Vaporiser

- principles of operation
- construction
- troubleshooting
- safety considerations

13.7.3 Maintain a Vaporizer

Unit B 13.7 Maintaining Ventilation and Anaesthesia equipment

Module 279 18 B Medical Instrumentation I

Function & Use

A vaporizers is part of an anaesthetic machine.
It is designed to convert a liquid anaesthetic agent into a vapour and to add a controlled amount of this agent to the gas mix that is to be administered to the patient.

There are three types of vaporizers:

- **Plenum vaporizers** for continuous (constant) flow systems and
- **Draw-over vaporizers** for draw-over systems.
- **Dual-circuit gas–vapour blender,** used only for the agent desflurane.

Here, the principles of all three types of vaporizers are explained, but further focus is on **Plenum Vaporizers**

Anaesthetic machine, showing Sevoflurane (yellow) and Isoflurane (purple) Plenum vaporizers on the right side

Different vaporizers for Continuous Flow and Draw-Over systems

During anaesthesia using a Boyles machine or **continuous flow system** (figure 1), compressed gases (oxygen and nitrous oxide or air) pass from cylinders mounted on the machine to rotameters (flow meter) and then through the **vaporizer** where a volatile agent such as halothane is added to the gas mixture. The resulting mixture is delivered to the patient via a breathing circuit. This type of anaesthesia system is dependent on a **supply of compressed gases**. If these run out during an operation, so does the anaesthetic!

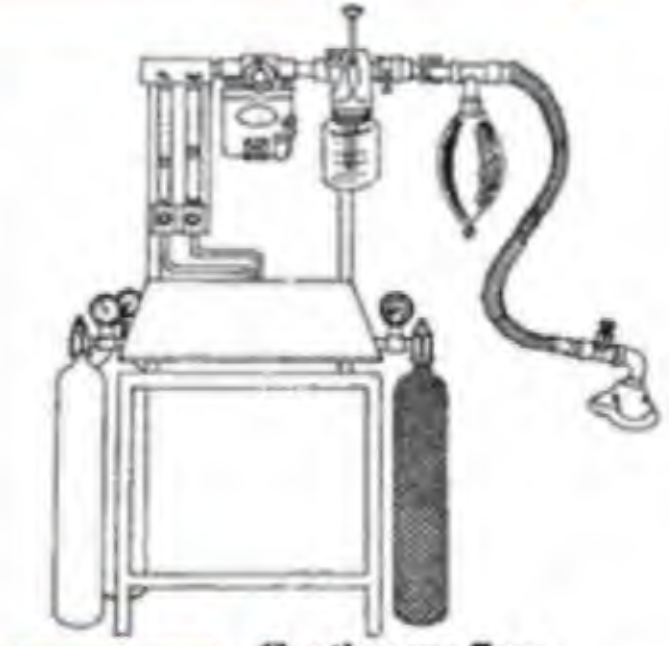


Figure 1 Continuous flow anaesthetic apparatus

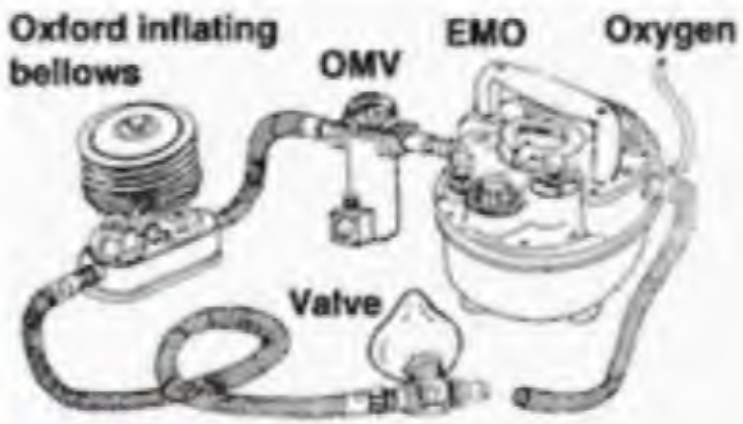
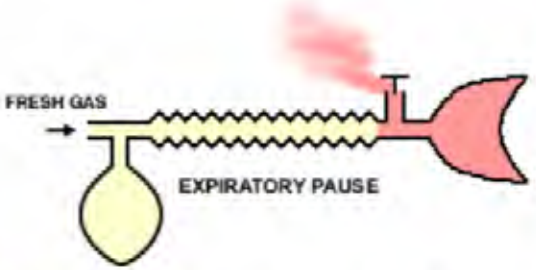


