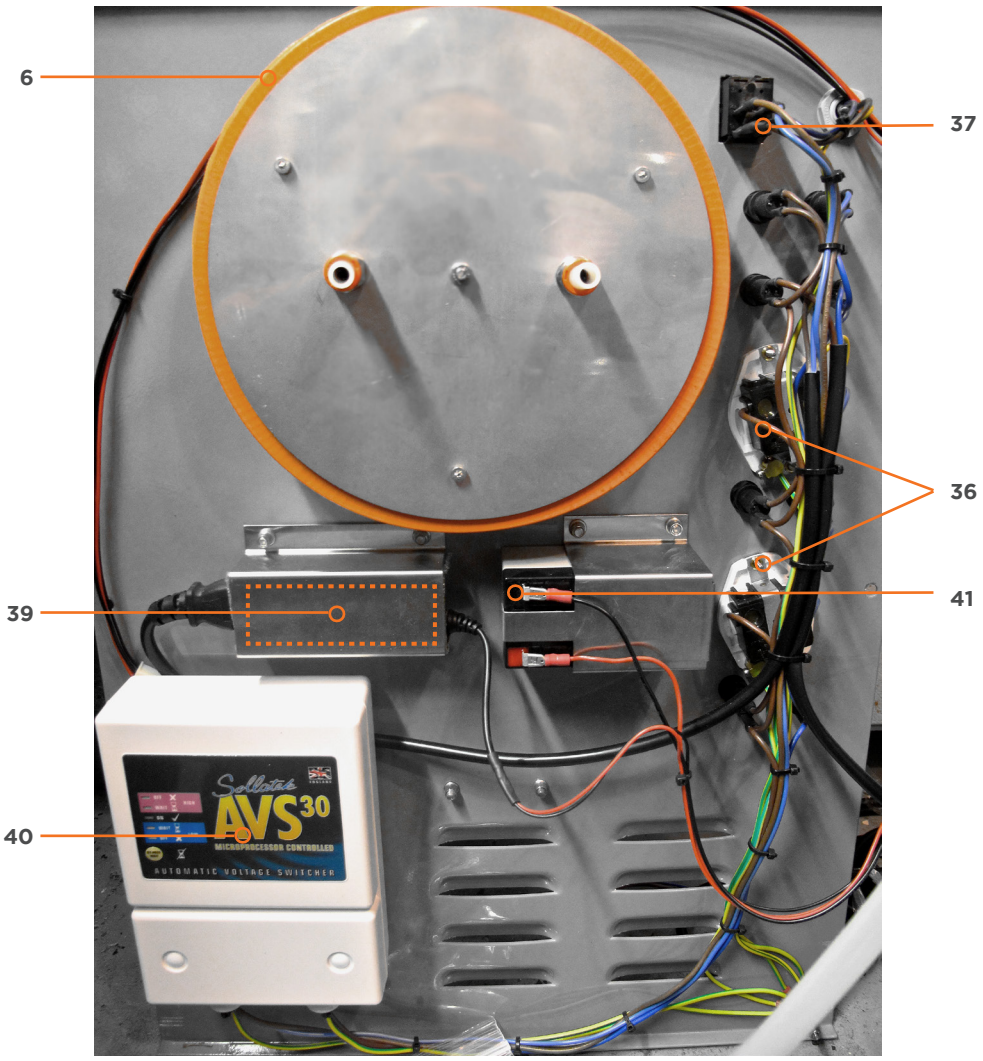
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