Medical Gases

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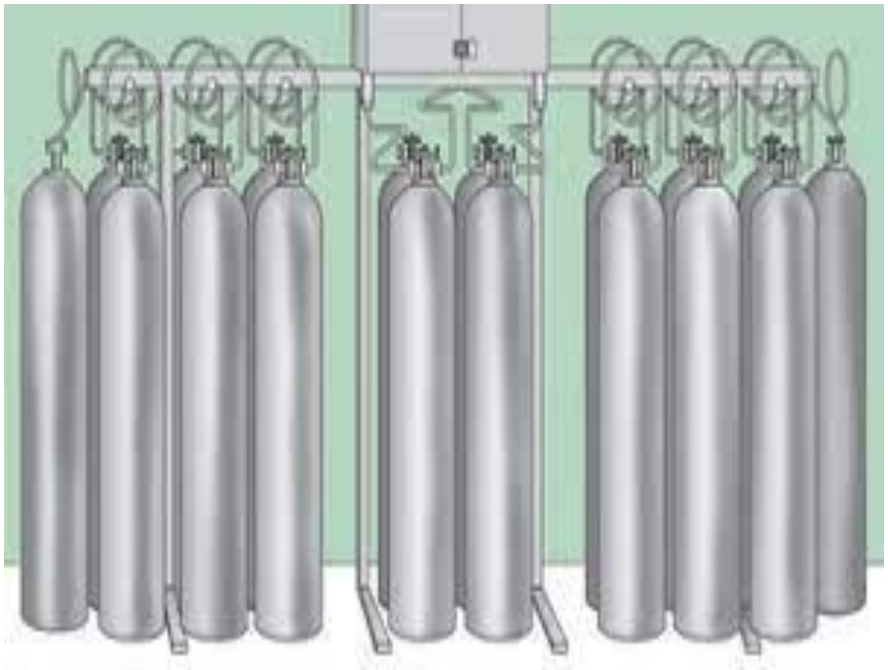
Gas supply: takes the form of either:

1-Cylinders

2-Piped gas system

Piped gas system

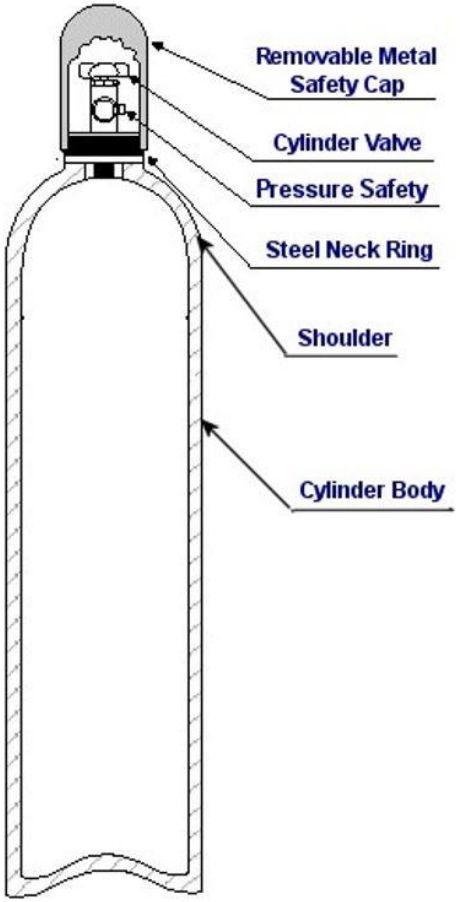
Bank of cylinders



Liquid Oxygen supply system

components of Medical gas cylinders

1. Removable metal safety cap.
2. Cylinder valve.
3. Safety pressure relief valve.
4. Steel neck ring.
5. Shoulders.
6. Cylinder body.



Removable metal cap

The body of the Cylinders

- ***Is made of seamless molybdenum steel.***
- ***It should be Rechecked every 5 years for testing tensile strength and the date of the check-up is marked with a label over the shoulder.***

The shoulder

Carries a label includes the following details :

1. ***Name ,chemical symbol , license , number and proportion of mixture.***
2. ***Batch number.***
3. ***Hazard warning and safety instructions.***
4. ***Cylinder size code.***
5. ***Cylinder content (liter).***
6. ***Maximum pressure (bars)***
7. ***Filling date , shelf life and expiry date.***
8. ***Directions for use.***
9. ***Storage and handling precaution.***

