1. INTRODUCTION

1.1. Nitric oxide (NO) is a colourless, non-flammable, toxic gas that supports combustion.

1.2. Inhaled nitric oxide (iNO) has been used for treatment of acute respiratory failure and pulmonary hypertension in adult patients in critical care unit.

1.3. NO an inhaled gas that is administered directly to the lungs via a ventilator and becomes a selective pulmonary vasodilator. It decrease PVR without affecting SVR.

1.4. NO improve blood flow to ventilated alveoli, which improves oxygenation.

2. PURPOSE

To describe the delivery of nitric oxide as a therapeutic rescue modality for use with mechanical ventilated patients.

3. POLICY

3.1 Initiation of NO must be ordered by the attending physician **inside ICUs only.**

3.2 The use of iNO during mechanical ventilation involves close monitoring and special exhaust systems to prevent exposure of health care personnel to NO and its potentially toxic by-products.

3.3 Indications

3.2.1 Nitric oxide induces vaso-relaxation in ventilated portions of the lung and redistributes pulmonary blood flow, thus reducing intrapulmonary shunting in most *hypoxemic patients*

3.4 Contraindications

3.3.1 Congenital heart disease.

3.3.2 High baseline Methaemoglobin (>5%) levels

3.3.3 Sudden discontinuation of iNO may be associated with sever pulmonary vasoconstriction.

3.5 Side effects

3.4.1. Methemoglobinemia

3.4.2. Administration of iNO is associated with NO_2 formation which is potentially toxic and level > 10 PPM are dangerous can cause cell damage, haemorrhage, pulmonary edema, and death.

3.4.3. Long term use of iNO causes a physical dependency and difficult to wean

3.6 Before initiation of iNO, the SENIOR Respiratory Care Practitioner must ensure that there is sufficient number of NO tanks.

3.7 The physician must be notified if there are limited numbers of NO tanks on hand.

3.8 Methaemoglobin should be measured 4hrs after commencing iNO and daily thereafter.

4. RESPONSIBILITIES

4.1 The senior RCP is responsible for ensuring the equipment is properly set up and monitored on all patients receiving iNO.

4.2 Junior RCS staff may manage iNO under the supervision of the senior RCP

5. DEFINITION OF TERMS

5.1 ICS: Intensive Care Services.

5.2 ICU: Intensive Care Unit.

5.3 PVR: Pulmonary vascular resistance.

5.4 SVR: systemic vascular resistance.

5.5 NO: Nitric oxide

5.6 NO2: Nitrogen Dioxide

6. APPLICABILITY

This policy applied to all Respiratory cares services staff that provides Inhaled nitric oxide therapy to patient on mechanical ventilation in the Intensive Care Unit.

7. PROCEDURES

7.1 Equipment Needed:

7.1.1. There are two machines of NO available in PSMMC

7. 1.1.1. *ARENOX*: with especial lines and gage

7. 1.1.2. *NOXBOX*: with especial lines and gage

7.1.2. Sufficient supply of NO

7.1.3. Resuscitation bag and Test lung with PEEP valve

7.1.4. ETT clamp

7.1.5. Pressure adaptor/connector (Special connector for manual ventilation using iNO)

7.1.6. Arterial Line placement

7.1.7. Pulse Oximetry

7.1.8. Cardiac monitoring HR, RR, ECG

7.2 Set Up

7.2.1 Correctly identify patient as per the hospital approved identification guidelines

7.2.2 Inspect medical records of patient and review history to ensure there are no contraindication(s) for iNO

7.2.3 Wash/disinfect hands, and use appropriate Personal Protection equipment (PPE) as per the Infection Control Guidelines

7.2.4 Set-Up/Calibration of Nitric Oxide machine by Bed-side/Senior Respiratory Care Practitioner as per **appendix A and B**

7.2.5 Set the Initial dose of delivered Nitric Oxide anywhere from 5 to 20 PPM, (If no clear, precise concentration of nitric has been documented)

7.2.6 Set all alarms appropriately

7.2.7 Initial Flow

Order NO x Flow of Ventilator/NO tank Concentration in psig

7.2.8 Perform blood gas 30 minutes after initial settings or if any change in ventilator parameters is done.

7.2.9 Repeated blood gases 4 hourly if no weaning of nitric oxide is done or if there is no change on ventilator settings