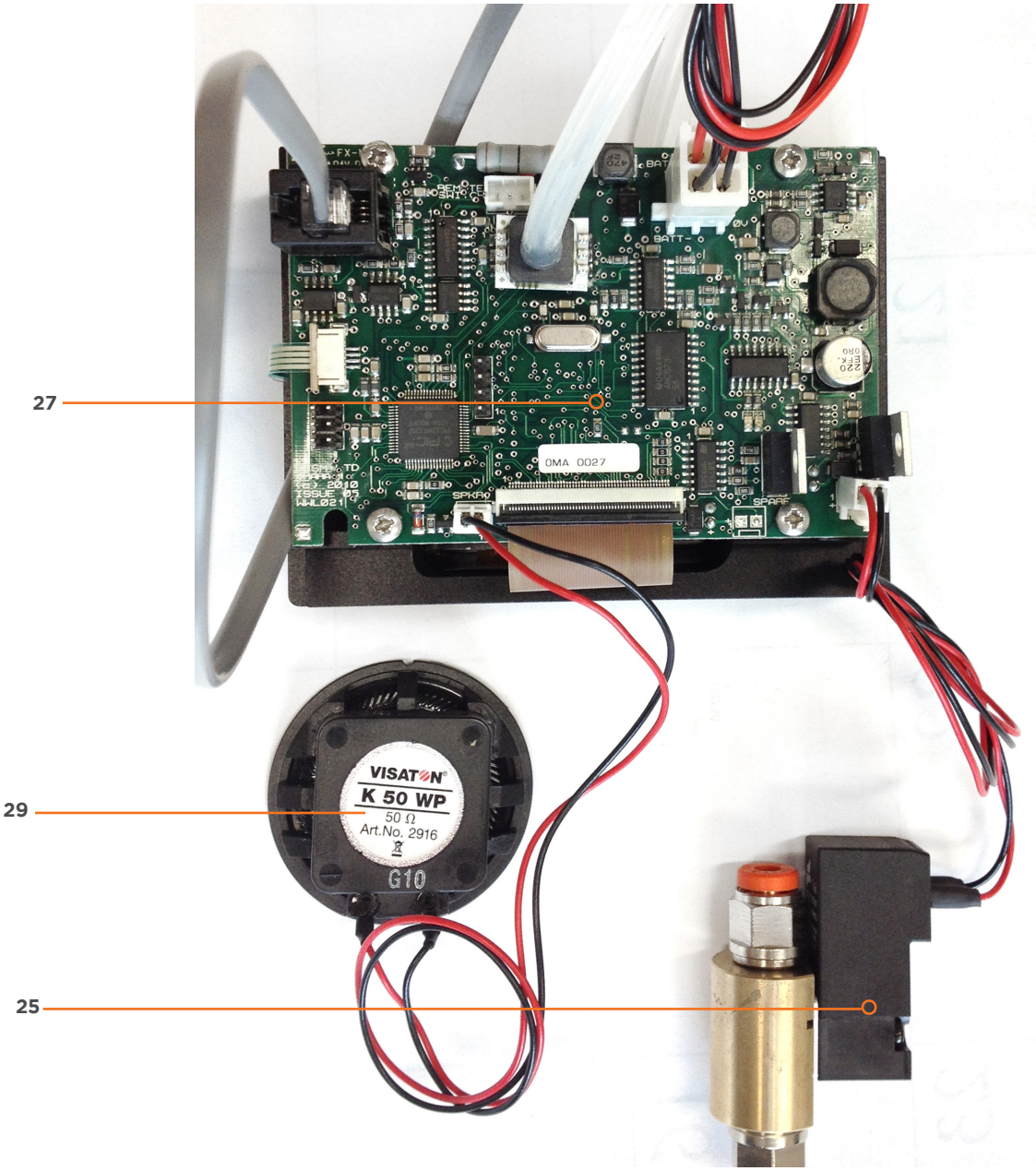
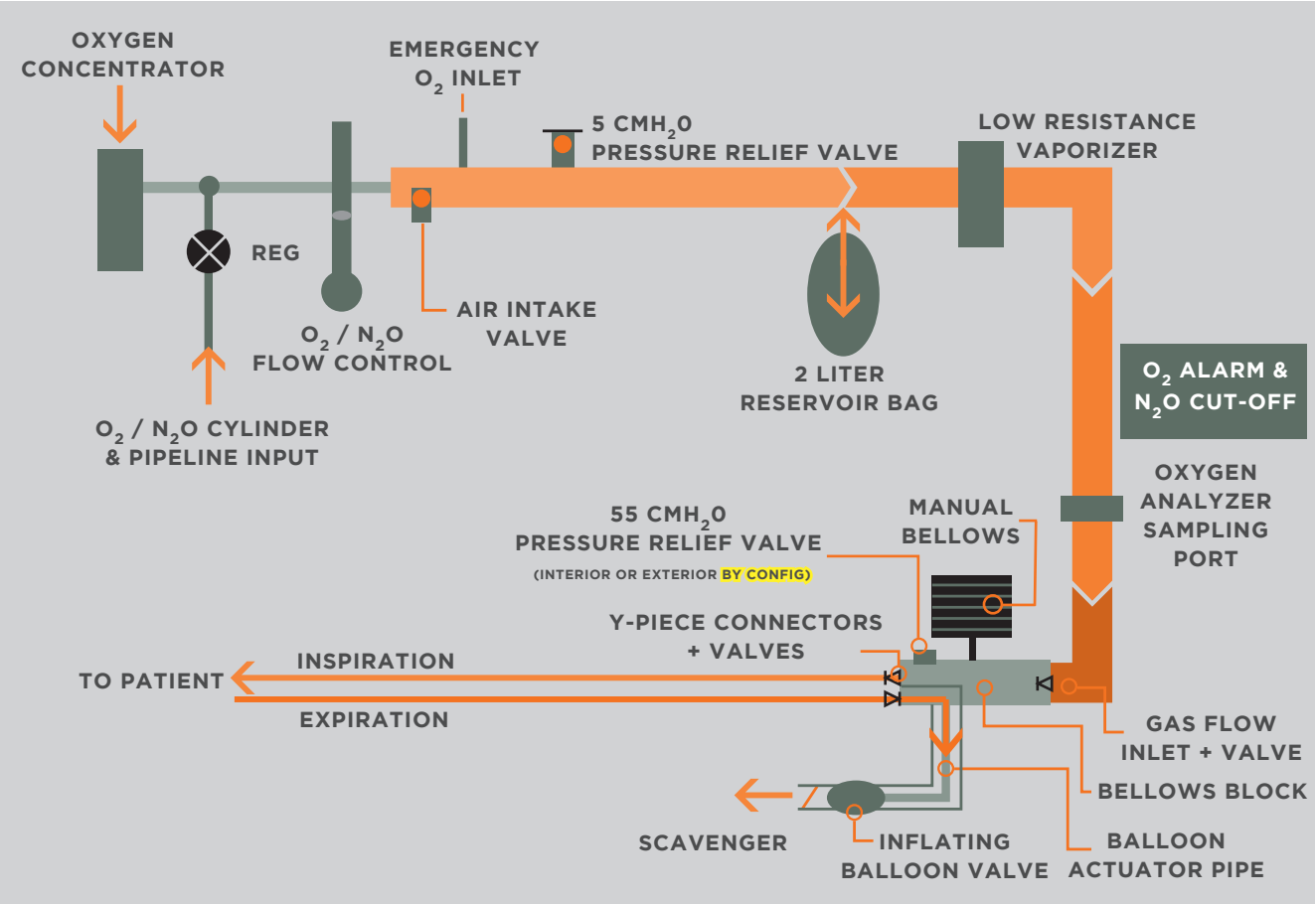
Sollatek
AVS30
MICROPROCESSOR CONTROLLED
AUTOMATIC VOLTAGE SWITCHER


