ANAESTHESIA MACHINE

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**HISTORY OF DEVELOPMENT OF ANAESTHESIA MACHINE**

1772- $\text{N}_2\text{O}$ inhalation through valves in spirometer by Joseph Priestley.

1800- First & simple anaesthetic apparatus used by Sir Humphry Davy - called as Mercurial air holder & breathing machine
Oct 16, 1846 - Morton Inhaler - glass draw over vaporiser
1847 - Ether inhaler designed by Dr John Snow
1862 - The entire Chloroform apparatus of Clover.
1876 - Clover’s apparatus for administration of Nitrous oxide and ether either singly or combined as oxygen & $N_2O$ started coming up in iron bottle.
1912 - Nitrous oxide - oxygen - ether anaesthesia apparatus.
• 1912 - Cotton & Boothby - Perfected apparatus with compressed gas cylinder reducing valve bubble flowmeter.
• 1915-Jackson anaesthesia machine
1917 - H.E.G. Boyle’s & Geoffrey Marshall designed while serving Royal Army Medical Corp, France.

Coxeters built HEG Boyle’s original machine in 1917 which was a modification of the American Gwathmey apparatus of 1912 & became the best known early continuous flow anesthesia machine.
1924 - $CO_2$ filtrate on in to &fro anaesthetic apparatus - Ralph Waters in USA.
1930 - First closed circle anaesthesia machine.
1930 - Coxeter dry gas meter (later on fitted on Boyle’s machine in 1933).

1937 - Connell ball-bearing flowmeter.

1952 - Copper kettle bubble through vaporiser, by Morris - major advance in vaporisation.
Boyles Anaesthesia Machine came into existence in 1927 with combined efforts of James an American & Boyle a British
• The Anesthesia Machine
Anesthesia machine is a device which dispenses a mixture of gases & vapors in varying proportions to control patient’s level of consciousness, analgesia or both during surgical procedures.

Purpose:
1. Provides oxygen,
2. Accurately mixes anesthetic gases & vapors,
3. Enables patient ventilation,
4. Minimizes anesthesia related risks to patients & staff
Components:

The Electrical components:
✔ Master switch: Activates the pneumatic and electric functions.
✔ Power failure indicator
✔ Reserve power
✔ Electrical outlets.
✔ Circuit breakers
✔ Data communication ports

The Pneumatic System:
• High pressure systems
• Intermediate pressure systems
• Low pressure systems
Pressure Division of Machine

✔ High Pressure
  Cylinder - O2: 2000 PSI
  N20: 750 PSI
  Pressure reducing device

✔ Intermediate Pressure
  Cylinder 35 - 50 PSI
  Pipe line 45-60 PSI
  flow meter

✔ Low Pressure
  14 - 20 PSI
**High Pressure System**
- Hanger yoke assembly
- Cylinder Pressure Gauge
- Pressure reducing device

**Intermediate Pressure System**
- Pipeline Connections
- Pipe / Cylinder Pressure Gauge
- Gas power outlet
- Master Switch
- Oxygen Pressure alarms
- Oxygen flush
- Flow Control Valves

**Low Pressure System**
- Flow meters
- Vapourizer circuit central valves
- Back pressure safety devices
- Low pressure pipe line
- Common gas outlet
High Pressure System

Receives gases from the high pressure E or A cylinders attached to the back of the anesthesia machine
(1900 psig for O2, 745 psig for N2O)

Consists of:
- Hanger Yoke (reserve gas cylinder holder)
- Check valve (prevent reverse flow of gas)
- Cylinder Pressure Indicator (Gauge)
- Pressure Reducing Device (Regulator)

Usually not used, unless pipeline gas supply is off
Hanger Yoke Assembly

To Orient and support the cylinder, Provides a gas tight seal

Ensures unidirectional flow of gases to machine parts of yoke

Consists of:

1. Body which is threaded into the frame of machine
2. Retaining screw which tighten the cylinder in the yoke
3. Nipple - through which the gas enters into machine
4. Index Pins to insert correct cylinder
5. Washer to produce a seal between the cylinder valve and yoke valve.
- filter between the cylinder and pressure regulator to prevent particulate matter entry
Pressure gauges

✔ Pipeline gauge - reflect pipeline pressure instead of pressure within the machine