7.2.10 At least Q6 Hourly check Meth Hemoglobin level (the acceptable value < 2.5%)

7.2.11 Documentation of NO_2 with each ventilator check; the values should be < 5.0 PPM (recommendation is < 2.0 PPM)

7.2.12 Platelet Count and Hemoglobin level at least Once a shift.

7.3 Weaning of NO

7.3.1 ABG criteria met

7.3.2 Hemodynamic stability

7.3.3 Physicians written order of weaning Nitric Oxide

7.3.4 Drop iNO after 4 hours from initiation of iNO therapy as clinically tolerated by the patient

7.3.5 FiO2 should be less than 50%;

7.3.6 PEEP low level as possible

7.3.7 Adults dosage of Nitric Oxide in PPM: 20 → 10 → 5 → 3 → 2 → 1

7.3.8 Or decrease NO by 2 every 2-4 hrs, as physician order.

7.3.9 The patient should be hyper-oxygenated (Fio_2 0.6 to 0.7) just before discontinuation of iNO.

8. REFERENCES

8. 1 Egan's Fundamental of Respiratory Care, Chapter 27, 37, Edition 10th, 2013.

8. 2 Germann, P., Braschi, A., Della Rocca, G. et al. Inhaled nitric oxide therapy in adults: European expert recommendations. Intensive Care Med 31, 1029–1041 (2005). https://doi.org/10.1007/s00134-005-2675-4

8. 3 Loakes' Ventilator Management A Bedside Reference Guide, Specific Techniques, 2009 edition.

9. APPENDICES

9.1 Appendix 1 Setup the NOxBOX

9.2 Appendix 2 Setup the Arenox

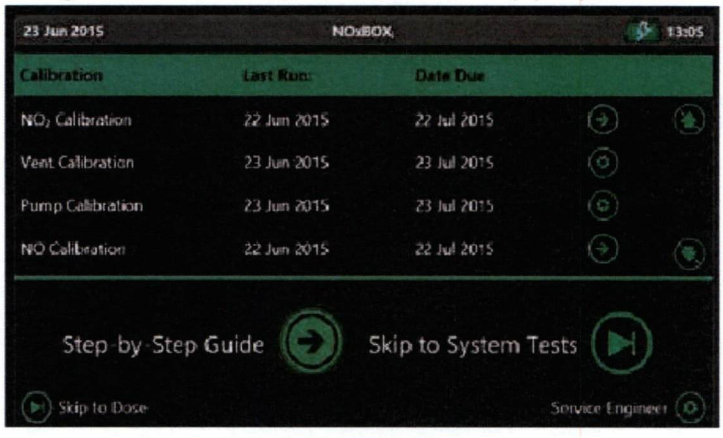
10. ORIGINATING DEPARTMENT/S

Intensive Care Services Department -.Respiratory Care Services

Compiled by: • **Mrs. Ekhlas Al-Hefdhi** **Team Leader & Chairman of Respiratory Care Services Policy and Procedure Committee**	**Signature:**	**Date:** 17-4-2023
• **Mrs. Bodour Al-Dossari** **Head of Respiratory Care Services**	**Signature:**	**Date:** 20/4/2023
Reviewed by: **Dr. Muhammad Kashif Malik** **Consultant & Head, CQI&PS Division, Intensive Care Services**	**Signature:**	**Date:** 2/APRIL/2023
Reviewed by: **Dr. Samir Mohammed Bawazir** **Director, Continuous Quality Improvement & Patient Safety (CQI&PS)**	**Signature:**	**Date:** 27.4.2023
Authorized by: **Brig. Gen. Dr. Adnan Al Ghamdi** **Director of Intensive Care services (ICS)**	**Signature:**	**Date:** 26-4-2023
Authorized by: **Brig. Gen. Dr. Abdulrahman Al Robayyan** **Director of Medical Administration**	**Signature:**	**Date:** 08/05/23
Authorized by: **Brig. Gen. Dr. Rashed Al Otaibi** **Executive Director for Health Affairs** **Chairman, Senior Medical Management Team (SMMT)**	**Signature:**	**Date:** 11.5.2023
Approved by: **Maj. Gen. Khalid Abdullah Al Hadaithi** **General Executive Director of Prince Sultan Military Medical City**	**Signature:**	**Date:** 21.5.2023

Connecting NO Gas Cylinders:

1- Using the on-screen Quick Start Guide (QSG) instructions set up the system.

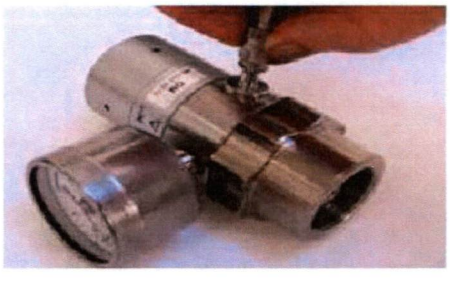


2- Check that the NOxBOX NO cylinder i concentration matches the value shown on the system screen.

3- Check the regulator sealing surfaces and connector thread. If your model has non-metal sealing elements, ensure that they are present and undamaged, showing no cracks, pock-marks, etc.