27
29
25
VISATON
K 50 WP
50 Ω
Art.No. 2916
G10
0MA 0027

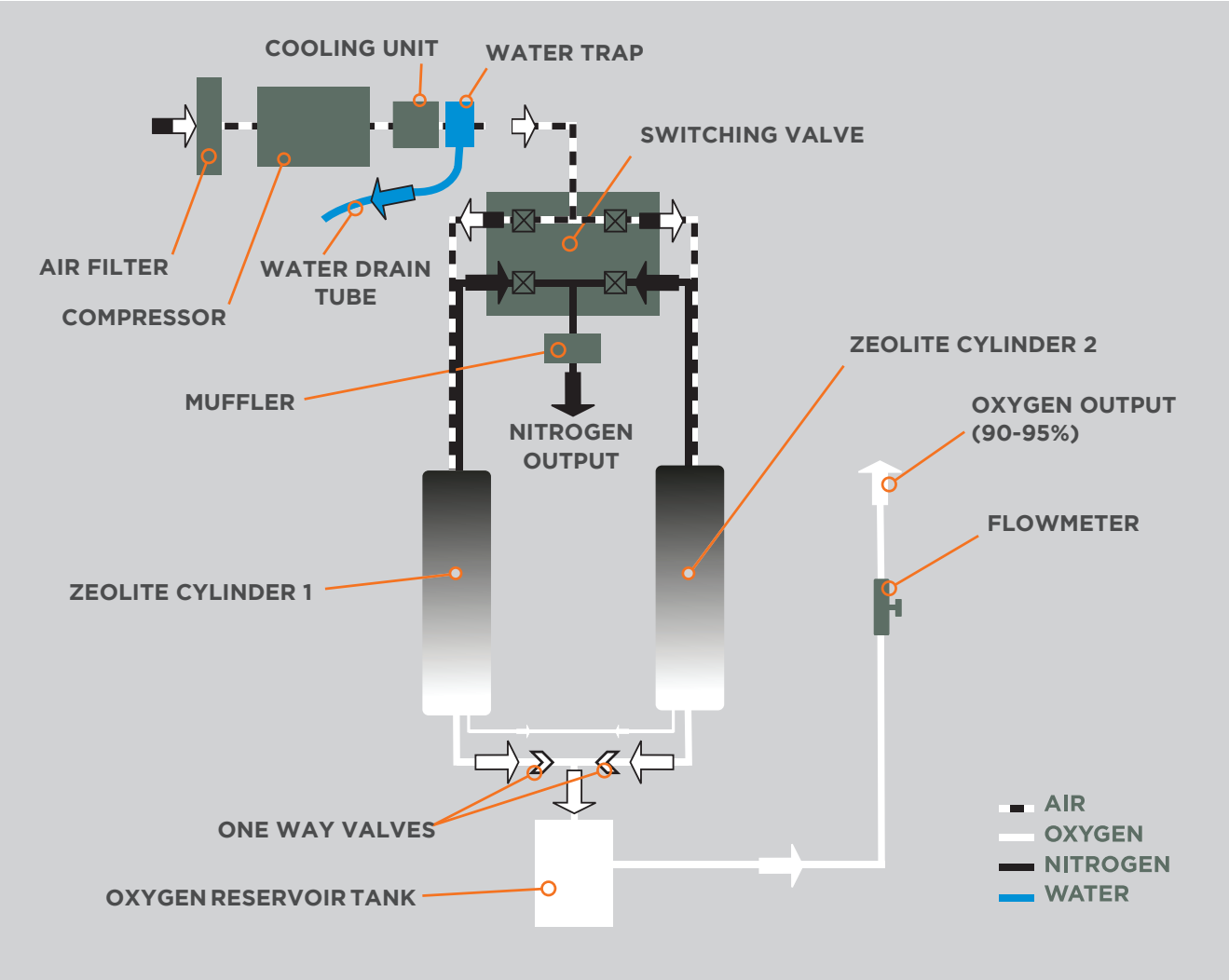
APPENDIX I

BREATHING CIRCUIT DIAGRAM



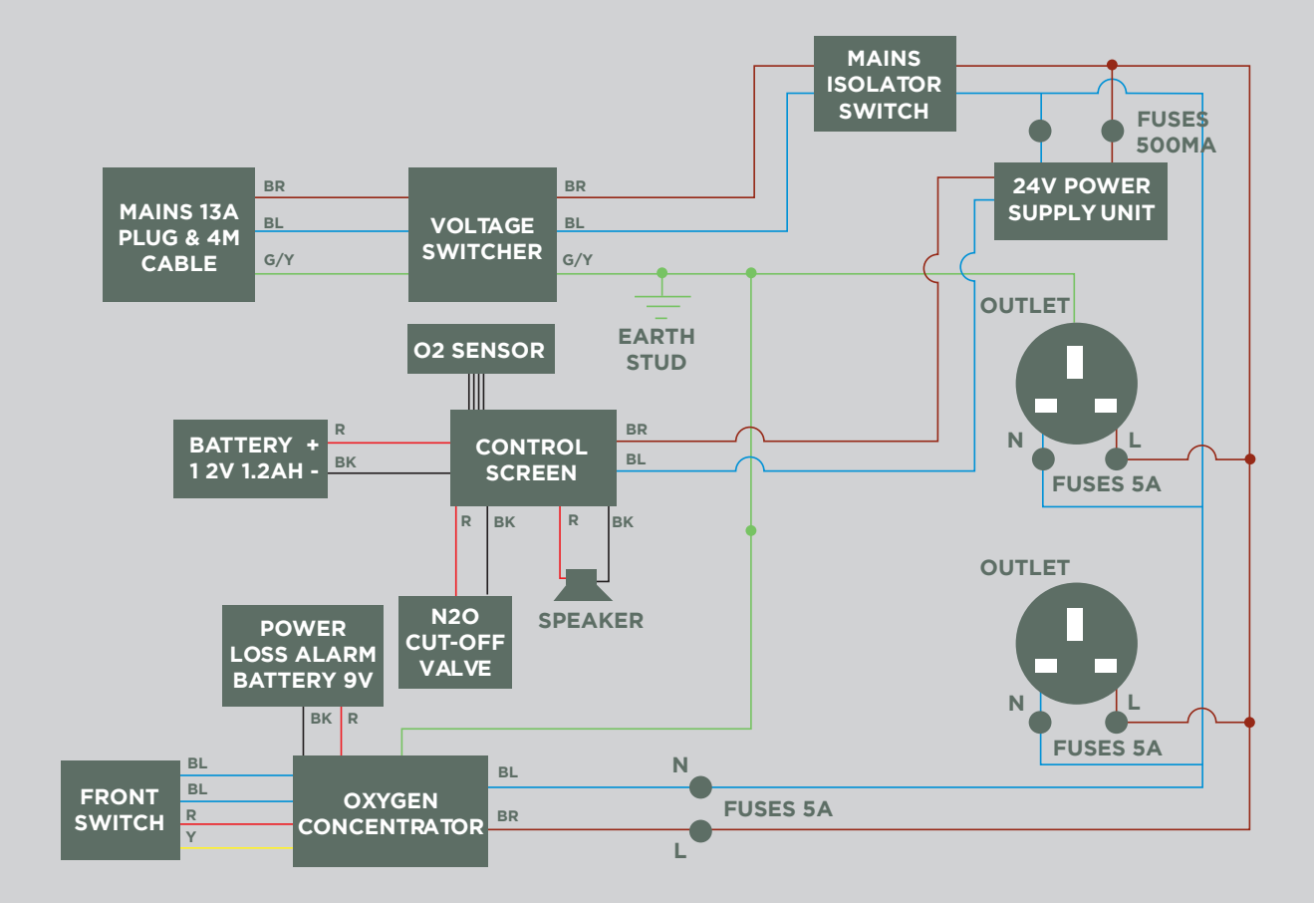
APPENDIX II

OXYGEN CONCENTRATOR FLOW DIAGRAM



APPENDIX III

ELECTRICAL DIAGRAM



APPENDIX IV UAM SERVICE RECORD

MACHINE SERIAL #	
CONCENTRATOR TOTAL HOURS RUN	
NEXT SERVICE CHECK DUE DATE	
ANALYZER SCREEN SOFTWARE REVISION #	

GASES USED: (check if available and write down pressure reading)		
OXYGEN CYLINDER		KPa
OXYGEN PIPELINE		KPa
NITROUS CYLINDER		Kpa
NITROUS PIPELINE		Kpa

TEST #	DESCRIPTION (Correspond to steps of the Full Function Test)	PASS (P)/ FAIL (F)	PROBLEM FOUND (and work carried out)
SYSTEM			
1	No modifications & all spares and accessories present		
2	Frame, hardware, wheels		
3	Mains cable and gas supply hoses		
4	Charging indicator		
5	Mains failure icon		
6	Battery condition icon		
7	Cylinder yokes		
8	Cylinder pressure gauges		
9	Pipeline pressure gauges		
10	Maximum O_2 and N_2O flows		
11	Zero O_2 and N_2O flows		
12	Emergency O_2 inlet		
OXYGEN CALIBRATION, SAFETY AND QUALITY			
13	Calibration with 100% O_2		
14	Calibration with Air		
15	Upper and lower O_2 alarms		
16	N_2O cut-off		
17	O_2 sensor disconnect alarm		
18	O_2 concentrator output		
BREATHING SYSTEM			
19	Apnea alarm		