✔ Cylinder gauge - reflect the cylinder pressure.
Pressure Gauge

Components:
Diameter 38 mm
A robust flexible coiled tube in cross section
Tube sealed at inner end and connected to needle pointer
Other end open to gas supply

Safety features:
Colour coded / calibrated
During sudden increase in pressure, gas vents to atmosphere from the back

Bourdon Pressure Guage
Pressure Reducing Device

- Reduces the high and variable pressures found in a cylinder to a lower and more constant pressure found in the anaesthesia machine (45 psig)
- Prevents damage to the machine components
- Reducing devices are preset so that the machine uses only gas from the pipe line (wall gas), when the pipeline inlet pressure is 50 psig.
- This prevents gas use from the cylinder even if the cylinder is left open (i.e. saves the cylinder for backup if the wall gas pipeline fails)
- Physical principle: a large pressure acting over a small area is balanced by a smaller pressure acting over a larger area.
PRESSURE RELIEF VALVE

- Spring loaded device.
- Each cylinder valve has a safety relief device prevents bursting of cylinder.
- Gas escapes through it to atmosphere, recloses after normal pressure is achieved.
- Set pressure at which it will escape is marked on the valve.
- In air, helium, oxygen, nitrogen cylinders up to 500 psig pressure relief device is present.
Pressure Relief Devices

- **Rupture Disc (Rated burst pressure)**
  - Non-reclosing device with a disc against an orifice
  - Disc ruptures if predetermined pressure is reached
  - Protects against excess pressure as a result of high temperature or overfilling

- **Fusible Plug (Yield temperature)**
  - Thermally operated
  - Protects from excessive pressure caused by high temperature.
  - Made of brass or bronze with alloy, yield temp: 70-74 deg C (158 - 165deg F)
Pressure Regulator

Purpose:
To deliver gases at constant pressure to patient and maintain constant flow

Types:
1. Pneumatic balance
2. Demand valve
   a. fixed pressure
   b. adjustable spring pressure

Force = Pressure × Area

\[ P_c \times A_1 = P_r \times A_2 \]
\[ P_c / P_r = A_2 / A_1 \]

Oxygen: 2200 psig to 45 psig
Nitrous Oxide: 750 psig to 45 psig
Pressure Regulators

Direct acting

cylinder pressure tends to open the valve

Indirect acting

cylinder pressure tends to close the valve
Direct acting pressure regulators
Intermediate pressure systems

- Pipeline Inlet Connections
- Pipeline pressure indicator
- Low pressure tubing
- Master switch - pneumatic & electronic
  - Oxygen pressure failure device
  - Oxygen failure safety device
  - Oxygen supply failure alarm
- Oxygen flush device
- Gas selector switch
- Gas power outlet
- Second stage reducing valve
- Flow control valve
Central Pipelines & Connections

parts to which the oxygen flows in the intermediate pressure system

• Oxygen flush valve
• Oxygen supply failure alarm system
• Oxygen failure safety device (Fail safe valve, Pressure sensor shut off valve, Oxygen failure protection device)
• Flow control valve
**Oxygen Flush Valve (O2+)**

- Receives O2 from pipeline inlet or cylinder pressure regulator and directs high, unmetered flow to the common gas outlet (downstream of the vaporizer)
- Bypasses the flowmeters and vaporizers
- Machine standard requires the flow to be between **35 and 75 L/min**
- Single purpose, for oxygen only; self-closing device.
- A protective rim reduces the possibility of unintentional activation
- Labelled “O2 +”

**Hazards**

- May cause barotrauma
- Dilution of inhaled anesthetic
- Accidental activation
- Internal leakage
- Flush may stick
Oxygen flush valve
Oxygen failure alarm

O2 pressurizes an O2 failure alarm system

Drop of pressure below 30 psig - an alarm sounds

Emits an audible alarm for at least 7 seconds when the pressure falls below threshold

In some machines, a continuous audible alarm rings whenever the O2 supply pressure falls below the threshold setting
**Oxygen Pressure Failure Protection**

**Oxygen fail safe device** ensures that:
"Whenever oxygen pressure reduces and until flow ceases, the set oxygen concentration shall not decrease at the common gas outlet"

Misnomer - it's not fail-safe

Controlled by oxygen supply pressure

Interrupts the supplies of N2O and other gases to their flowmeters if the O2 supply pressure to the machine is reduced