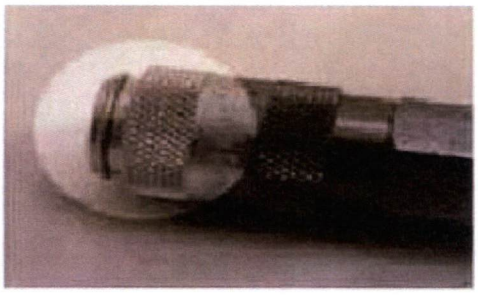
4- Attach the regulator to the cylinder valve connection. Tighten the connection using the hand wheel. Do not use a tool to tighten the regulator

5- If the supply line is not already connected to the regulator, then click the quick-connector over the port on the regulator as shown. Ensure the collar on the quick-connect is drawn back prior to fitting. The quick-connect will click positively into place an nd lock, creating an air-tight seal.

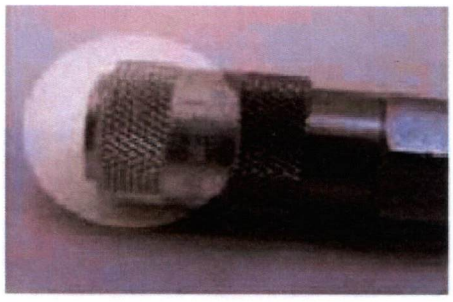


6- Connect the line from the regulator on cylinder 1 to port 1 at the back of the monitor

7- Ensure the collar on the hose is drawn back prior to fitting onto the port stump. The collar should spring forward and lock into place with a positive click.

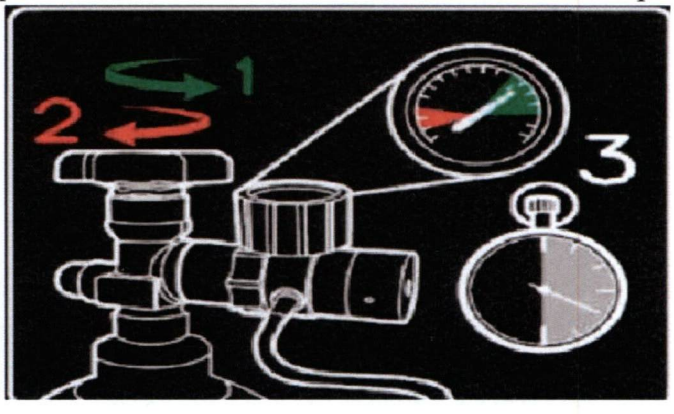


Collar drawn back



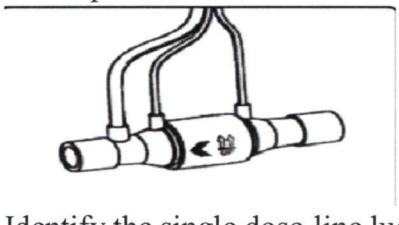
Collar sprung forward

8- To test connection, gently pull back on the rear of the connector, ensure that you are not pulling on the collar release element. The connection should be secure.
9- Check that each supply cylinder has sufficient contents to commence treatment: open cylinder valve fully, then close valve fully. A supply cylinder should have a fill pressure greater than 20 bar before commencing treatment.
10- If the gauge needle is in the red area, the cylinder is empty and must not be used for treatment. Replace this supply cylinder to begin setup. If the cylinder is empty, the system test for cylinder pressure contents in the onscreen QSG will pause setup.
11- To test that each supply line is correctly setup, perform a high-pressure leak test as follows: a. with the valve open, note where the pressure gauge needle is pointing. b. Close the cylinder valve and observe the gauge for 30 seconds. c. If the needle remains constant, the line is correctly set up; press the check mark. d. If the needle shows a drop in pressure, a leak exists; press the X.

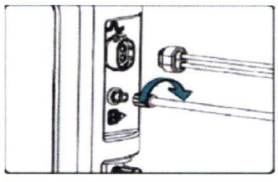


System test setup:

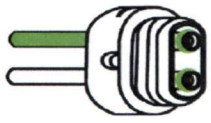
1- Unwrap a new NOxFlow sensor and unroll the lines.



2- Identify the single dose-line luer connector and attach to the monitor dose luer port as shown. Twist connector to lock.

