Electrical Safety, Humidity and Scavenging

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Electrical Safety

- Ohms Law:

$$E=I\times R$$

- E= Electromotive force,
- I= Current in amperes,
- R= Resistance in ohms.
- Electrical Power is measured in Watts:
- W=E×I, Watt/sec=Joule (work done).

Electrical Safety

- 1volt of EMF across a 1-ohm resistance will cause 1 ampere of current to flow.

Direct and Alternating Current :

- Current is a flow of electrons through a conductor
- Direct Current if flow in one direction.
- Alternating current if the flow reverses direction at regular intervals.

Electrical Safety

- Electrical shocks occur when a person becomes a part or completes an Electrical circuit.
- Damage can be :

3. Electricity can disrupt cellular function.
4. Electricity can dissipate throughout the body.



Electrical Safety

- The longer the individual is in contact with the electrical source the more dire the consequence.
- Greater chance of VF from excitation of the heart during the vulnerable period of ECG.

Grounding:

- Applied to 2 separate concepts namely – grounding of electrical power and electrical equipment.

Electrical Safety

- Electrical power is grounded at home but not in OR.
- Electrical equipment at home may be grounded or ungrounded but must be grounded in OR.
- Grounding is done to prevent electrical charges from building up in the wires during electrical storm.
- Also prevents high voltage entering the home in case of an equipment failure.

Electrical Safety

Electrical Shock Hazard:

- An electrical shock is possible if an individual comes in contact with a live wire and completes the circuit may lead to injury or death.
- VF caused by 3 times DC in comparison to AC.
- A power cord contains a live wire and neutral wire to maintain the voltage constant.

Macroshock	
1mA(0.001 A)	Threshold of perception
5mA(0.005 A)	Maximum harmless current
10-20 mA	Let go current
50 mA	Pain, fainting, mechanical injury
100-300 mA	VF, respiration intact
6000 mA	Sustained myocardial contraction, followed by Sinus rhythm.
Microshock	
100 μA	VF

Electrical Safety

- Two wires carry power from the electric company to a home and from the junction box three wires carry current to the electrical outlet.
- Live wire is colour coded as black, neutral wire is white and ground wire is green.
- A circuit breaker or fuse is connected between the ground and neutral together and the live wire to a maximum amperage of 15-20 A for lighting and 30-50 A for heating outlet.

Electrical Safety

- Supplying ungrounded power to the OR requires an isolation transformer.
- There is no direct electrical current between the power supplied by the company and the power induced by the transformer on ungrounded side.
- Thus any individual coming in contact with a live wire will not complete the circuit.
- If the two wires of the isolated circuit are connected the short circuit will trip the circuit breaker or fuse.

Electrical Safety

Electrosurgical Cautery

- Invented in 1926 by Prof Bovie
- Lead to introduction of nonflammable inhalational anaesthetics.
- Cautery interferes with all equipment like ECG, CO, pulse oximeter, and pacemaker.
- Operates by generating very high frequency currents 500,000 to 1 million Hz.
- Heat energy is concentrated to the tip of a Bovie pencil, this high frequency current can pass thro the myocardium without any effect.

Electrical Safety

- The current entering the body thro' the tip disperses via a ground plate or correctly named as dispersing plate.
- If the contact of the dispersing plate is correctly placed the current disperses over a large area, if contact is defective the current exits in the area of contact or an alternative path in contact with any conductor.

Humidity

The amount of water vaporization is directly proportional to its temperature, the amount of humidity depends on ambient temperature.

- The warmer atmosphere can hold more water vapor than a cold one.
- Saturated humidity is the maximum amount of water vapor held by an atmosphere and again is dependant on temperature.
- Absolute humidity is the actual amount of water content in a given volume of gas at a given temp and pressure.

Humidity

- Maintaining proper environmental humidity is essential in reducing static electricity in the OR and also to have a comfortable working condition for the personnel.
- Static electricity is a potential source of ignition in OR.
- When RH is optimal the static electricity is conducted via the film of humidity to the surrounding thus preventing the sparks.
- A RH of 40-70% prevents bacterial or viral growth, thus reducing infections in the patients and personnel alike.

Humidity

Measurement of Humidity :

- The instruments used for measurement of humidity are called Hygrometers.