In addition, the loss of oxygen pressure results in alarms, audible and visible

Fail-safe systems *don't prevent hypoxic mixtures*, which is a function of Hypoxic Guards
Oxygen failure safety device

A: Normal function

B: $\text{N}_2\text{O}$ cut off due to oxygen pressure failure ($< 20$ psig)
Pressure sensor shut off valve:
At 20 psi oxygen, the flow of all other gases are shut off

Oxygen failure protection device (OFPD):
Flow is reduced proportionally

Second-stage O2 pressure regulator:
Ensures constant oxygen flowmeter input until supply pressure is less than 12-16 psi

Oxygen ratio monitor controller (ORMC):
It shuts off nitrous oxide when oxygen pressure is less than 10 psi
Oxygen Failure Protection Device (OFPD)

It interfaces the pressure in the high pressure system for O2 with that in the high pressure system for N2O.

A decrease in O2 pressure causes a proportionate decrease in the supply pressure of N2O.

Proportionally reduce and ultimately interrupt the supplies of N2O if O2 supply pressure is reduced.

The supply of N2O and other gases is completely interrupted when the pressure in the O2 high pressure system falls below 12 psig.

Present in Drager machines.
Oxygen Ratio Monitor Controller (ORMC)

Limits the N2O flow according to the O2 flow & create a mixture of at least 25% O2 at the flowmeter level.

It is a pneumatic O2-N2O interlock system designed to maintain a fresh gas oxygen concentration of at least 25%.

At O2 flow rates of less than 1 L/min, even higher concentrations of O2 are delivered.

Present in Drager machines
2nd stage pressure regulator

Regulates the O2 supply pressure to the flowmeter to **14 psi**

Just upstream to the flow meter assembly

This ensures a constant supply pressure to the flowmeter

Present in Ohmeda machines, Not present in Dräger machine because the OFPD performs this function
Flow control valve

- Current standard requires that there be only one flow control valve for each gas. It must be adjusted or identifiable with its flow indicator.
- Body - screws into the anaesthesia machine
- Stem and Seat - have fine threads,
  - when valve is closed the pin at the end of the stem fits into the seat, occluding the orifice.
  - when stem is turned outward an opening between pin and stem is created allowing gas to flow.
- Flow control knob
- Touch coded.
- Color coded.
- Joined to stem.
  It should be large enough so that it can be turned easily.
Flow control knob for O2 must have fluted profile
Oxygen knob should be bigger
Interknob distance is 2.5cm
Low pressure systems

- Flow indicators
- Hypoxia prevention safety devices
- Unidirectional (check) valve
- Pressure relief device
- Low pressure piping
- Vaporizer mounting devices
- Common (fresh) gas outlet
Flowmeters
(Flow indicators/Rotameters/Flow tubes)

• Indicate the rate of flow of a gas passing through them

• May be:
  • Mechanical
  • Electronic

• Measuring gas flow in a mechanical flowmeter is based on the principle that flow past a resistance is proportional to pressure

• Mechanical flowmeters measure the drop in pressure that occurs when a gas passes through a resistance
**Principle of working:**

- Float is buoyed by flowing gas that passes between the float and walls of the tube.
- Narrowing of cross sectional area at the float creates resistance to flow and causes pressure drop.
- Float will settle where the force represented by pressure difference multiplied by cross section area equals to gravity.
Physical principles

- **Pressure drop across the constriction**
  As gas flows around the indicator, it encounters frictional resistance between the indicator and the tube wall. The loss of energy is reflected in a pressure drop.

  This pressure drop is constant for all positions in the tube and is equal to the weight of the float divided by its cross-sectional area.

- **Size of the annular opening**
  In the variable orifice flowmeter, the annular cross-sectional area varies while the pressure drop across the indicator remains constant for all positions in the tube.

  So these are called constant-pressure flowmeters.

  Increasing the flow does not increase the pressure drop but causes the indicator to rise to a higher position in the tube, thereby providing greater flow area for the gas.

  The elevation of the indicator is a measure of the flow.
Physical properties of the gas

- When a low gas flow passes through the tube, the annular opening between the float and the wall of the tube will be narrow. As flow increases, the annular opening becomes larger.

- With a longer and narrower constriction (low flows), flow is laminar and is a function of the viscosity of the gas (Hagen-Poiseuille equation).