Fig 2 Drawover apparatus



classic Magill breathing circuit

A **Draw-over** system (fig.2) is designed to provide anaesthesia without requiring a supply of compressed gases. Atmospheric air is used as the main carrier gas and is **drawn by the patient's inspiratory effort** through the vaporizer, where the volatile agent, normally ether or halothane, is added. The mixture is then inhaled by the patient via a non-rebreathing valve.

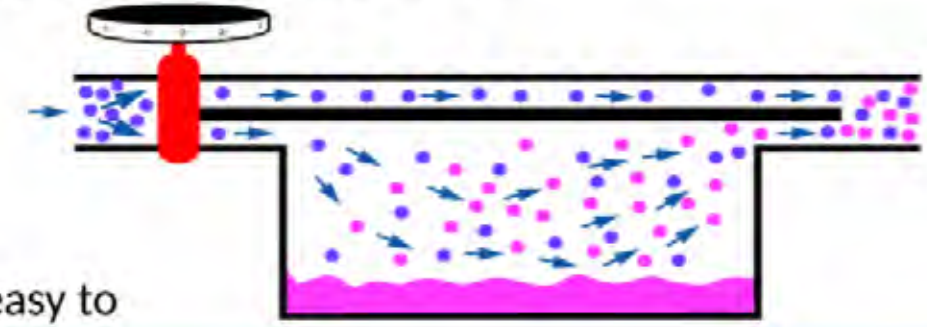
Draw-over Vaporizer

The **Draw-over Vaporizer** is driven by negative pressure developed by the patient, and must therefore have a low resistance to gas flow. Its performance depends on the minute volume of the patient: its output drops with increasing minute ventilation.

The design of the drawover vaporizer is simple: in general it is a simple glass reservoir mounted in the breathing attachment. Drawover vaporizers may be used with any liquid volatile. Many designs have a lever which adjusts the amount of fresh gas which enters the vaporising chamber. Because the performance of the vaporizer is so variable, **accurate calibration is impossible**.

Drawover vaporizers typically have no **temperature** compensating features. With prolonged use, the liquid agent may cool to the point where condensation and even frost may form on the outside of the reservoir. This cooling impairs the efficiency of the vaporizer. One way of minimising this effect is to place the vaporizer in a bowl of water.

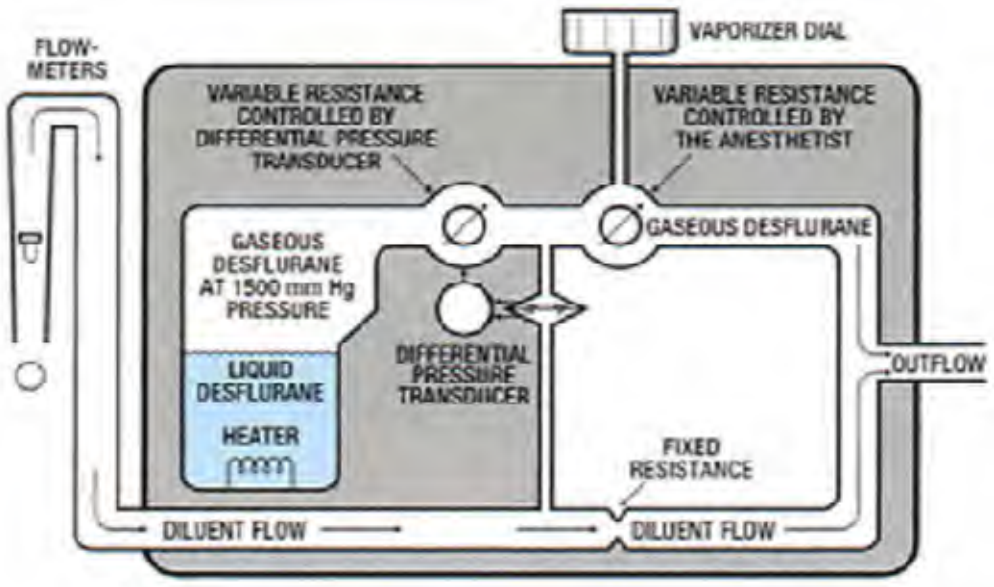
The output concentration from a drawover vaporizer may greatly exceed that produced by a plenum vaporizer, especially at low flows. For safest use, the concentration of anaesthetic vapour in the breathing attachment should be **continuously monitored**.