Cylinder label

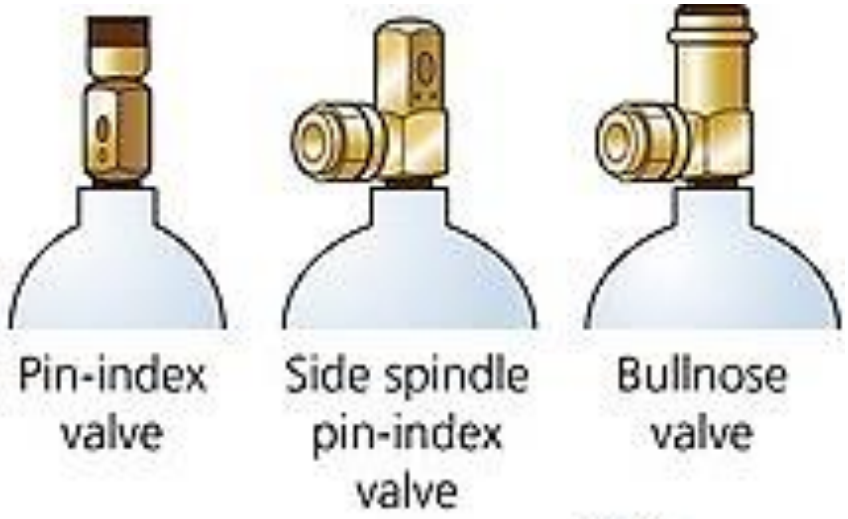
The neck

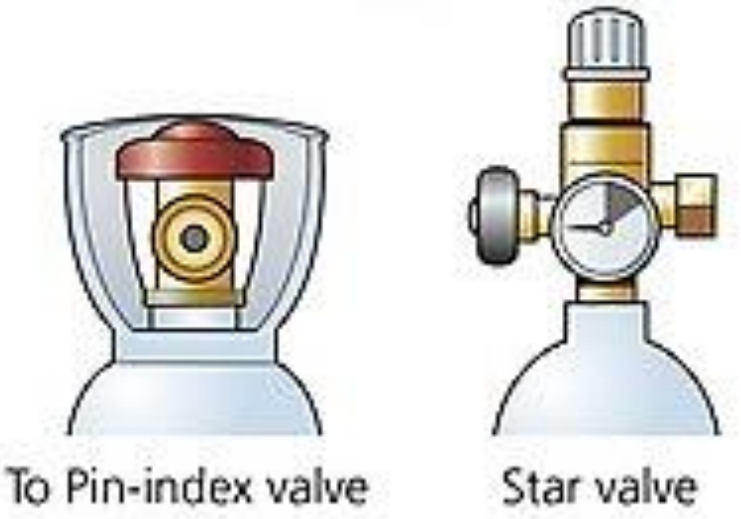
- *Ends in a tapered screw thread into which the valve is fitted .*
- *The thread is sealed with a material that melt when the cylinder is exposed to intense heat, allowing the gas to escape and reducing the risk of explosion.*

The neck

Cylinder valve

1. *Seals the cylinder content.*
2. *The chemical formula of the particular gas is engraved on it.*
3. *Have different types)the bullnose ,the hand wheel and the star) used in different circumstances.*





Valve types

Types of Cylinder valve

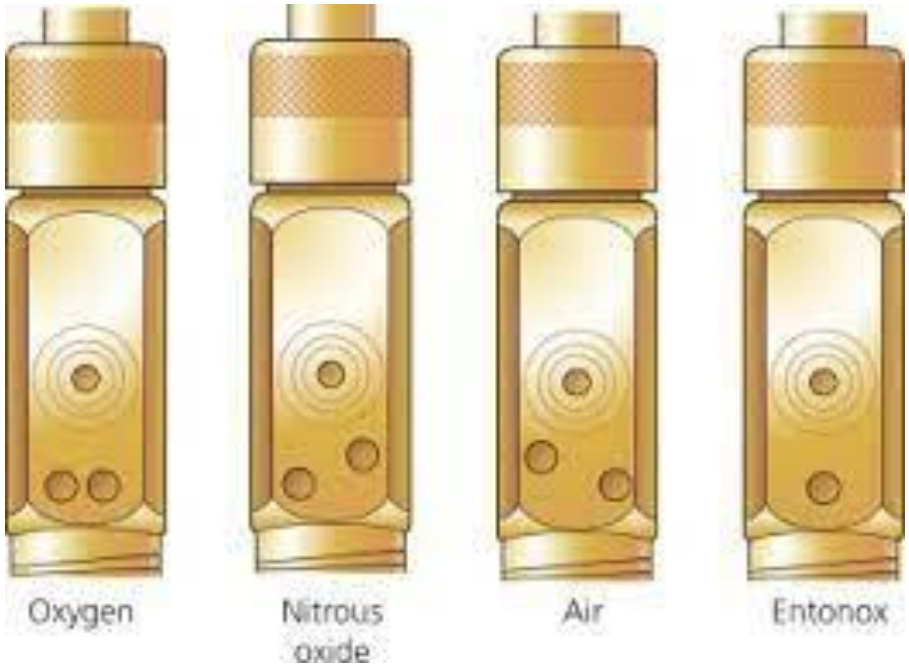
Components of gas cylinder valves

1. An On/off spindle to open and close the valve.
2. Exit port for supplying gas to the medical apparatus (e.g. anesthetic machine).
3. A safety relief valve to discharge excess contents to atmosphere if the cylinder is over pressurized.
4. A non-interchangeable safety system(e.g. pin index system) is used on small size cylinders

(E ,F or even G) to prevent wrong gas connection.

Pin index system

Pin index valves



Yoke on the anesthetic machine

The yoke

PROBLEMS IN PRACTICE AND SAFETY FEATURES OF CYLINDER VALVES

1. *The exit port of cylinder valves may be occluded by dust , grease or dirt ,thus the plastic wrapping of the valve should me removed just before use or the valve must be slightly opened and closed before connecting to the anesthetic machine.*
2. *The valve should be opened slowly to avoid rapid rise in the pressure and thus temperature of the gas in the machines pipelines, then fully opened (2 full revolutions).*
3. *Avoid over tightening of the valve.*
4. *Check Bodok seal for damage and have spare one.*

BODOK SEAL /WASHER
FOR PIN INDEX REGULATOR

Cylinder sizes

Cylinders are manufactured in different sizes (from A to J).