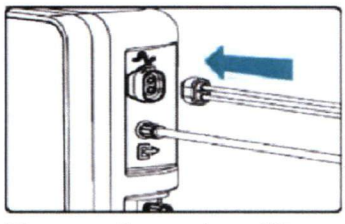


3- Identify the twin sensor line connector, Verify that both o-rings are present prior to connecting to the NOxBOX



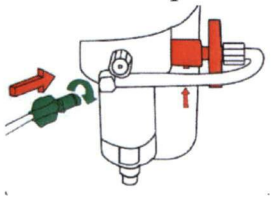
4- Push the sensor line connector into the socket on the side of the NOxBOX monitor, the green i tube is uppermost

5- Connector will click in place when locked. To assist insertion, the release button located on the underside of the socket may need depressed whilst attaching connector



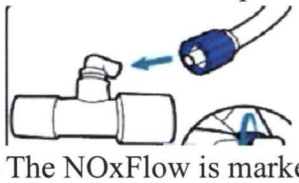
6- Unwrap the patient filter and attach the new filter to the rear of the water trap, by using the quick release connector. Then use the fastening luer lock to complete the connection

7- Connect sample line.

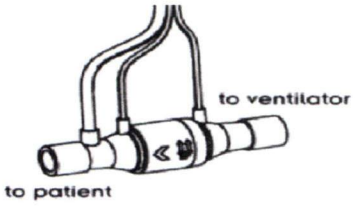


8- Select the NOxKIT that matches the patient ventilator circuit size (10mm, 15mm, or 22mm).

9- From the NOxKIT, select the male-female single-sized connector and assemble one of the female luer ports by pushing it firmly home into the side port of the adaptor. Screw the male luer lock at the end of the sample line onto the ventilator adaptor

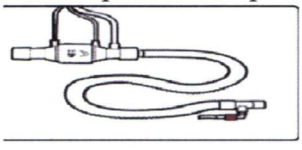


10- The NOxFlow is marked with a flow direction arrow in green. This points in the direction of the ventilator air flow, towards the patient sampling point.

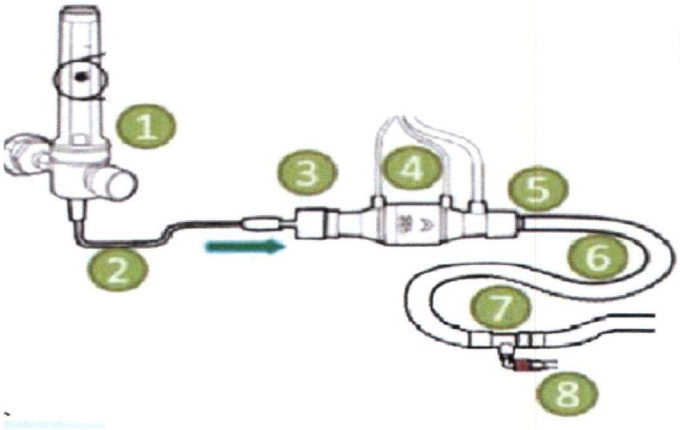


11- Select 1 meter of new ventilator tubing that corresponds with the ventilator connections kit size chosen.

12- Connect the 1m ventilator tubing to the patient (arrow) end of the NOxFlow sensor. Connect the sample line adaptor to the free-end of the ventilator tubing as shown in the diagram below

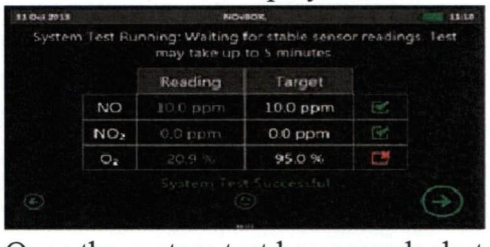


13- Connect the Test Line Assembly to a regulated oxygen supply. Ensure that the valve on each NO supply cylinder is fully open. Set the air flow rate to 10 L/min, and press the Next button on the monitor to initiate the system test



1. O_2 flow meter
2. Oxygen tubing
3. 22F – 4.6mm connector
4. NOxFlow™
5. 10M – 10F, 12M – 12F, 15M – 15F or 22M – 22F luer port connector
6. 1m corrugated tubing (15mm or 22mm)
7. 15M – 15M luer port or 22M – 22F luer port connector
8. NOxBOX sample line

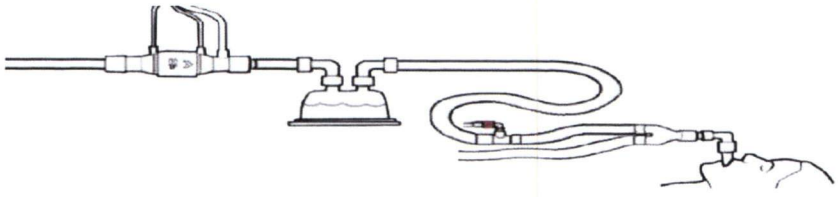
14- A process animation will be displayed as the system performs the system test. During this time the system will deliver NO into the ventilator test line to achieve an equivalent dose of 10ppm. The monitor will display whether the system test was successful or not