Despite its drawbacks, the drawover vaporizer is cheap to manufacture and easy to use.

Dual-circuit gas–vapour blender

The **Dual-circuit gas–vapour blender** was created specifically for the agent **desflurane**. Desflurane boils at 23.5 °C, close to room temperature. This means that at normal operating temperatures, the saturated vapour pressure of desflurane changes greatly with only small fluctuations in temperature. Therefore, the features of a normal plenum vaporizer are not sufficient to ensure an accurate concentration of desflurane. Additionally, on a warm day, all the desflurane would boil, and very high (potentially lethal) concentrations of desflurane might reach the patient.



A desflurane vaporizer is heated to 39°C and pressurised to 200kPa (and therefore requires electrical power). It evaporates a chamber containing desflurane using heat, and injects small amounts of pure desflurane vapour into the fresh gas flow. A transducer senses the fresh gas flow.

A warm-up period is required after switching on. The desflurane vaporizer will fail if mains power is lost. Alarms sound if the vaporizer is nearly empty. An electronic display indicates the level of desflurane in the vaporizer.

The expense and complexity of the desflurane vaporizer have contributed to the relative lack of popularity of desflurane, although in recent years it is gaining in popularity.

Principle of Operation: Plenum Vaporizer

The **Plenum Vaporizer** is driven by positive pressure from the anaesthetic machine, and is usually mounted on the machine. The performance of the vaporizer doesn't change regardless of whether the patient is breathing spontaneously or is mechanically ventilated.

The Plenum Vaporizer works by accurately splitting the incoming gas into two streams (see figure next sheet). One of these streams passes straight through the vaporizer in the **bypass channel**. The other is diverted into the **vaporising chamber**. Gas in the vaporising chamber becomes **fully saturated** with volatile anaesthetic vapour. This gas is then mixed with the gas in the bypass channel before leaving the vaporizer.