3. Wet and Dry bulb hygrometer.
4. Dew point hygrometer.
5. Electric dew point hygrometer.
6. Hair hygrometer.
7. Electric hygrometer with Dunsmore Sensor.

Hygrometers

1. Wet and Dry Hygrometer:

- Two thermometers placed next to each other.
- One end of a wick wraps around the bulb of one thermometer and the other end of the wick is dipped in water.
- The other thermometer is open to the room air.
- The evaporation of water from the wick decreases the temperature of the wrapped thermometer and this depends on the moisture content of the room.
- The difference of temp is used to calculate the RH value from a table.

Hygrometers

2. Dew-point Hygrometer :

- The dew point is the temperature at which the ambient air is fully saturated with water vapor.
- Consists of a silver tube containing ether and a thermometer to measure the temperature of ether.
- Air is pumped thro' the ether to cool it.
- When dew point is reached water begins to condense on the outside of the tube.

Hygrometers

- The higher the moisture content the higher the dew point.
- If the temperature at dew point = 10deg C: the SVP of water at this temperature is ~10mm Hg, and the SVP at 20 deg C is 18 mm Hg.
- The RH of the OR is 10/18 = 56%.

Hygrometers

3. Electric Dew point hygrometer:

- A beam of light is reflected into a photoelectric cell by a mirror cooled by an air conditioning coil.
- The temperatures of the room and the mirror are measured.
- When the mirror starts to fog the water globules collecting on the surface deflect the light onto a photoelectric cell connected to a light meter.
- This light meter reads the deflected light and RH.

Hygrometers

4. Hair Hygrometer :

- Useful for measurement of RH between 15% and 85%.
- Commonly used in OR and neonatal incubators.
- Human hair lengthens as ambient humidity increases.
- The increase in length, magnified by a system of levers, is used to move a pen across a circular chart bearing calibrations in RH.

Hygrometers

5. Electric Hygrometer with Dunsmore Sensor :

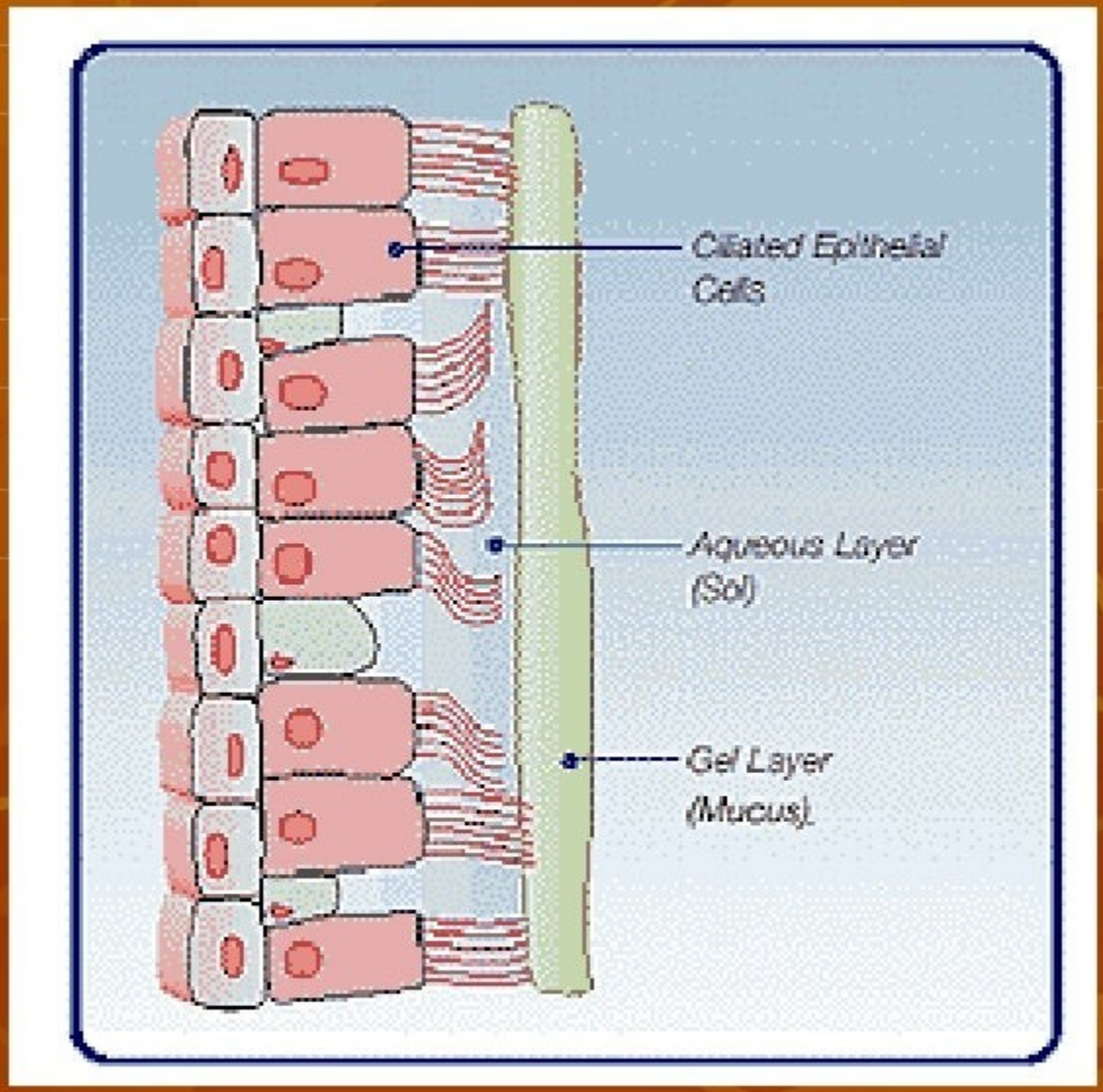
- Dunsmore sensor consists of a bifilar palladium wire wound around an insulated core, the wire is coated with hygroscopic film.
- The sensor is mounted on a Wheat-stone bridge, galvanometer reads 0 when the bridge is balanced.
- Resistance of the sensor increases when moist gases flow.
- The changes in the resistance are read as RH by way of nomograms provided by the manufacturer.