- When the constriction is shorter and wider (high flows), flow is more turbulent and depends on gas density (Graham's law).
Temperature and pressure effects

- Flowmeters are calibrated at atmospheric pressure (760 torr) and room temperature (20°C).
- Temperature and pressure changes will affect both the viscosity and the density of a gas and so influence the accuracy of the indicated flow rate.
- Variations in temperature as a rule are slight and do not produce significant changes.
- In a hyperbaric chamber, a flowmeter will deliver less gas than indicated.
- With decreased barometric pressure (increased altitude), the actual flow rate will be greater than that indicated.
- The following equation can be used to derive an approximate correction factor for changes in atmospheric pressure:

\[ F'_1 = F_0 \times \frac{d_o}{d_1} \]

where

- \( F'_1 \) is the flow at ambient pressure,
- \( F_0 \) is the flow indicated on the scale calibrated at sea level,
- \( d_o \) is the density of the gas at sea level, and
- \( d_1 \) is the density of gas at ambient pressure.
Flowmeter assembly

- Tube
- Indicator
- Stop
- Scale

- Lights are available on most machines to allow them to be observed in a dark room.
- Marked with the appropriate color and name or chemical symbol of the gas measured.
- The flowmeter assembly empties into a common manifold that delivers the measured amount of gases into the low pressure system.
Flowmeter tube

Usually made of glass

Those intended for a ball indicator have rib guides (hold the ball indicator in the center of the tube)

As the tube widens, the space between the indicator and the inside of the tube increases

The flowmeter tube can have a single or double taper

• Single-taper tubes have a gradual increase in diameter from the bottom to the top (used where there are different tubes for low and high flow)

• Dual-taper flowmeter tubes have two different tapers on the inside of the same tube—one corresponding to fine flows and one for coarse flows (used when only one tube is used for a gas)
Indicator (Float/Bobbin)

Free-moving device within the tube

- The nonrotating float-type indicator - gas flow keeps the float in the center of the tube if the tube is kept vertical. The reading is taken at the upper rim.

- Rotating indicators (rotameters) have an upper rim of which the diameter is larger than that of the body. Slanted grooves, or flutes, are cut into the rim. There is often a colored dot on one side. When gas passes between the rim and the tube wall, the flutes cause the indicator to rotate. If the tube is vertical, the free spinning maintains the float in the center of the tube. Deviations from the vertical position will result in the rotor striking the side of the tube. The reading is taken at the upper rim.

- With a ball indicator the reading is taken at the ball's midpoint. The ball is kept in the center of the tube by rib guides. Rotation is evidence that gas is flowing and the indicator is not stuck.
Stop
Located at the top of the flowmeter

prevents the indicator from plugging the outlet, which could lead to damage to the tube

prevents the indicator from ascending to a point in the tube where it cannot be seen

Broken stop may fell into the tube, its descent may cause the indicator to register less flow than is actually occurring
Flowmeter Tube Arrangement

Tubes for different gases are grouped side by side.

The various gas flows meet at the common manifold (mixing chamber) at the top.

Sometimes, there are two flowmeters for the same gas: One for low and one for high flows. The tubes are arranged in series (tandem).

There is one flow control valve for the both flowmeter tubes. Gas from the flow control valve first passes through a tube calibrated up to 1 L/minute, then passes to a second tube that is calibrated for higher flows.

The total flow is not the sum of the two tubes but that shown on the higher flow tube.

Series flowmeter tubes offer increased accuracy.
Flowmeter tube sequence can be a cause of hypoxia. Normal gas flow is from bottom to top in each tube and then from left to right at the top.

In Figure A/B, a leak is shown in the unused air flowmeter, showing potentially dangerous arrangements because the nitrous oxide flowmeter is located in the downstream position. A substantial portion of oxygen flow passes through the leak while all the nitrous oxide is directed to the common gas outlet.

Safer configurations are shown in Figure C/D. By placing the oxygen flowmeter nearest the manifold outlet, a leak upstream from the oxygen results in loss of nitrous oxide rather than oxygen.
workstation standard requires that the oxygen flowmeter be placed on the right side of a group of flowmeter as viewed from the front.