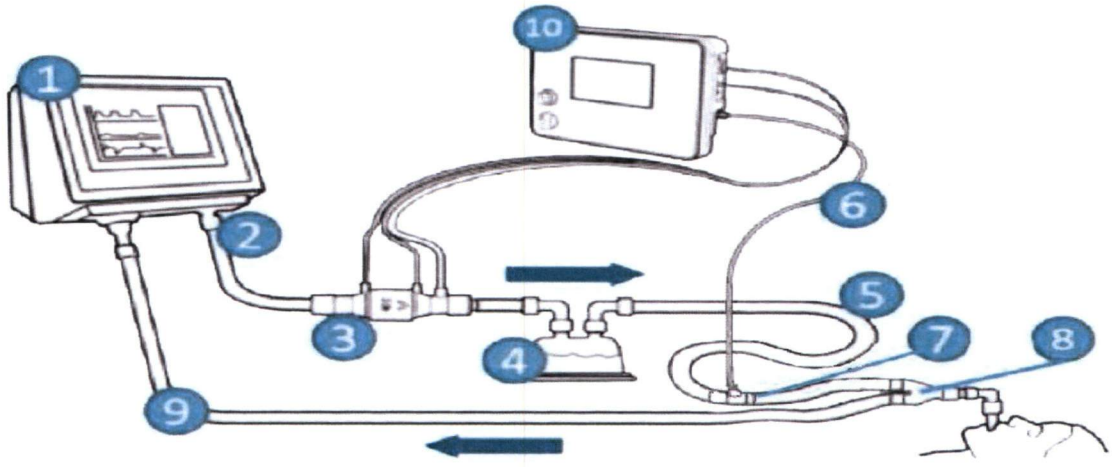
15- Once the system test has passed; shut off the O Assembly from the supply line. The verified Line Assembly is ready to connect into the patient ventilator circuit

16- Connect the NOxBOX to the patient ventilator inspiratory limb (The sample point adaptor should be connected immediately behind the patient Y-piece on the inspiratory limb. To achieve consistent results, place a one-way flutter valve between the sample connector and the Y-piece to prevent contamination of the sample from exhaled breath.

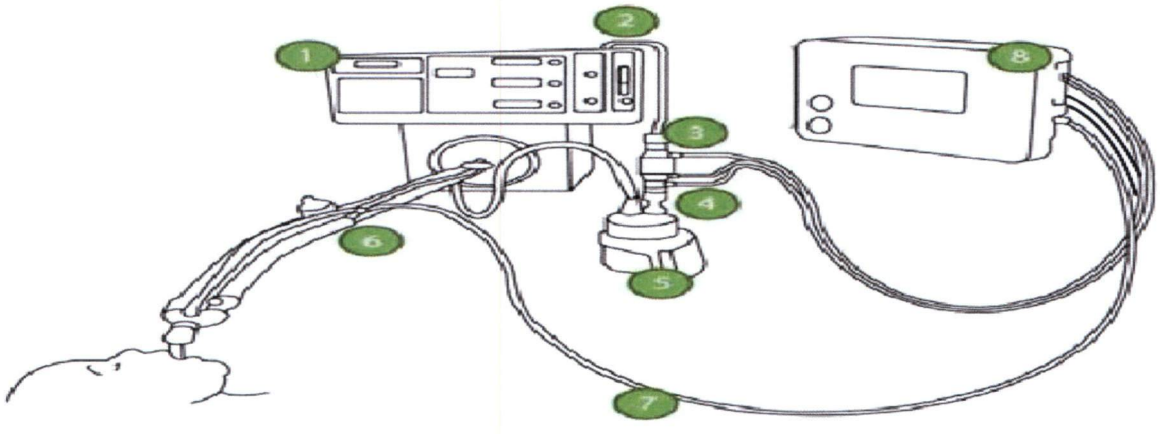
17- Connect the upstream end of the NOxFlow sensor to the upstream inspiratory limb tubing The NOxFlow should be situated upstream of the humidifier



Ventilator inspiratory limb showing NOxFlow placement before humidifier



18- With HFOV



Prince Sultan Military Medical City

مدينة الأمير سلطان الطبية العسكرية

Intensive Care Services

قسم الرعاية التنفسية

Respiratory Care Department

وزارة الدفاع
MINISTRY OF DEFENSE

1) **AeroNox set-Up**:

1.1 Turn power on

1.2 Connect the barbed fitting to standard oxygen tubing.

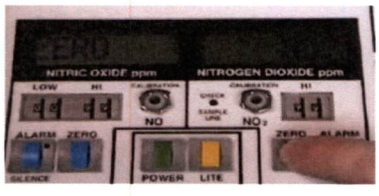
1.3 Run wall O_2 through the calibration circuit at 5 LPM.