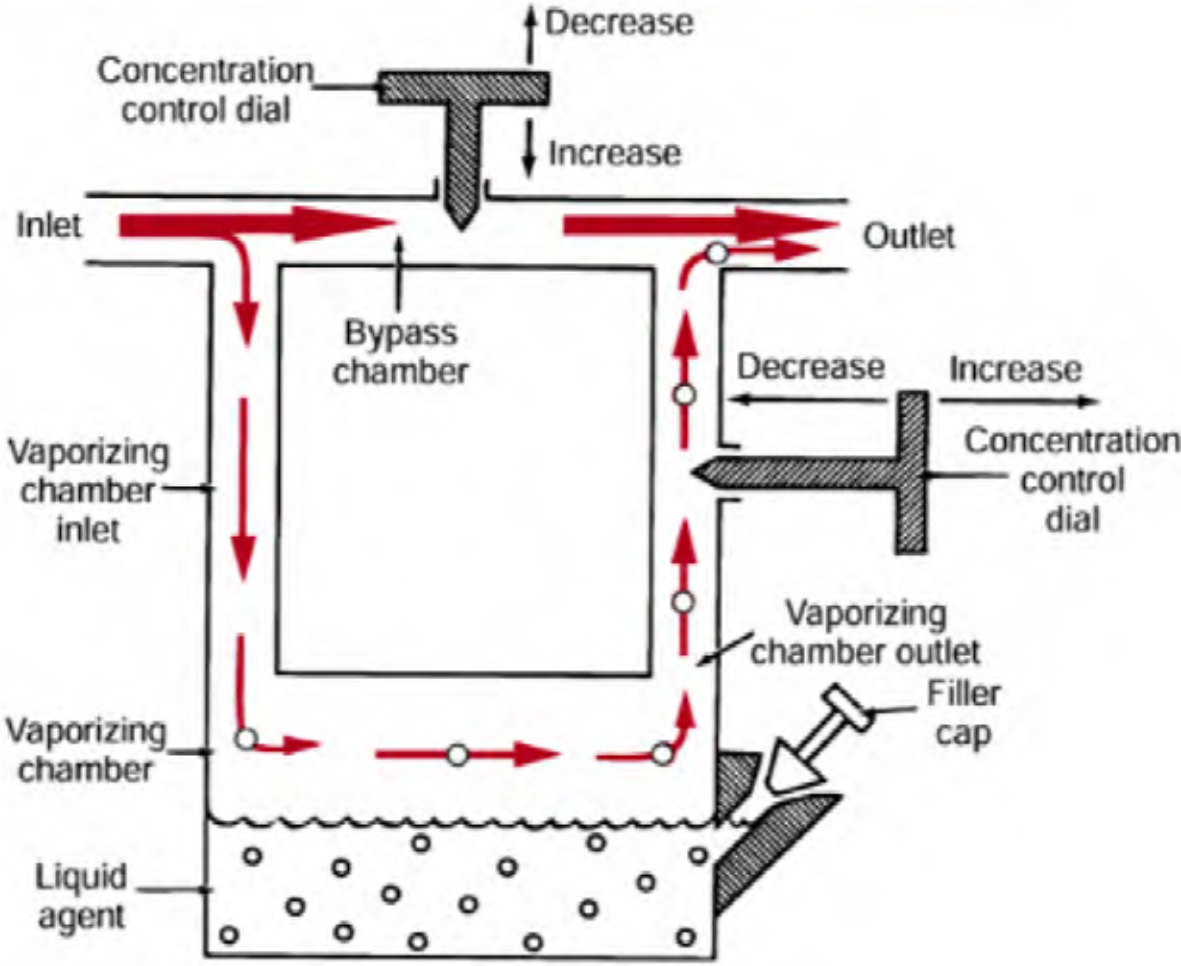
The internal resistance of the vaporizer is usually high, but because of the supply pressure is constant the vaporizer can be accurately calibrated to deliver a precise concentration of volatile anaesthetic vapour over a wide range of fresh gas flows. The Plenum Vaporizer is an elegant device which works reliably, without external power, for many hundreds of hours of continuous use, and requires very little maintenance.

Plenum Vaporisers

- As air enters the vaporiser, it is directed into either the vaporising chamber or a bypass chamber.

- The anaesthesiologists controls the bypass valve to allow more or less of the incoming gases to flow through the vaporising chamber usually via a large knob on top of the vaporiser.

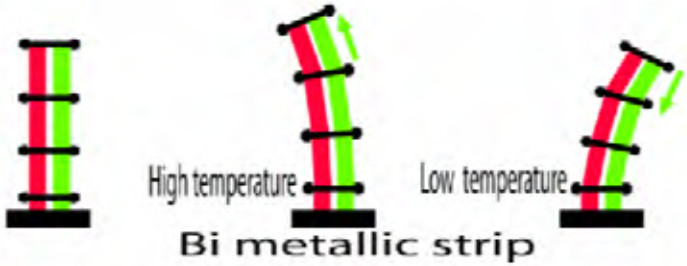
- The liquid anaesthetic agent resides in the lower part of the unit. As the gas moves across the top of the liquid, the anaesthetic agent vaporises and is carried by the gas towards the outlet, where it is blended with the gas that had bypassed the chamber