There is no consensus on the location of the air or nitrous oxide flowmeters as long as they do not occupy the location next to the manifold outlet.
Auxiliary Oxygen Flowmeter

- Self-contained flowmeter with its own flow control valve, flow indicator, and outlet

- Has a short tube with a maximum flow of 10L/minute and a barbed fitting on the outlet

- Usually mounted on the left side of the machine

- This can be used to supply oxygen to the patient without turning ON the anesthesia machine

- On some older machines, this flowmeter will work only on pipeline gas. On newer machines, it will work on both cylinder and pipeline supplies.
Problems with Flowmeters

• Inaccuracy
  The tube assembly calibrated for one gas cannot be used for a different gas

• Indicator Problems
  Damage to the flow indicator can result from a sudden projection to the top of the tube when a cylinder is opened or a pipeline hose is connected with the flow control valve open

• Leaks
  A leak in a flowmeter downstream of the indicator result in a lower than expected concentration of that gas in the fresh gas
  A leak may occur if a flow control valve is left open and there is no cylinder or yoke plug in the yoke

• Using the Wrong Flowmeter
  The problem most likely occur between air and nitrous oxide, as the position of oxygen is generally fixed by national standards.
**Hypoxia Preventing Devices**

- **Mandatory minimum oxygen flow**
  Some anesthesia machines require a minimum (50 to 250 mL/minute) flow of oxygen before other gases will flow.
  The minimum oxygen flow does not in itself prevent a hypoxic gas concentration from being delivered.

- **Minimum oxygen ratio device**
  Prevents delivery of mixture of gases with oxygen less than 21%.

- **Link Device**
  1. Mechanical linkage
  2. Electronic linkage
- **Proportioning device (Link 25)**
  - A gear with 14 teeth is integral with the N2O flow control spindle
  - A gear with 29 teeth “floats” on a threaded O2 flow control valve spindle
  - The two gears are connected by a precision link chain
  - For every 2.07 revolutions of the N2O flow control spindle, an O2 flow control, set to the lowest O2 flow, rotates once because of the 14:29 ratio of the gear teeth

- **Electronic Linkage**
  - An electronic proportioning valve controls the oxygen concentration in the fresh gas
  - If the nitrous oxide flow control valve is opened sufficiently to cause a flow higher than the maximum allowable, the proportioning valve reduces the nitrous oxide flow to supply a minimum of 25% oxygen.
Unidirectional (Check) Valve

• When ventilation is controlled or assisted, positive pressure from the breathing system can be transmitted back into the machine; Using the oxygen flush valve may also create a positive back pressure.

• This pressure can affect flowmeter readings and the concentration of volatile anesthetic agents delivered from the vaporizers on the machine.

• Unidirectional (check) valve minimize these effects.

• This valve is located between the vaporizers and the common gas outlet, upstream of where the oxygen flush flow joins the fresh gas flow.

• This valve will lessen the pressure increase but not prevent it, because gas will be continually flowing from the flowmeters.

• Testing the breathing system for leaks will not detect a leak upstream of the check valve in a machine equipped with a check valve.
• **Pressure Relief Device**
  • Located near the common gas outlet to protect the machine from high pressures.
  • This valve opens to atmosphere and vents gas to atmosphere if a preset pressure is exceeded.

• **Common (Fresh) Gas Outlet**
  • Receives all of the gases and vapors from the machine and delivers the mixture to the breathing system.
  • Some outlets have a 15-mm female slip-joint fitting (that will accept a tracheal tube connector), with a coaxial 22-mm male connector.
  • Because the common gas outlet is a common location for a disconnection, the machine standard mandates that it be difficult to accidentally disengage the delivery hose from the outlet.
  • The fresh gas supply tube, which conveys gas to the fresh gas inlet in the breathing system, attaches to the common gas outlet.
Alternative Oxygen Control

When using an anesthesia machine electronics may fail.

Some machines provide an alternative means to administer oxygen.