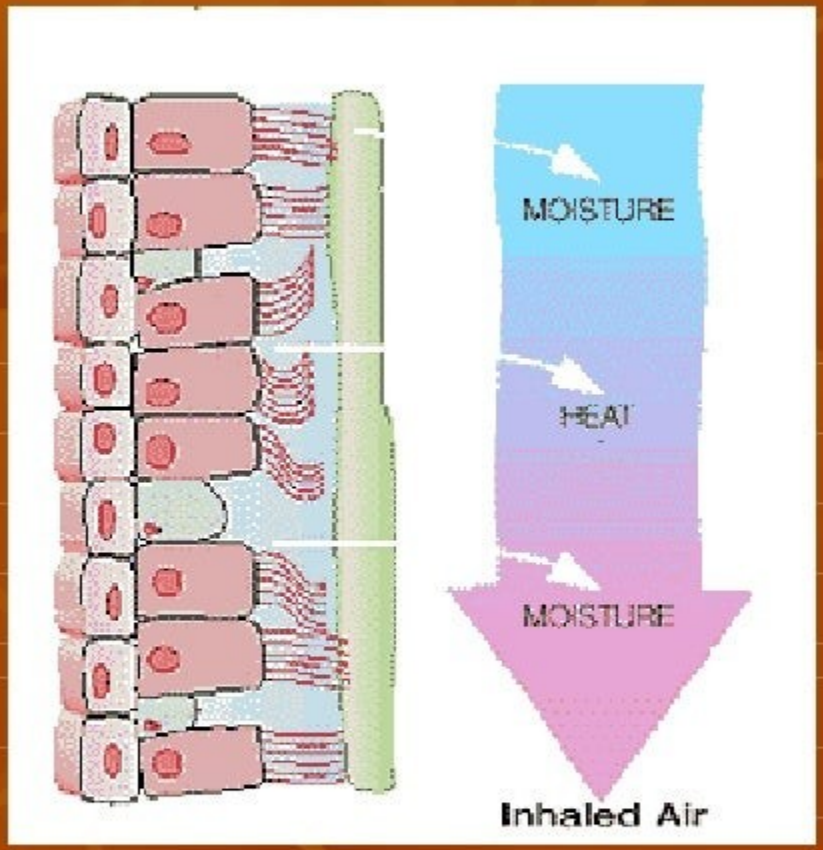
Humidity in Anaesthesia Circuits

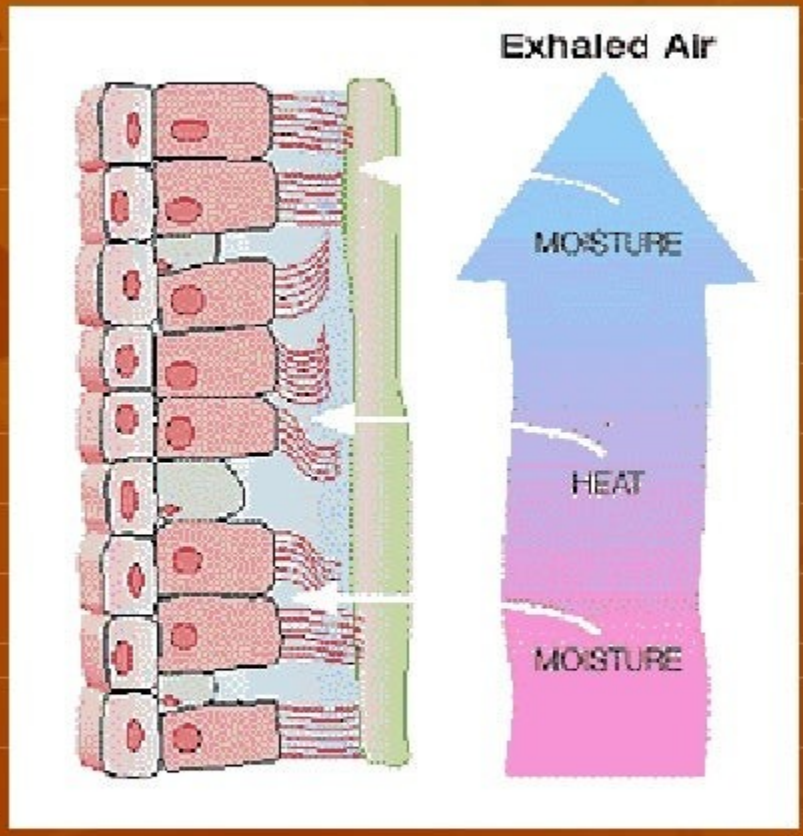
- Water is intentionally removed from medical gases to prevent clogging of pressure regulators.
- 15% moisture from Soda Lime and the patient's exhaled gases are a source of water.
- This process takes at least an hour (60% humidity) but a 100% humidity is required at 32 deg C.

Importance of Humidification

- Insufficient humidity- During IPPV via an ETT the upper airway is bypassed hence the load humidification falls on lower airways.
- The inhalation of cold dry air leads to ciliary immobility, twisting, inspissation of secretions and tracheal encrusting.
- If this extends to the bronchiole level the resistance to airway increases and V/Q mismatch may occur.
- Mucosal inflammation, microatelectasis, decreased Pul. compliance and ↓ FRC ensue.


Ciliated Epithelial Cells
Aqueous Layer (Sol)
Gel Layer (Mucus)


MOISTURE
HEAT
MOISTURE
Inhaled Air


Exhaled Air
MOISTURE
HEAT
MOISTURE

Importance of Humidification

Hazards of Overhumidification-

- Increased airway resistance.
- Hyperthermia.
- Airway thermal burns.
- Positive water balance.
- Infection and growth of bacteria.
- Altered ciliary epithelium.
- Altered Pul.function.
- Altered surfactant function.
- Atelectasis.

Humidification

Methods of humidification of Circle System

2. Low gas flow system.
3. Design improvement of circuit.
4. Exogenous humidity.

Exogenous humidity is the most important, there are various methods of providing exogenous humidity.

Humidification



Heat Moisture Exchangers:

- "Artificial noses" are used for both humidification of inspired gases as well as for bacterial and viral filtration.
- The pore size is around 0.2 μm which allows only water vapour and not liquid water to pass.
- These are inexpensive and disposable.
- They deliver 28-30 mg/L of water at 28-30 deg C.