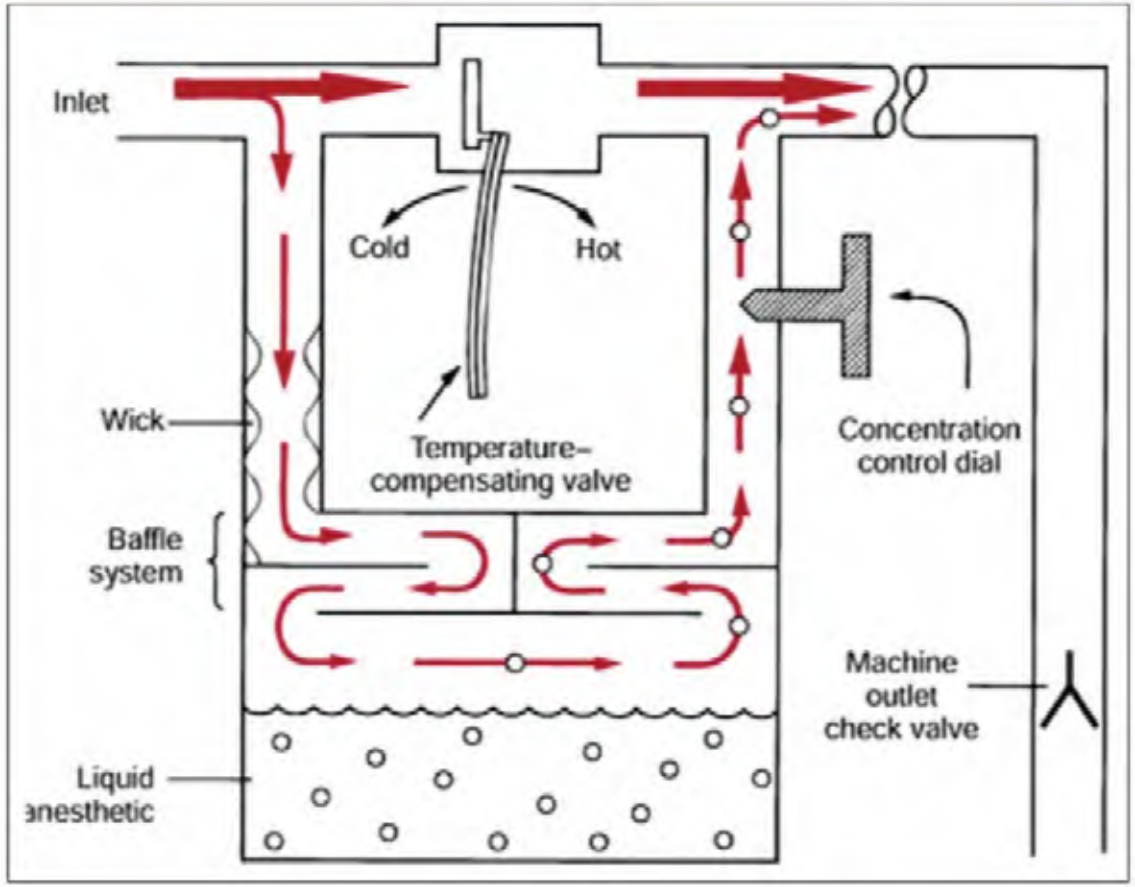


Plenum Vaporisers: Temperature compensation

Since vapour pressure is affected by temperature, a warm environment causes more of the anaesthetic agent to vaporize and a cold environment less. To compensate this, either

- the temperature of the vaporizing chamber is kept constant with heater and thermostat, or
- a bi-metallic valve is added to the by-pass system to compensate for temperature effects. The bi-metallic valve physically distorts to adjust for temperature changes.