20	Air intake valve		
21	Reservoir bag		
22	Bellows assembly condition		
23	Bellows expiratory pressure		
24	Patient water trap (if applicable)		
25	Fenton balloon operation		
26	Pressure relief valve		
VAPORIZER			
27	Vaporizer condition and indicator		
28	Vaporizer performance		
29	Residual flow test		
30	Complete and adhere service label		

Service carried out by (name of technician):

Signature: **Date:**

APPENDIX V
UAM INSPECTION LABEL

Gradian Health Systems®

UAM INSPECTION LABEL

DATE: **BY:**

RE-INSPECT BEFORE:

APPENDIX VI
PRESSURE CONVERSIONS

Using the Table

1. **Find the units you wish to convert FROM in the left hand Column.**
2. **Find the units you wish to convert TO in the top row**
3. **Insert the multiplier shown at the intersection into the following formula:**

FROM units X MULTIPLIER = TO units
Example: 100 psi x 6.894757 = 689.475 kPa

DESIGNATION	PSI	KPA	CM OF H2O	BAR
PSI	1	6.894757	70.306927	.06894757
KPA	.1450377	1	10.19745	.01
CM OF H2O	.0142229	.0980634	1	.000980634
BAR	14.5038	100	1019.7466	1

COLOR IDENTIFICATION FOR MEDICAL GASES

GAS	ISO	USA
OXYGEN	White	Green
NITROUS OXIDE	Light Blue	Light Blue
MEDICAL AIR	Black and White	Yellow
SUCTION	Yellow	White

NOTES:

Gradian Health Systems®

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