Humidification



Hot Water Systems:

- When gases are bubbled through water humidification decreases as the temperature falls.
- Thermostatically controlled humidifiers like the cascade humidifier produces small bubbles by a special process.
- The temperature of the gases exiting are adjusted to 32 deg C at the Y piece (33 mg/L water).
- Disadvantage if temp >32 deg C “rain out” is common and temp should be monitored carefully.

Humidification



Units with rain out prevention :

- An electrically heated wire runs along the circuit to prevent water from condensing distal to the humidifier.
- A thermistor probe is used to measure temperature at the patient end and the outlet of the humidifier.
- These can generate in excess of 40 g/L of water at 37 deg C.

Humidification

Aerosol Generators:

- Also known as nebulizers deliver small particles of water instead of water vapor.
- Particles < 1 µm in diameter can reach the alveoli easily.
- 1µm to 3µm reach brochioles and 3-5 µm are arrested in the trachea.
- 5-10 µm are deposited in the pharynx, particles < 5 µ are in respirable range and < 0.5µ are exhaled without being deposited.

Humidification

Compressed gas nebulizers:

- A jet of gas is directed above a capillary tube immersed in water this draws up water by the Bernoulli principle.

Ultrasonic nebulizer:

- The rapid oscillations of the peizo electric crystal (1.5 MHz) breaks the water drops to very fine droplets measuring 2.8- 4.0 µm in diameter.

Scavenging in Anaesthesia

Trace Anaesthetic Gases:

- A study conducted in 1967(Vaismann) concluded that waste gases like N2O, Inhalational vapors like Halothane and Ether caused a high rate of abortions in female medical personell.
- Other effects like nausea, vomiting, irritability and fatigue were due to chronic inhalation of anaesthetic vapors.

Scavenging

- NIOSH recommends halogenated vapors to a maximum of 2 ppm and N2O of 25 ppm if used as a sole anaesthetic.
- Parts/million or ppm for N2O =

100% N2O= 1,00,00,000 ppm

1% N2O= 10,000 ppm

(1/100)×1%N2O= 100 ppm

(1/400)×1%N2O=25 ppm.

Scavenging

2 ppm of Halothane represents =

100 ppm = (1/100)×1% Halothane

2 ppm = (1/100×1/50)× 1% Halothane

(1/5000)×1%= 0.0002%

0.5 ppm = (1/20,000)×1%= 0.00005%

To express in terms of MAC divide the above by the MAC of the drug

2 ppm=0.0002% ÷ 0.76 = 0.00026 MAC of Halothane.

Scavenging

- When no attempt has been made to scavenge the waste gases N_2O 400-600 ppm and Halothane 5-10 ppm have been detected.
- Volume of gas to be released into the OR can be easily calculated to maintain at 25 ppm.
- Assume OR is 5m × 5m × 4m

  500 cm × 500 cm × 400cm = 100,000,000.

NIOSH limit is 25/100,000,000.

If vol. of OR is 100×100,000,000 the limit is reached by a release of 25×100 = 2500 ml of N_2O.

Scavenging

Sources of Anaesthetic Gas Spillage:

- The main sources are- APL valve, high and low pressure systems of anaesthesia machine, anaesthesia ventilator, cryosurgery and other sources.
- The APL valve is the outlet for waste gases and CO2, >5 lts of gas can exit depending on FGF.
- Large vol. of gases are discharged via APL valve in Jackson- Rees circuit.(NO2 level may reach >2000 ppm around the anaesthesiologist.

Scavenging

High Pressure Leaks:

- Includes leaks from high pressure system of the machine to the central supply connections.
- The pressure in the central supply is 50-70 psig, leaks contribute significantly to the pollution.
- Most of the anaesthesia machines have been found to be leaking when properly tested for leaks in the high pressure area.

Scavenging

Low Pressure System:

- Includes the NO2 flowmeter, the vaporizers, FGF tubing, CO2 absorber, unidirectional valves, ventilator and parts of the scavenging system.
- The leak is α to pressure in the breathing circuit.
- Scavenging system may be ineffective and release the waste gases into the OR.

Scavenging

O R Ventilation Systems:

- This is the most important factor to reduce anaesthetic air pollution.
- The components of typical OR ventilation include- 1) Fresh air intake from exterior, 2)Central Pump, 3) Series of Filters, 4) AC units, 5)Manifold supplying fresh air to OR, 6)Manifold that collects air from OR, 7)Fresh air inflow port to each OR.