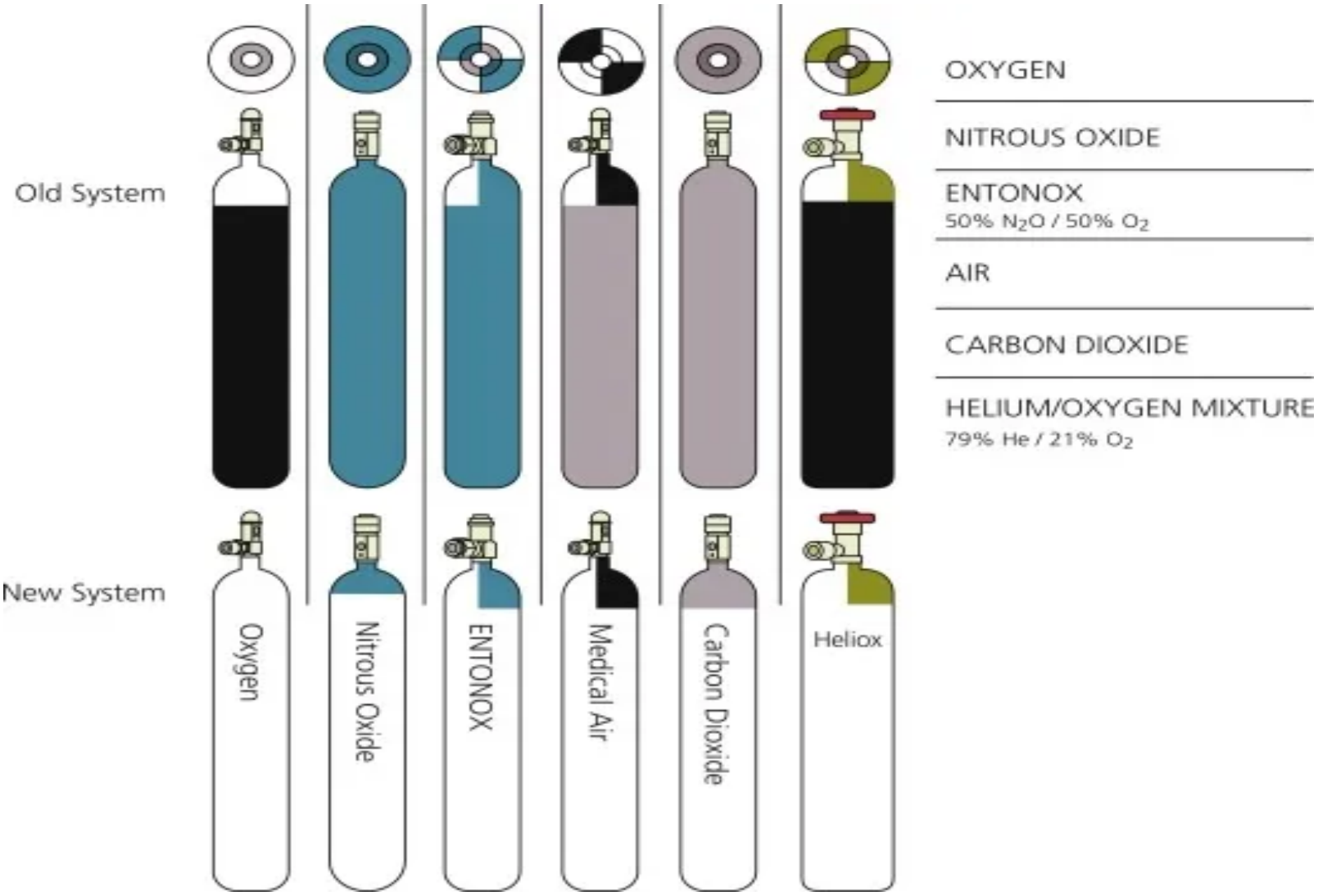
Sizes A & H are not used for medical gases.

Size (E) cylinders are usually attached to the anesthetic machine.

- *Size (J) cylinders are commonly used for cylinder manifolds.*
- *Size (E) oxygen cylinders contain 680 L, whereas*
- *Size (E) nitrous oxide release 1800 L.*
- *Size (C) is the smallest size and can hold 1.2 L water.*
- *Size (E) can hold 4.7 L ,while*
- *Size (J) can hold 47.2L*

Dimension Ht./ Full wt.	0.2 m 2.3 kg	0.5 m 3.9 kg	0.8 m 6.5 kg	1.3 m 39 kg	1.5 m 78 kg
O2 capacity at 137 bar	300 L	400 L	680 L	3400 L	6800 L
Water capacity	1.5 L	2.9 L	4.7 L	23.6 L	47.2 L

Medical gas cylinders color codes



Medical gas cylinders new color codes

Example :

1. *Oxygen cylinders have White body and shoulder .*
2. *Nitrous oxide cylinders have White body and Blue shoulder .*
3. *CO2 cylinders have White body and Grey shoulder .*
4. *Entonox (50% oxygen and 50% nitrous oxide) cylinders have White body and Blue/White quarters shoulder.*
5. *Medical air cylinders have White body and White/Black quarters shoulder.*

British system

Color coding

GAS	SHOULDER	BODY
OXYGEN	WHITE	BLACK
NITROUS OXIDE	BLUE	BLUE
CYCLOPROPANE	ORANGE	ORANGE
CARBON DI OXIDE	GREY	GREY
AIR	WHITE	GREY
NITROGEN	BLACK	BLACK
ENTONOX	WHITE	BLUE

Color Coding of Gas Cylinders

Gas	USA	ISO*
Oxygen (O_2)	GREEN	WHITE
Air	YELLOW/SILVER	WHITE/BLACK
Carbon dioxide (CO_2)	GRAY	GRAY
CO_2 and O_2	GRAY/GREEN	GRAY/WHITE
Helium (He)	BROWN	BROWN
He and O_2	BROWN/GREEN	BROWN/WHITE
Nitrous Oxide (N_2O)	BLUE	BLUE
Cyclopropane (C_3H_6)	ORANGE	ORANGE
Ethylene (C_2H_4)	RED	VIOLET
Nitrogen	BLACK	BLACK

Light weight cylinders

These are made from aluminum alloy with a fiberglass covering in epoxy resin matrix.

These can be used to provide O2 at home, during transport or in MRI scanner.

Basic physics

- ***Critical temperature**: of a substance is the temperature above which the substance can not be liquefied whatever pressure is applied. Critical temp. of Nitrous oxide and Oxygen are:*

  (36.5◦C and -118◦C) respectively.