1.4 Connect the luer connector of the calibration circuit to the

1.5 Zero both NO and NO_2 sensors:

1.5.1 Zero the NO sensor by depressing and holding the NO zero button down. ZERO NO appears on.

1.5.2 zero the NO_2 sensor by depressing and holding the NO zero button down. ZERO NO2 appears on.



2) **Calibrate NO2 sensor:**

2.1 Disconnect calibration circuit from the AeroNox.

2.2 Disconnect the O_2 and attach NO_2 calibration gas to the calibration circuit.

2.3 Connect the calibration circuit to the AeroNox. As step 1.4.

2.4 Run the NO_2 calibration gas at 0.5 LPM. Re- attach calibration circuit as in step 1.5, allow the NO_2 reading to stabilize for 2-4 minutes. Adjust the NO_2 potentiometer on the front panel with the calibration screwdriver until the reading matches the chemist's reported NO_2 concentration on the NO_2 calibration gas tank.

2.5 Disconnect the NO_2 calibration gas and run oxygen through the calibration circuit at 0.5 LPM until both sensors read zero.

3) **Calibrate NO sensor:**

3.1 Disconnect the O2 and attach NO calibration gas, run the NO calibration gas at 0.5 LPM.

3.2 re-attach the calibration circuit as step 1.4

3.3 Allow the NO reading to stabilize for 2-4 minutes.

3.4 adjust the NO potentiometer on the front panel with the calibration screw driver until the reading matches the chemist's reported NO concentration on the NO calibration gas tank.

3.5 Disconnect the calibration circuit and allow room air to be sampled into the AeroNOx until the NO and NO_2 displays return to zero and oxygen sensor reads 21%.

3.6 (This will flush out any calibration gas remaining in the AeroNox sampling circuit after calibration, this step will help ensure the longevity of the AeroNox sensors)

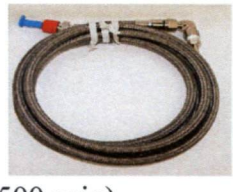
4) Ready to go:

4.1 Attach regulators to 800 ppm NO tanks.

4.2 The AeroNox is calibrated and ready for use.

4.3 Source gas:

4.3.1 Connect metal webbed reinforced high pressure quick-connect port on the AeroNox delivery system.

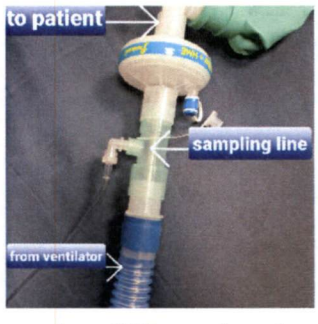


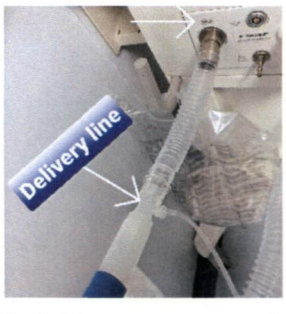
4.3.2 Connect this high pressure nitric delivery hose to the cylinder regulator and attach regulator assembly to the large nitric oxide cylinder

4.4 record NO tank pressure=_____psig (Confirm the tank pressure is greater than 500 psig)

4.5 Connect the Aero Nox delivery system's power cord to an electrical outlet (protected circuit). Confirm the LED screen is illuminated.

4.6 Using the <u>Aero Nox delivery line</u> connect the delivery line to the delivery outlet on the front panel of the Aero Nox delivery system. Connect the other end to the inspiratory inlet of the humidifier (Ventilator side)





4.7 Attach AeroNOx <u>sampling line</u> from AeroNOx to inspiratory limb/ bagger near patient connection.

4.8 (Connect one end of green oxygen tubing (cut to size) to the sampling port of the front panel of the Aero Nox system. Connect the other end to a pressure line adapter at the patient way on the inspiratory limb side.

4.9 Open main cylinder valve

4.10 Switch on the system and set alarm limits

4.11 Connect the patient with iNO through ventilator (Conventional/HFOV)

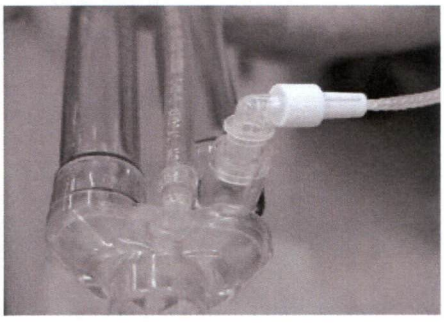
To set up through HFOV:

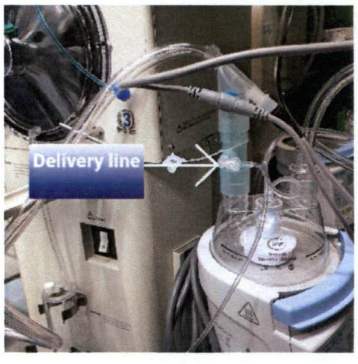
* Connect the Delivery Line immediately post humidifier.