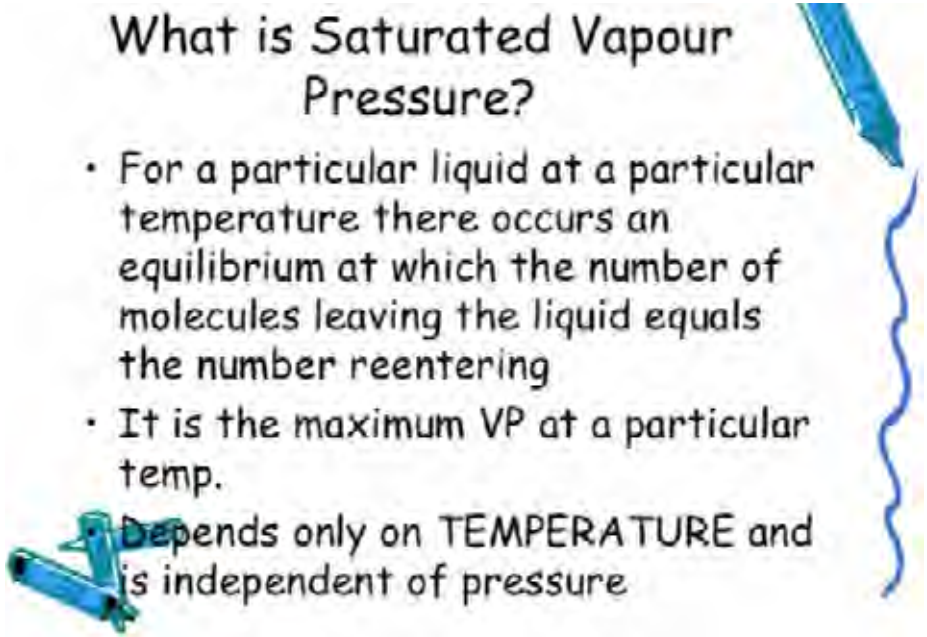




Principle of Operation: Plenum Vaporizer

A typical volatile agent, isoflurane, has a **saturated vapour pressure** of 32kPa (about 1/3 of an atmosphere). This means that the gas mixture leaving the vaporising chamber has a partial pressure of isoflurane of 32kPa. At sea-level (atmospheric pressure is about 101kPa), this equals conveniently to a concentration of 32%.

The output of the vaporizer is typically set a 1-2%, which means that only a very small proportion of the fresh gas is diverted through the vaporising chamber. This proportion is known as the **splitting ratio**.