This is separate from the auxiliary (courtesy) flowmeter.
Safety Features of Anaesthesia Machine

Bulk storage / pipe line supply:
• Indicators system / Service area alarms
• Shut off valves
• Gas specific wall outlets

Cylinders:
• DISS for large cylinders
• PISS for small cylinders
• Relief valves – woods metal
• Color coding of cylinder
High pressure system:
- Pressure regulating valves
- Pressure relief valves

Intermediate pressure system:
- Gauges of manometer
- Low oxygen pressure cut off systems

Low pressure systems:
Flow meters
- Placement of knobs at distance
- Down stream placement of knob
- Back light display
- Link devices
- Back pressure check valves
- Audible alarms etc
Vapourizers
- Construction of advanced Tec series
- Bimetallic strip for temp. compensation
- Colour coded Key filling system

Miscellaneous
- Antistatic wheels

This list is by no means exhaustive and newer anaesthesia machines have added lots of new features to enhance the safety.
Newer Safety Features

• Reduced external connections: internal modular or manifold
• Electronic control and measurement of vaporization (Anaesthesia delivery units)
• Automated checkout and monitoring
• Streamlined communication with information management systems (IMS)
Safety mechanisms in anaesthesia machine for not to deliver a hypoxic mixture

• Oxygen pressure failure device
  - Oxygen failure safety device
  - Oxygen supply failure alarm
• Safety devices
  - Mandatory minimum oxygen flow - a stop or a resistor
  - Minimum oxygen ratio device
• Mechanical linkage
• Pneumatic linkage
• Electronic linkage
• Oxygen analyzer
Hypoxic breathing is possible

Hypoxic guard systems can permit hypoxic breathing mixtures if:
- Wrong supply gas in oxygen pipeline or cylinder.
- Defective pneumatic or mechanical components.
- Leaks exist downstream of flow control valves.
- If third inert gas (such as helium) is used
American Society of Anesthesiologists Guidelines for Determining Anesthesia Machine Obsolescence

Absolute Criteria
1. Lack of Essential Safety Features

- Minimum oxygen ratio device ($O_2/N_2O$ proportioning system) on a machine that can deliver nitrous oxide
- Oxygen supply pressure failure alarm
- Oxygen failure safety (“fail-safe”) device
- Vaporizer interlock device
- Pin Index Safety System
- Noninterchangeable, gas-specific (e.g., Diameter Index Safety System [DISS]) connectors on the gas pipeline inlets
2. Presence of Unacceptable Features

- Measured flow (flowmeter-controlled) vaporizers
- More than one flow control knob for a single gas delivered to the common gas outlet of the machine
- Vaporizer with rotary concentration dial such that the anesthetic vapor concentration increases when the dial is turned clockwise
- Connection(s) in scavenging system of the same (i.e., 15 mm or 22 mm) diameter as a breathing system connection
3. Adequate Maintenance No Longer Possible

- when the manufacturer or certified service personnel will not or cannot service the machine
- When obtaining acceptable replacement parts can be a problem
Relative Criteria
Consideration should be given to replacing an anesthesia machine if any of the following apply:
1. Lack of Certain Safety Features

- Means to isolate the APL (adjustable pressure limiting) valve during mechanical ventilation
- Oxygen flow control knob that is fluted and larger than the other flow control knobs
- Oxygen flush control protected from accidental activation
- Main ON/OFF switch for electrical power to integral monitors and alarms
- Antidisconnection device at the fresh gas outlet
- Airway pressure alarm (for detecting sustained positive pressure, negative pressure, and high peak pressure)
2. Problems with Maintenance

The maintenance history indicates that problems with the machine (e.g., increasing frequency of service calls, machine frequently not available for use)
3. Potential for Human Error

4. Differences between older and newer machines can be a source of confusion and error if certain features (e.g., automatic activation of monitors and alarms by a main ON-OFF switch) are present on some machines but not on others or are in different locations on the machines.
5. Inability to Meet Practice Needs

- The machine cannot accept vaporizers for newer potent inhaled volatile agents.
- The machine cannot deliver fresh gas flows that are low enough for current anesthetic techniques.
- The integral anesthesia ventilator is incapable of safely and effectively ventilating the lungs.
Anaesthesia machine testing and safety features

Regardless of the level of training and support by technicians, the anesthesiologist is ultimately responsible for proper functioning of all equipment used to provide anesthesia care.
when to do-

Every day before administering anaesthesia to the first patient

Whenever any change has been made to the system
Moving the machine even within the OT

A short checkout of the breathing system should precede each administration of an anesthetic
1. Verify backup ventilation equipment is available and functioning e.g. properly functioning manual resuscitator.