Scavenging

Nonrecirculating Ventilation System:

- Pumps fresh air from outside the OR and removes the stale air.
- The no. of air exchanges/hour is an important determinant of pollution, rate of 10 or more is recommended, but > 30 is uncomfortable to OR personnel.
- Eddies are more efficient than a laminar flow to cause good air mixing and removal of “hot spots” in the OR.

Scavenging

Recirculating Ventilation System:

- Partial recirculation of stale air, more economical as it require less AC.
- The recirculating system is common in very hot or very cold climates.
- Filtering does not cleanse air of anaesthetic pollution it may contaminate clean OR from a a polluted OR by recirculating polluted air.

Scavenging

- An ideal scavenging system will not affect the dynamics of breathing, ventilation or oxygenation of a patient.
- A typical scavenging system consists of 1) A relief valve, 2) tubing to conduct the system to scavenging interface, 3) the interface, and 4) the disposal line.
- The scavenging may be active (negative pressure applied to the disposal line) or passive.

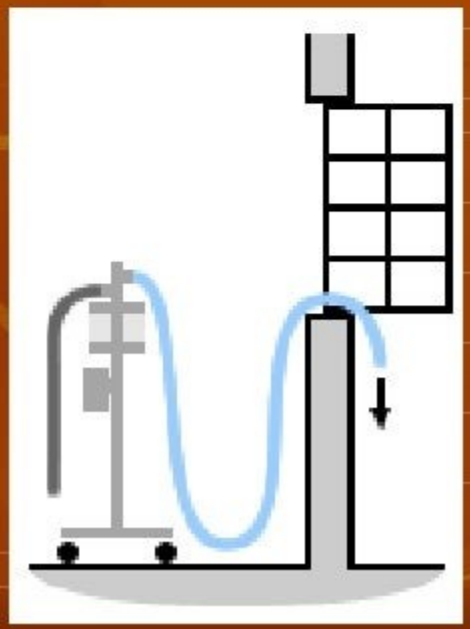
Scavenging

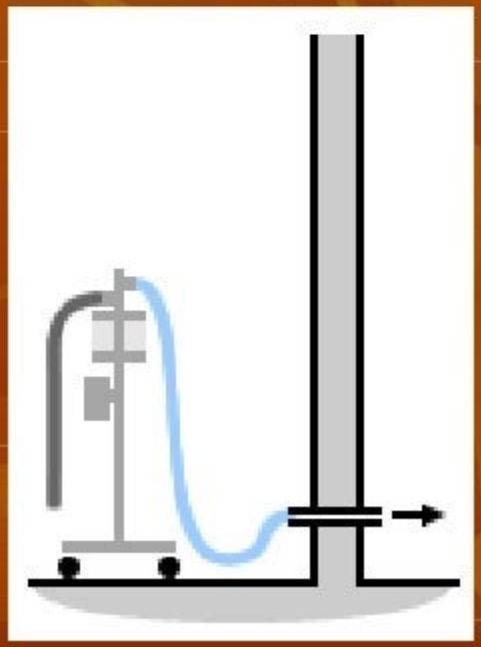
Passive systems

- 1. A collecting and transfer system that consists of a shroud connected to the automatic pressure limiting (APL) valve (or expiratory valve of the ventilator). A 30 mm connector attached to the transfer tubing leading to the receiving system.

Scavenging

- 2. A receiving system (reservoir bag) can be used. Two springloaded valves guard against excessive positive (1000 Pa) or negative (-50 Pa) pressures in the scavenging system.