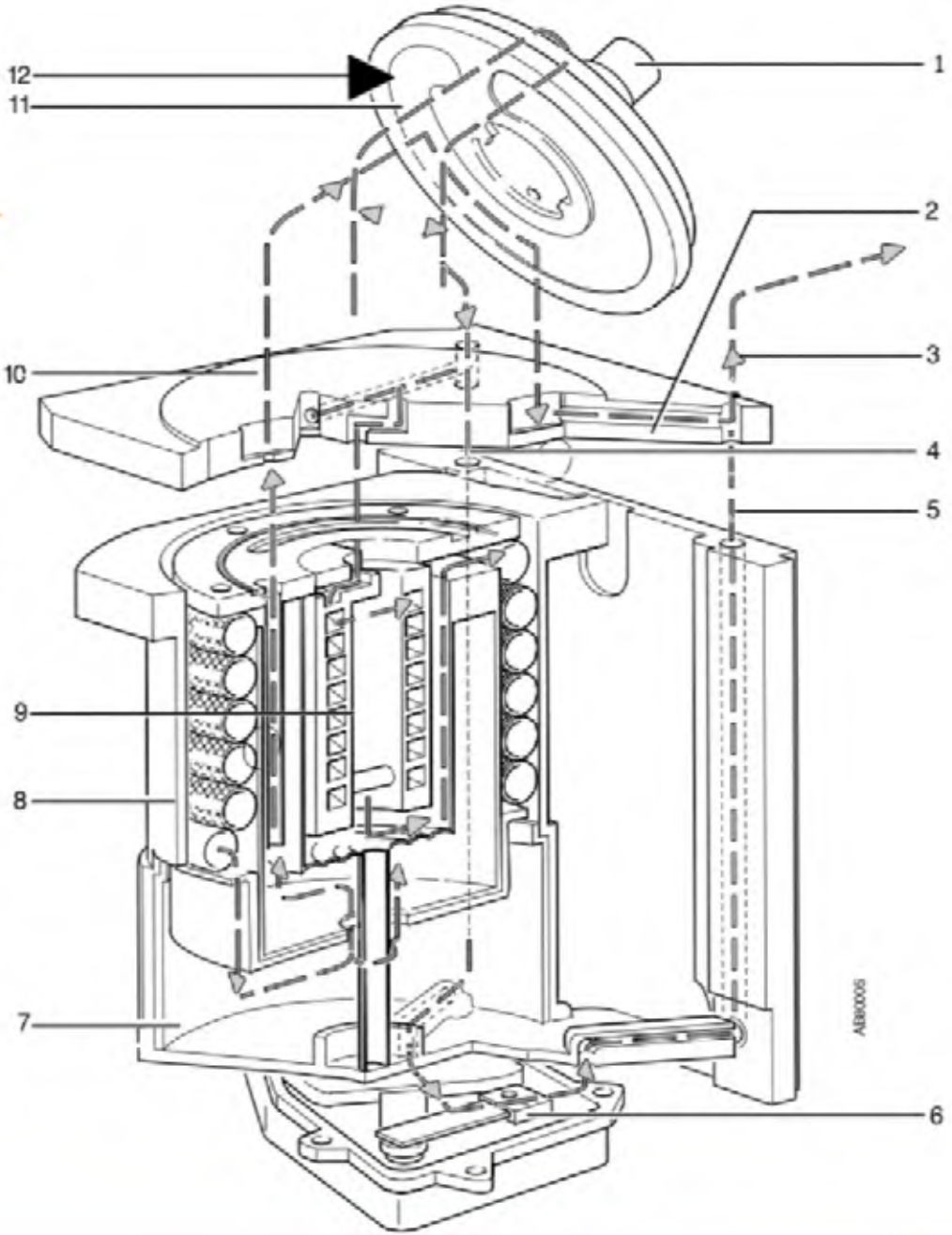


The performance of the plenum vaporizer depends critically on the saturated vapour pressure of the volatile agent. This is unique to each agent, so it follows that **each agent must only be used in its own specific vaporizer**.

The vaporizer should be kept level (horizontal) as operation out of level can affect the calibration

Construction: Components

1. Rotary valve
2. Enriched fresh gas out
3. Combined fresh gas and enriched gas out
4. Fresh gas bypass
5. Fresh gas out
6. Thermostat
7. Vaporizing chamber
8. Wick assembly
9. IPPV compensating assembly
10. Sump cover
11. Vapor control channel
12. Shown in ON position



Troubleshooting; identifying & rectifying faults

Vaporizers are very reliable, but if the vaporizer breaks, it must be sent back to the factory or other qualified repair service. There is little a field engineer can do to repair a broken vaporizer."

Repairs and service procedures must be performed at a Datex-Ohmeda Authorized Service Center. Contact your Datex-Ohmeda Service Representative or Datex-Ohmeda Authorized Distributor for information on maintenance and shipping.

Internal contamination

If the vaporizer is filled or partly filled with an incorrect volatile agent or other contaminant (such as water), proceed as follows:

1. Remove the vaporizer from service immediately and label the vaporizer stating that it is contaminated. Discard all liquid.
2. Return the vaporizer to a Datex-Ohmeda Authorized Service Center stating that the vaporizer is contaminated and, if possible, the type of contaminant in the vaporizer.

⚠ **WARNING** Do not modify, tamper with, or disassemble the vaporizer. Doing so can damage the unit and alter the graduation accuracy.

Check the service manual !

Preventive Maintenance

Maintenance intervals

Prior to performing any maintenance procedures or returning to a service center for repairs, clean and disinfect the vaporizer.

Every two weeks: When the agent is low, drain the contents of the vaporizer into an appropriately marked container and discard the agent. For Halothane vaporizers check the output of anesthetic agent periodically with an agent monitor. See note below.

Three years from purchase date and every six months thereafter:	Planned safety inspections together with the anesthesia system by qualified personnel.
	Inspect and perform output concentration check.

Note The decomposition of Halothane causes the release of halides, which may corrode metal components particularly in the presence of moisture. Also a preservative added to Halothane by its manufacturers to impede decomposition can leave a residue, which may cause vaporizer components to stick. If Halothane is used infrequently the vaporizer should be drained after use.

Vaporizers should generally be calibrated every six months.

Preventive Maintenance

Output concentration check

Connect the Tec 7 to an Anesthesia Machine.

1. Set the oxygen output of the anesthesia machine to a flow of 5± 0.5 L/min.
2. Ensure that the fresh gas output is connected to a gas scavenging system.
3. Measure the concentration at the fresh gas outlet, using an agent monitor which is calibrated to measure the specific agent.
4. Allow the readings to stabilize and check that the readings are within specified tolerances.
5. Document and maintain the test results, including the date, person performing the test, and serial number of the unit tested.

User & Patient Safety

Care should be exercised not to tip vaporizer as this can cause a hazardous spill. Should a spill occur, water can be used to clean up the anaesthetic agent and doors should be opened to clear the vapours.

Vaporizers are an integral part of the anaesthesia machine and therefore can be the cause of problems and a threat to a patient's life. It is important to respect the service manual's instructions on preventive maintenance and output checks.

END

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