2. Check the oxygen cylinder supply
   • Open O2 cylinder and verify it is at least half full (about 1000 psi).
   • Close cylinder.
   • Check Central Pipeline Supplies
     a. Check that hoses are connected and pipeline gauges read about 50 psi.
3. Verify patient suction is adequate to clear the airway Prior to each use

4. Low pressure system; initial status
   a. Close flow control valves and turn vaporizer off
   b. Check fill level and tighten vaporizers’ filler caps

5. Leak check; Low pressure system
   a. Verify that the machine master switch and flow control valves are OFF
   b. Attach “suction bulb” to common (fresh gas) outlet
   c. Squeeze bulb repeatedly until fully collapsed
   d. Verify bulb stays fully collapsed for at least 10 seconds
   e. Open one vaporizer at a time and repeat steps c and d
   f. Remove suction bulb, and reconnect fresh gas hose
6. Turn on the Master switch

7. Test Flowmeters
   a. Check flow of all gases through their full range, for smooth operation of floats and undamaged flow tubes
   b. Attempt to create a hypoxic O₂/N₂O mixture by turning N₂O knob and verify correct changes in flow and/or alarm

8. Check scavenging system
   a. Ensure proper connections between scavenging system and both APL (pop-off) valve and ventilator relief valve
   b. Fully open APL valve and occlude Y-piece
   c. With minimum O₂ flow, allow scavenger reservoir bag to collapse completely and verify that absorber pressure gauge reads about zero
   d. With O₂ flush activated, allow the scavenger reservoir bag to distend fully, then verify that absorber gauge reads < 10 cmH₂O
9. Calibrate Oxygen monitor
   a. Ensure monitor reads 21% in room air
   b. Verify low O2 alarm is enabled and functioning
   c. Re-install sensor in circuit and flush breathing system with O2
   d. Verify that monitor now reads greater than 90%

10. Check breathing system
    a. Set selector switch to “bag” mode
    b. Check that breathing circuit is complete, undamaged and unobstructed
    c. Verify that CO2 absorbent is adequate
    d. Install breathing circuit accessory equipment(e.g. humidifier) to be used during the case
11. Breathing system; leak check

a. Set all gas flows to zero (or minimum)
b. Close APL (pop-off) valve and occlude Y-piece
c. Pressurize breathing system to about 30 cmH2O with O2 flush
d. Ensure that pressure remains fixed for at least 10 sec
e. Open APL (pop-off) valve and ensure that pressure decreases

If the bulb reinflates in less than 10 seconds, a leak is present somewhere in the lowpressure circuit

This test detects leaks as small as 30 mL/mins
12. Ventilation system & Unidirectional valves

a. Set appropriate ventilator parameters for the patient
b. Switch to automatic ventilation (ventilator) mode
c. Fill bellows and breathing bag with O2 flush and then turn ventilator ON
d. Set O2 flow to minimum, other gas flows to zero
e. Set O2 flow to minimum, N2O to zero
f. Verify that during inspiration bellows delivers appropriate tidal volume and that during expiration bellows fill completely
g. Set fresh gas flow to about 5L/min
h. Verify that the ventilator bellows and simulated lungs fill and empty appropriately without sustained pressure at end expiration
i. Check for proper action of unidirectional valves

j. Turn ventilator OFF and switch to manual ventilation mode

k. Ventilate manually and assure inflation and deflation of artificial lungs and appropriate feel of system resistance and compliance
13. Set Alarm limits of monitors

- Capnometer
- Oxygen Analyzer
- Pressure Monitor with high and low airway alarms
- Pulse Oximeter

14. Check Final status of the machine

a. Vaporizers off
b. APL valve open
c. Selector switch to “bag”
d. All flowmeters to zero
e. Patients suction level adequate
f. Breathing system ready to use
15. Document completion of checkout procedures prior to each use

Just before starting the case -

Confirm ventilator settings and evaluate readiness to deliver anesthesia care

Immediately prior to initiating the anaesthetic equipment
Steps 1 to 9

1: Verify backup ventilation equipment is available and functioning
2: Check oxygen cylinder supply
3: Check central pipe line supplies
4: Check initial status of low pressure system
5: Perform leak check of machine low pressure system
6: Turn on machine master switch and all necessary electrical equipment
7: Test flowmeters
8: Adjust and check scavenging system
9: Calibrate O2 Monitor
Thank You.....