- ***Gas**: exists in the gaseous state at room temperature. Its impossible to change it into liquid at room temperature whatever pressure is applied since room temperature is above its critical temperature.*
- ***Vapor** :is the gaseous state of a substance below its critical temperature. At room temp. and atmospheric pressure the substance is liquid.*
- ***Filling ratio:** is weight of fluid in a cylinder divided by the weight of water required to fill the cylinder.*

Cylinders content & delivery

- ***O2 is stored as gas at a pressure of 13700 Kpa.***
- ***N2O is stored a liquid with its vapor on top at a pressure of 4400 Kpa (the cylinder should be partially filled as liquid is less compressible.***
- ***Partial filling protects against risk of increase in pressure with increase ambient temp.***
- ***A full O2 cylinder can deliver 130 times its capacity at atmospheric pressure.***
- ***Typical E size full O2 cylinder delivering 4L/min will last for 2h &50 min , but at a rate of 15l/min can last only 45 min.***

At a constant temperature

- ***Gas containing cylinders shows a linear reduction in the pressure as it empties.***
- ***Liquid containing cylinders initially the pressure decrease constantly until the liquid part ends up, later on the pressure decreases.***
- ***The temperature in such cylinders decreases as a result of loss of latent heat of vaporization leading to ice formation at the outside of the cylinder.***

Problems in practice and safety features of medical gas cylinders

- *Gases and vapors should be free of water vapor when stored in cylinders as it freezes at the exit ports on opening during cold weather.*
- *color coded cylinders and pin index system prevents wrong gas connection to the anesthetic machine hence improving safety.*
- *Cylinders must be checked regularly for sufficient content .*
- *Cylinders must be stored in a purpose-built (dry ,well ventilated and fireproof)room, away from flammable materials as oil or grease ,they should not be exposed to continuous dampness , corrosive chemicals or fumes.*
- *Full cylinders should be stored separately from empty ones to avoid mishaps.*
- *Over pressurized cylinders are hazardous and must be reported to the manufacturer.*

Piped gas supply (piped medical gas and vacuum-PMGV)

- ***PMGV is a system where gases are delivered form central supply points to different sites in the hospitals at a pressure of about 400 Kpa through special outlet ports.***

- ***Oxygen ,nitrous oxide , Entonox, compressed air and vacuum are commonly supplied through the pipeline system.***

Piped gas supply
(piped medical gas and vacuum-PMGV)

Components

1. *Central supply points (cylinder banks or liquid oxygen storage tanks).*
2. *Network of pipelines made of special high-quality copper alloy(prevents degradation of the gases ,and has bacteriostatic properties. The fitting used are made of Brass and are brazed rather than soldering.*
3. *The diameters of the pipelines differ according to the demand (42 mm for those leaving the manifold and 15 mm after repeated branching.*

Components

Bank of cylinders/manifold

Liquid oxygen

pipelines made of special high-quality copper alloy

42 mm for those leaving the manifold and 15 mm after repeated branching

Components

4-Outlets are identified by color coding ,gas name and by shape (quick connect / disconnect probes) with am indexing collar specific for each gas (or gas mixture).

5-Outlet are installed as flush-fitting ,surface fitting units, on booms or pendants .

6-Flexible color-coded hoses connect to the outlets to the anesthetic machine. The machine end is fixed is thread specific non-interchangeable screw thread.

7-Area valve service units behind break glass covers at strategic points throughout the pipeline network. They can isolate the supply to an area in case of fire or an emergency.

(Quick connect / disconnect probes)

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(Quick connect / disconnect probes)

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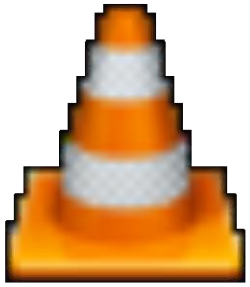

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Outlets are identified by color coding, gas name and by shape