Scavenging

The waste gases can be ducted out of the building via:

- An open window
- A pipe passing through an outside wall

An extractor fan vented to the outside air (N.B. not into the building's air-conditioning system)

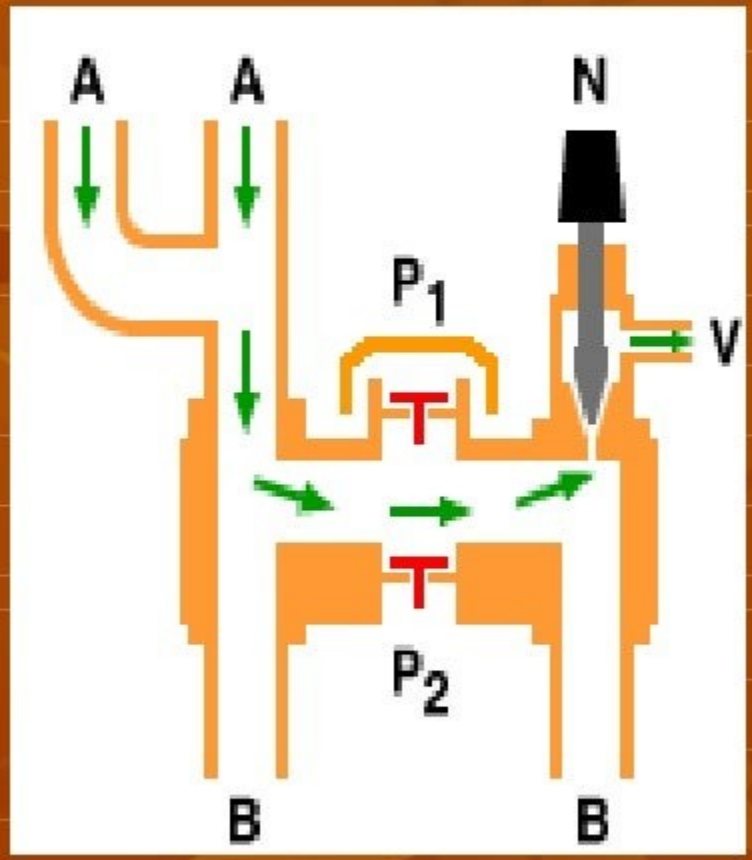
Scavenging

Active systems

- These systems connect the exhaust of the breathing system to the hospital vacuum system via an interface controlled by a needle valve.

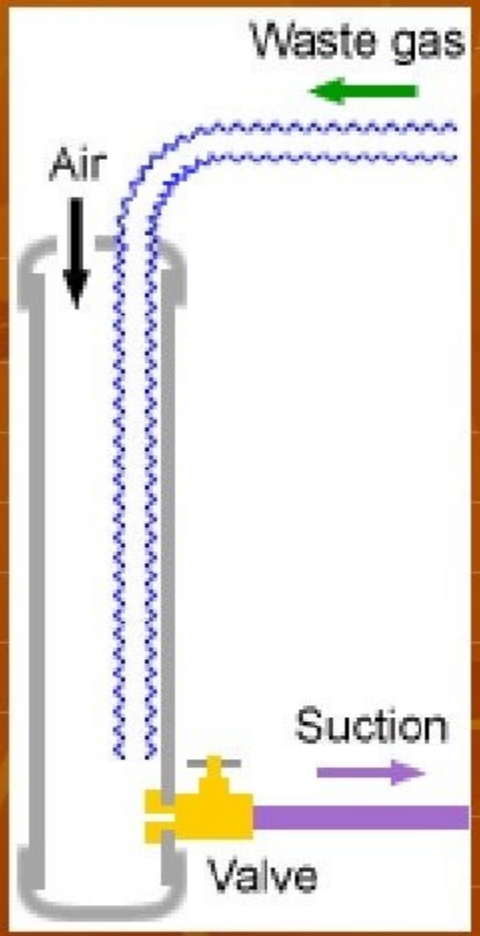





A
A
N
P1
V
T
T
P2
B
B

Scavenging

- The Ohio scavenging interface has connections for the outlets from the breathing system and ventilator (A), one or two reservoir bags (B) and the vacuum line (V).
- The suction is controlled by the needle valve (N). There are both positive (P1) and negative (P2) pressure relief valves in case the reservoir bag becomes empty or too full.



Drager open reservoir scavenging system

Scavenging

- This consists of a reservoir made of plastic pipe of around 3" in diameter and 2 feet in length, capped at both ends and with a needle valve fitted at the bottom.
- Two holes are drilled in the top cap, one to allow the hose from the outlet of the anaesthetic machine to be inserted and the other to allow passage of atmospheric air.
- The valve is adjusted so that air is slowly sucked into the pipe when the anaesthetic machine is in use: this will prevent waste gases escaping into the atmosphere.


Thank You