**To connect the sampling line, you will require sample port adapter.

(The port can be placed in "temperature probe ports" in the inspired limb of the flexible circuit.

The Proximal Temperature Probe Port



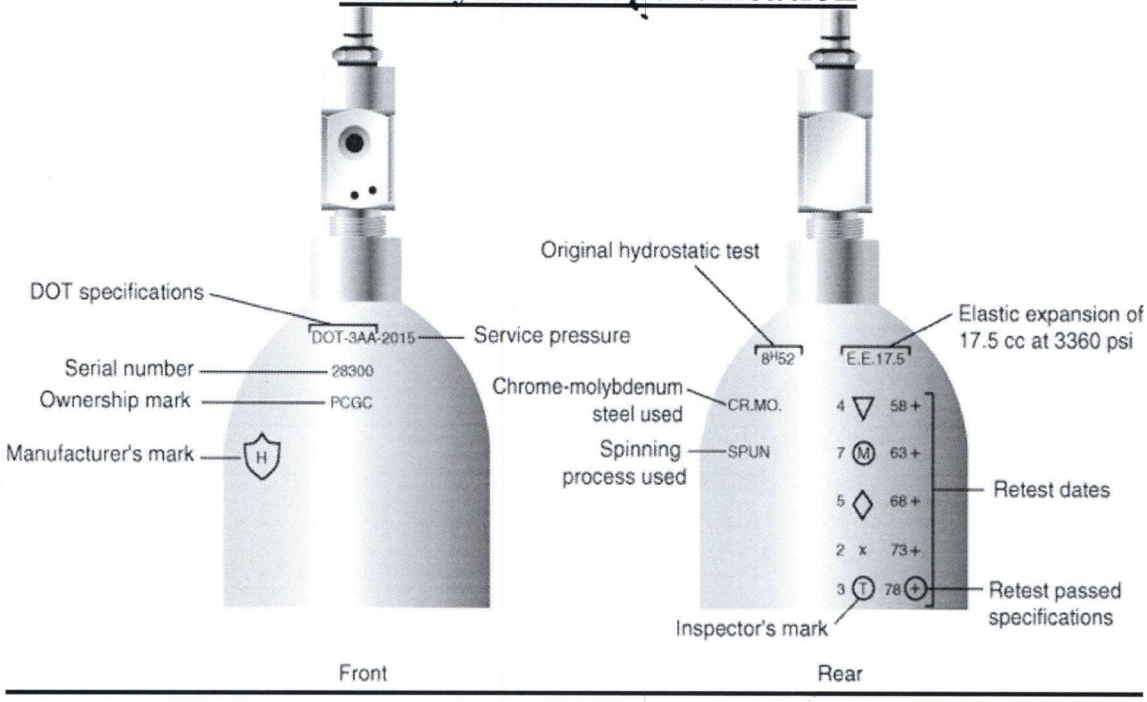


RCD POLICY: Medical Gas Cylinder Identification, Connection & Storage at PSMMC

Appendix: 1

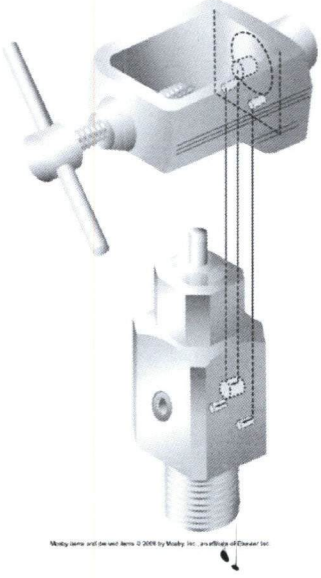
Medical Gases cylinders:

Gas Cylinders Identification

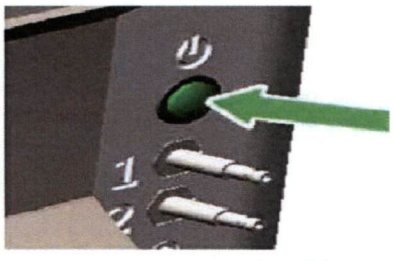


Connection of Medical Gases:

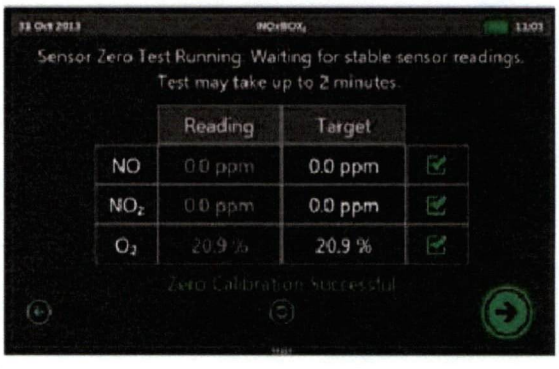
Pin-Index Safety System



1- The manual control valve immediately below this switch should be set appropriately for the patient
2- Power switch at the rear of themonitor. After the power is turned on, the NOxBOX system runs through a start-up procedure. Once complete the system will guide you through system setup

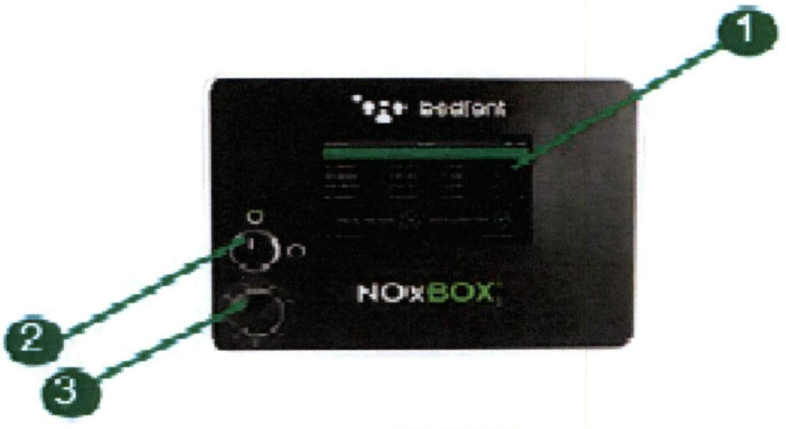


3- As system starts up it will run some self-test procedures to ensure correct function ability. The alarm strip should light up red and the alarm should sound.
4- If the NOxBOX fails to alarm or show the red alarm strip, there is a system fault. Do not use this system for patient treatment as this may result in the system not being able to correctly alert the medical user to an alarm condition during use.
5- The alarm strip and alarm sounder should automatically switch off once the system enters the zero screen. If this does not happen then there is a system fault, do not use the system.
6- Sensor Zero Test: The system performs an automatic sensor zero test to establish a baseline reading for the sensors.
7- Once complete, the system will display whether the zeroing process was successful and proceeds to the home screen.
8- If any sensor fails the test this may indicate an aged or failed sensor. Please try a retest. It is strongly recommended that it be replaced prior to treating a patient as system stability and accuracy will be compromised If the retest fails, call the Service.

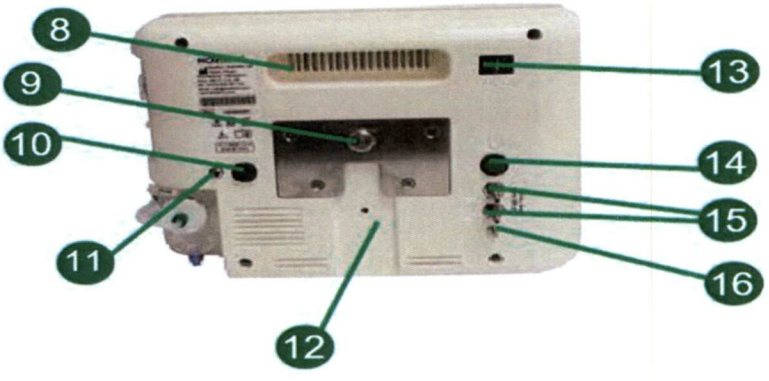


Appendix 1:

iNO setup NOxBOX:



1. Touch Screen Display
2. Mode Selection Valve
3. Manual Override Flow Control Valve



8. Handle
9. Quick Release Button
10. Power Inlet Socket
11. Charging Indicator LED
12. Zero Inlet
13. USB Port
14. Power Button
15. NOxBOXi gas inlets: 4 bar max.
16. Gas Line Purge Needle

1. Ensure that the system trolley brakes are engaged during setup and in use.
2. Insert the monitor end of the power cord into the power socket at the rear of the monitor, and push it in until the locking mechanism clicks.
3. Connect the power supply plug to a hospital-grade electrical outlet that is backed up by an emergency power generator.
4. Secure each cylinder to the trolley using the straps provided.
5. Select the number of available NOxBOX iNO supply cylinders that are being setup on the system (one or two).
6. Ensure that the system is set to intelligent delivery; the mode selection valve should be in the vertical position, as shown here