outlets

probes

PMGV outlets

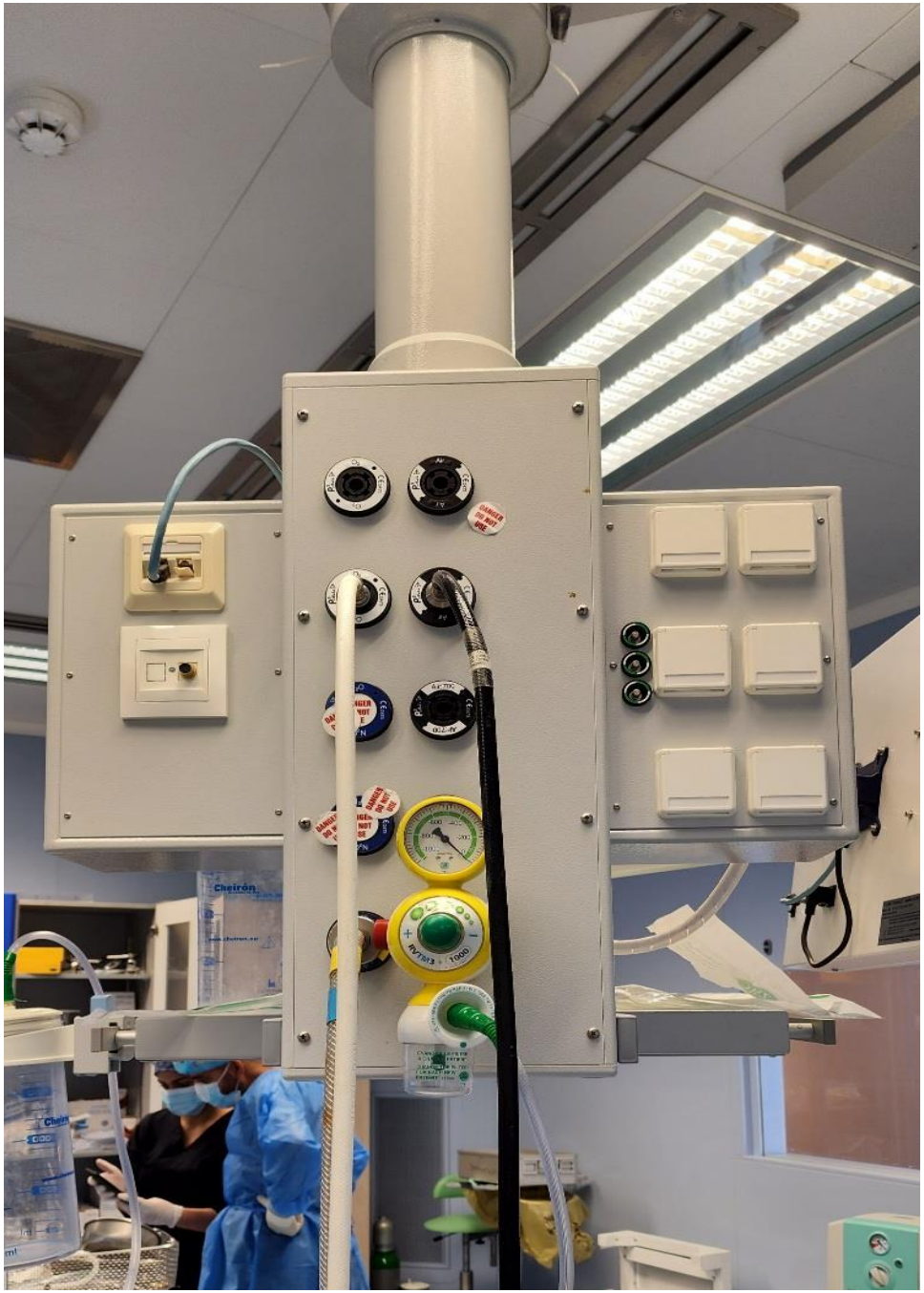
Booms

pendants

PMGV outlets

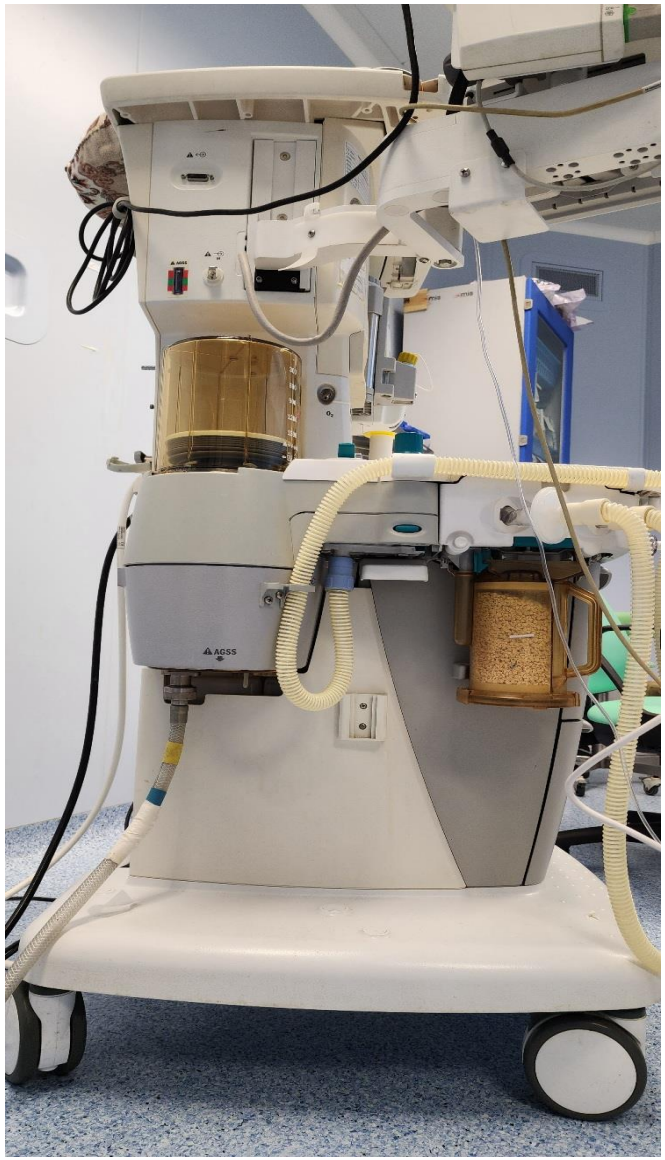
Booms

pendants


Cheiron

The machine end is fixed

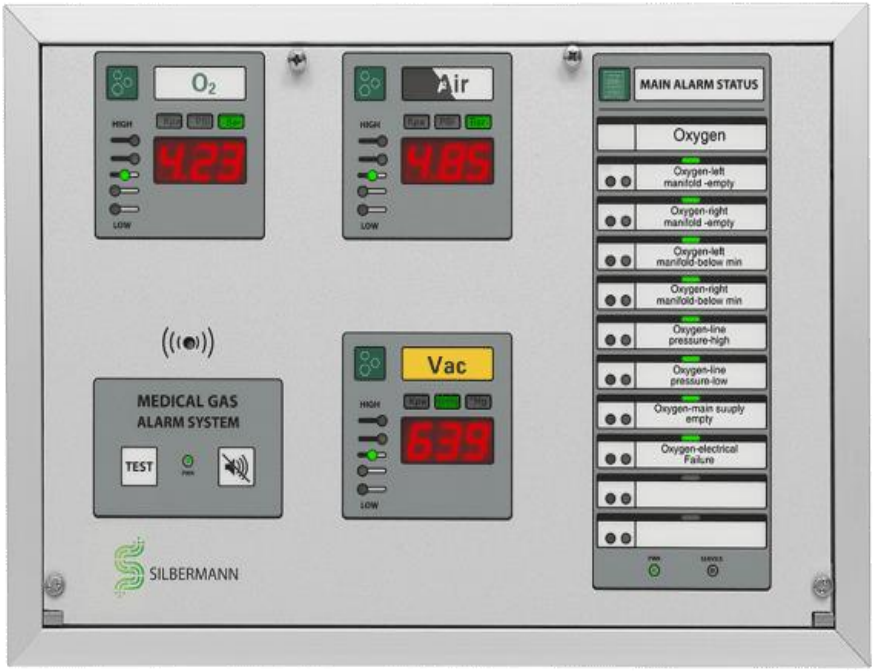
The machine end is fixed



Area valve service units behind break glass covers

Area Valve Service Unit

Medical gas alarm panel
Main & area



Problems in practice and safety features

1. *A reserve bank of cylinders is available if the primary supply fails.*
2. *Single hose test for detection of cross connection.*
3. *Tug test to detect misconnection*
4. *Regulations for PMGV installation , repair and modification are enforced.*

Tug test

- Connect O2 pipeline to oxygen wall outlet using the Schrader quick coupler system
- Correct coupling will not allow detachment of pipeline from the Schrader coupler when a tug is given to the pipeline.
- Similar test can be performed with N2O pipeline with N2O wall outlet.

Problems in practice and safety features

5- Anesthetists are responsible for gases supplied from the terminal outlet through the anesthetic machine. Pharmacy and engineering departments share the responsibility for gas pipelines 'behind the wall'.

6-There is a risk of fire from worn or damaged flexible high pressure hoses that transfer gases from the cylinders or outlets to the ventilators or anesthetic machine, regular inspection and replacement , every 2-5 years, of all gases hoses.

Sources of gas supply

Sources in central pipeline system can be:

1. ***Cylinder manifold(s).including other gases***
2. ***Liquid oxygen storage tank.***
3. ***Oxygen concentrator.***

Cylinder manifold components

1. *Two equal groups of J-size cylinders (primary and secondary), alternate in supplying the pipeline. The number depends on the demand.*
2. *Cylinders in each group are connected to a common pipe through a non-return valve, the two common pipes are connected through a pressure regulator to the pipeline.*
3. *Nitrous oxide is only available in cylinders thus its manifold is larger. O2 manifold acts as a back up for liquid O2 supply.*

Mechanism of action

1. ***All the cylinders in either group are opened ,this allows them to empty simultaneously.***
2. ***When the primary group is nearly empty, the supply is automatically changed to the secondary group through a pressure sensitive device.***
3. ***The change over activates an electrical signaling system to alert the staff that cylinders change is needed.***

Problems in practice and safety features

1. ***Manifold should be housed in well-ventilated and fire proof building away from the hospital building.***

2. ***Manifold room should not be used as a general cylinder store.***

3. ***All empty cylinder should be removed immediately from the manifold room.***

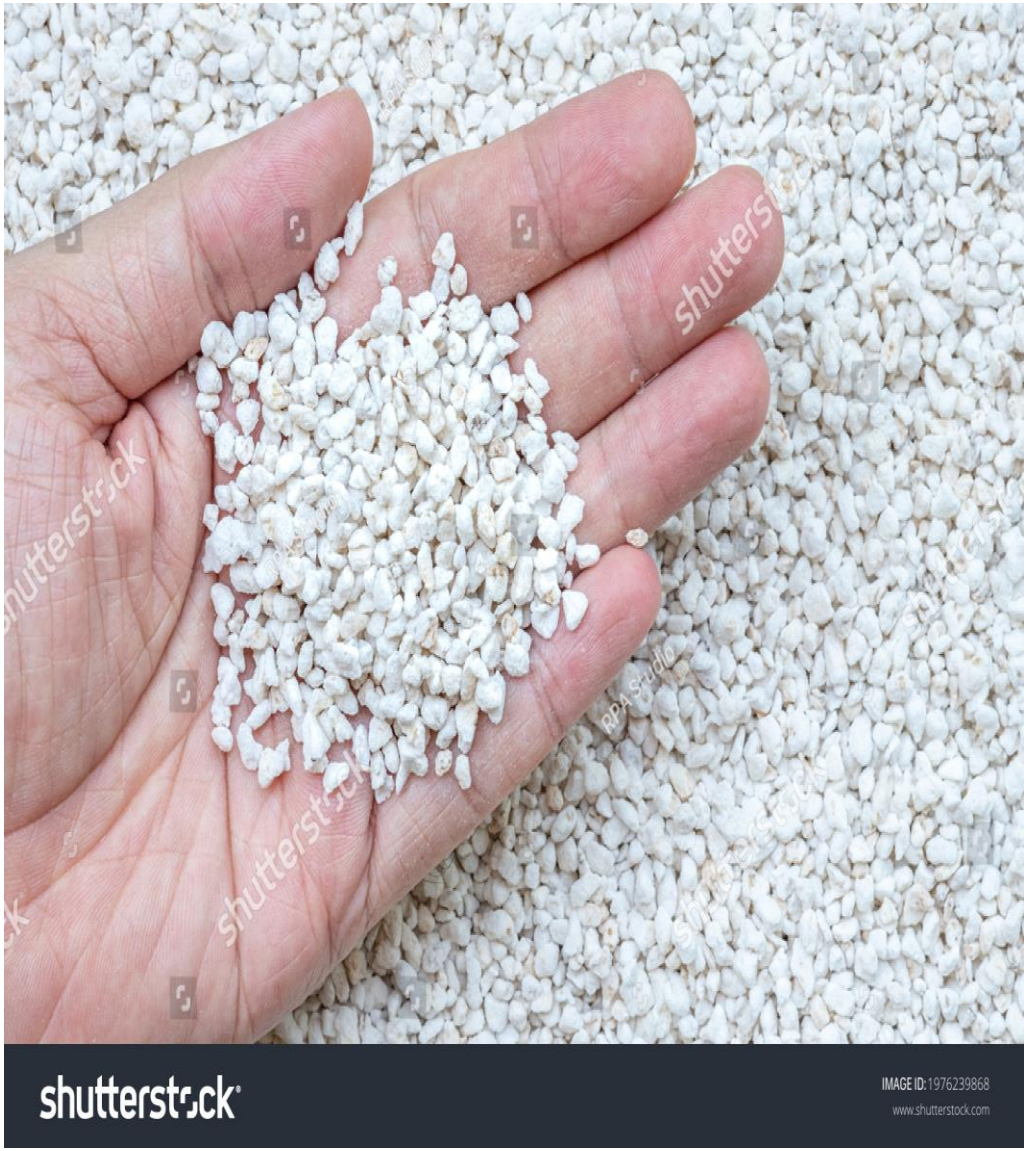
Liquid Oxygen

A vacuum insulated evaporator (VIE) or giant thermos flask is the most economical way to store and supply O2.

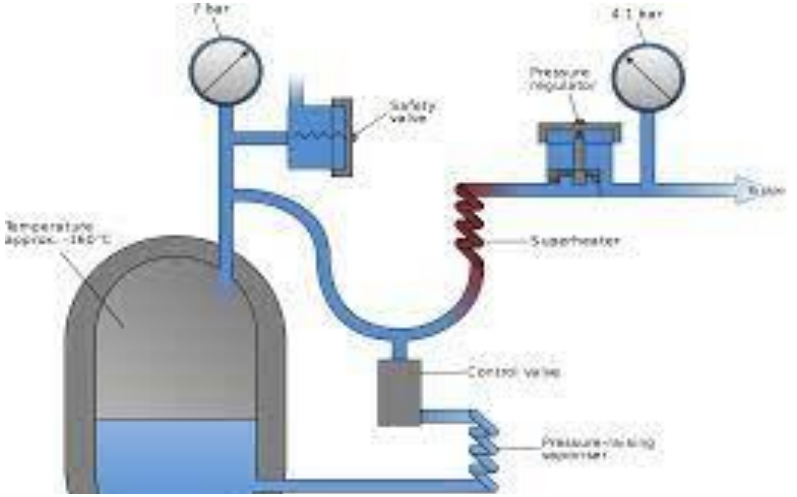
Components:

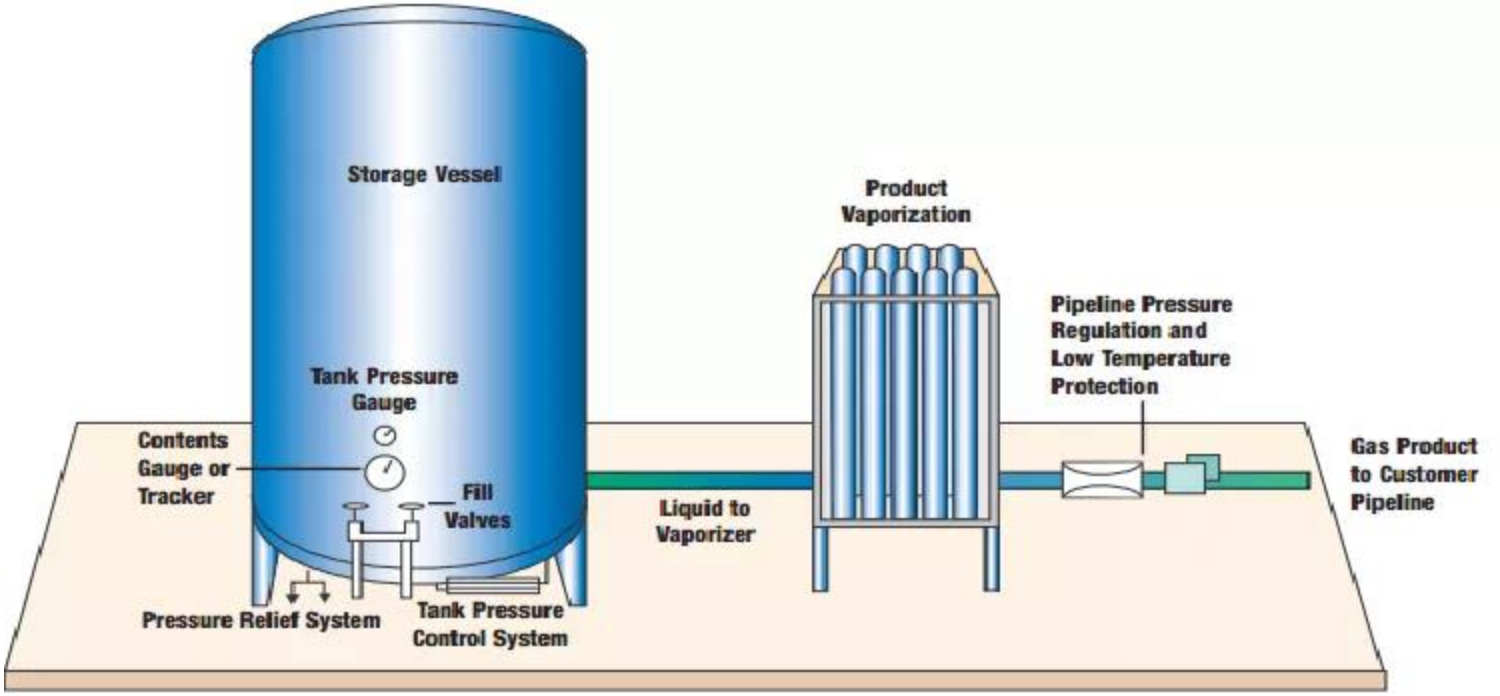
1. ***A thermally insulated double walled steel tank with a layer of perlite in a vacuum is used as the insulator.***
2. ***A pressure regulator maintains the pipeline pressure of about 400 kpa.***
3. ***A safety valve that opens at 700 kpa relieves build-up pressure within the vessel which results from under demand for O2.***
4. ***A control valve opens when there is extra demand on O2. this allows liquid O2 to evaporate by passing through super heater made of insulated coils of copper tubing.***

Perlite



Liquid Oxygen





Mechanism of action

1. *Liquid O2 is stored (up to 1500 L) at (-150 to -170)C lower than the critical temperature and at a pressure of 10.5 bars.*
2. *The temp. of the vessel is maintained by the high vacuum shell. Evaporation of liquid O2 needs heat (latent heat of vaporization) which is taken from the liquid O2 helping to maintain its low temp.*
3. *The contents of the vessel can be calculated through a special device. When required fresh liquid O2 can be pumped from a tanker to the vessel.*
4. *The cold O2 gas is warmed in a coiled copper tubing, once outside the vessel, the rise in the temp. causes an increase in the pressure.*
5. *At a temp. of 15C and atmospheric pressure ,liquid O2 can give 842 times its volume as gas.*

Problems in practice and safety features

1. ***Reserve banks of cylinders are kept in case of supply failure.***

2. ***A liquid O2 storage vessel should be away from the hospitals main building.***

3. ***Spillage of cryogenic liquid can cause cold burns or frostbite and hypothermia.***

Oxygen concentrators

- ***Extract O2 from air by differential adsorption.***
- ***Either small that supply O2 for a single patient or anesthetic machine or ;***
- ***Large to supply O2 for a medical gas pipeline system.***

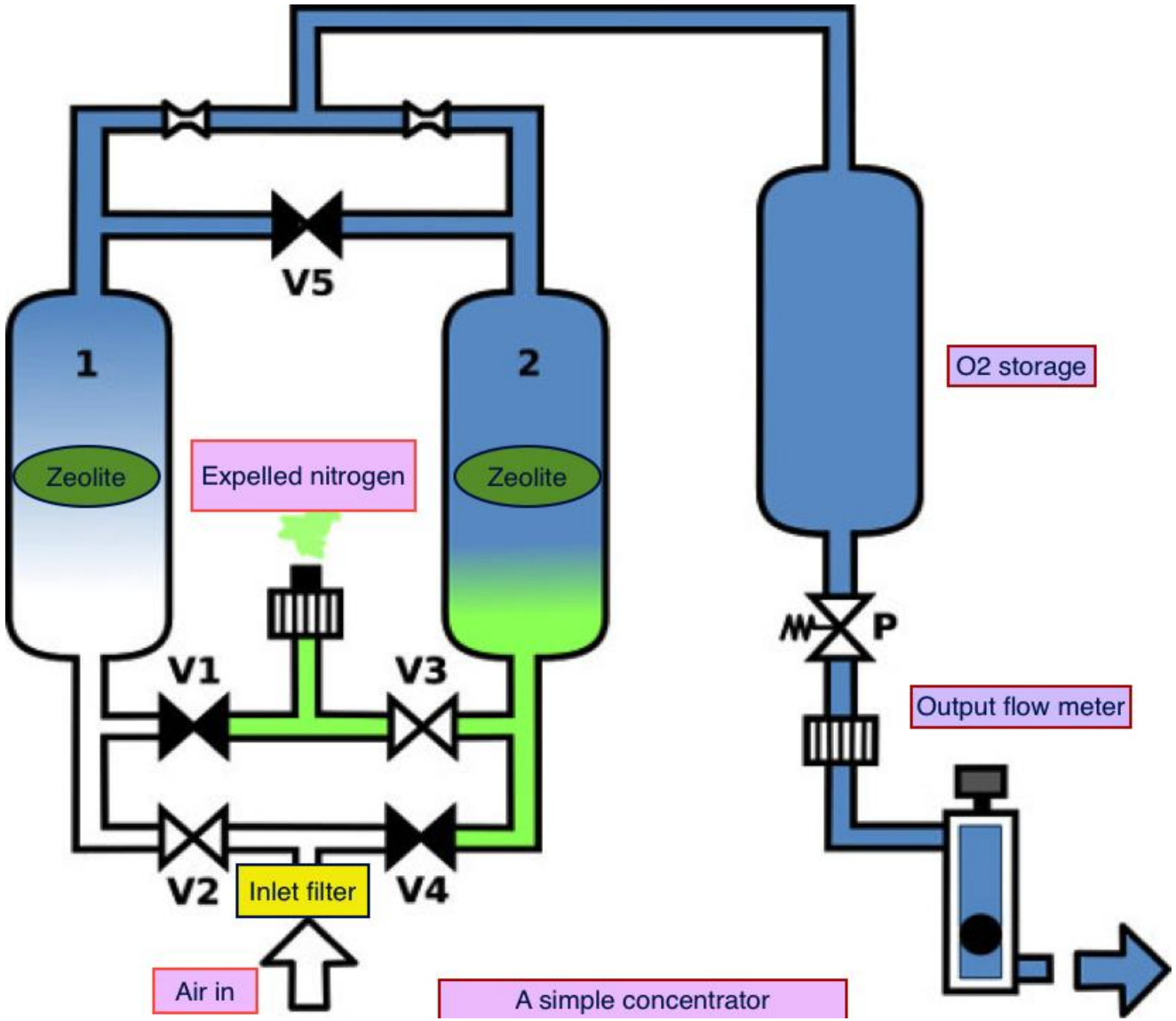
Components:

many columns of hydrated Aluminum silicates of the alkaline earth metals in a powder or granular form.

Small O_2 concentrator single patient use

Large O_2 concentrator

Large O_2 concentrator



Mechanism of action

1. ***Ambient air is pressurized by a compressor at 137 kpa .***
2. ***Air is exposed to the filter that is composed of the aluminum columns ,it retains nitrogen and the other unwanted components that are released to the atmosphere .***
3. ***The maximum O2 concentration is 95%.***
4. ***The life of the filter is at least 20 000 hours or 10 years.***
5. ***Routine maintenance is to change the filter.***

Entonox

- *Is a compressed gas mixture of 50% O2 and 50% N2O.*
- *Its commonly used in the casualty and labor room to provide analgesia.*
- *A 2-stage pressure demand regulator is attached to it.*
- *The gas flow =s only when the patient inspires through a mask or mouth piece.*
- *Entonox is compressed at 13700 kpa.*
- *The cylinders should be stored at 10`C for 24 hours before use.*

Entonox

Entonox

Mouth piece

***Face* mask**

Problems in practice and safety of Entonox

- *At temperatures below -5.5 C liquefaction and separation of the two components occur, forming a vapor part rich in O2 and a liquid part with poor O2 content, thus rewarming and shaking reverses separation and liquefaction.*
- *The horizontal positioning increases the surface area for diffusion.*
- *If the contents are mixed by repeated inversion it can be used earlier than 24 hours.*

Compressed air

- ***Medical air is supplied in hospitals for clinical use at a pressure of 400 kpa***
- ***or to drive tools like orthopedic saw or drill at a pressure of 700 kpa***
- ***The terminal outlets for each is different to avoid misconnection.***
- ***Medical air is oil free ,cleaned by special filters and separators.***
- ***Its supplied from cylinder manifolds, or more economic compressor plant with duty and back-up compressors.***

Compressed Medical air