Anesthesia Vaporizers

Procedure No. 436-20081015-01 (Major)

Used For:
Anesthesia Unit Vaporizers [10-144]

Commonly Used In:
Operating rooms, emergency departments, delivery rooms, trauma departments, ambulatory surgical centers, and any areas requiring the administration of an inhalation agent (with anesthesia units)

Scope:
Applies to the various anesthesia vaporizers used to deliver a known concentration of vaporized liquid anesthetic

Risk Level: High

Type	Interval	Time Required
Major	6 Months	0 hours
Minor	0 NA	0 hours

Overview:
An anesthesia unit vaporizer is used to vaporize a liquid anesthetic agent and deliver a controlled amount to the patient.
According to the American Society for Testing and Materials (ASTM) standard ASTM F1850, anesthetic agent vaporizers are required to be concentration calibrated (i.e., a calibrated knob controls the output concentration). Older vaporizers that do not have a single control for selecting anesthetic vapor concentration should be removed from service. there are two types of concentration-calibrated vaporizers: variable bypass and heated blender.
Conventional (variable-bypass) vaporizers.In a variable-bypass vaporizer, the total background gas flow that enters the unit is split into two streams. The smaller stream, which acts as the carrier gas, passes through the vaporizing chamber containing the anesthetic agent and becomes saturated with agent vapor; the remainder of the gas bypasses this chamber. A wick may be used in the vaporizing chamber to provide increased surface area for efficient evaporation of the drug and saturation of the carrier gas. The saturated carrier gas leaves the chamber and mixes with the bypass gas. One adjustment is made to set the desired concentration. This adjustment simultaneously balances the carrier and bypass flows to produce the blend required for the set concentration. The mixture exits the vaporizer and is delivered from the anesthesia machine as the fresh gas to be inspired by the patient.

Evaporation of the liquid agent contained in the chamber is driven by heat absorbed from the walls of the vaporizer; consequently, when evaporation is occurring, the vaporizer and its contents cool. Because the equilibrium vapor pressure of an agent changes with temperature, a temperature-sensitive mechanism is used to automatically adjust the carrier and bypass flows to compensate for temperature changes. Figure 1 presents a schematic of a variable-bypass vaporizer.

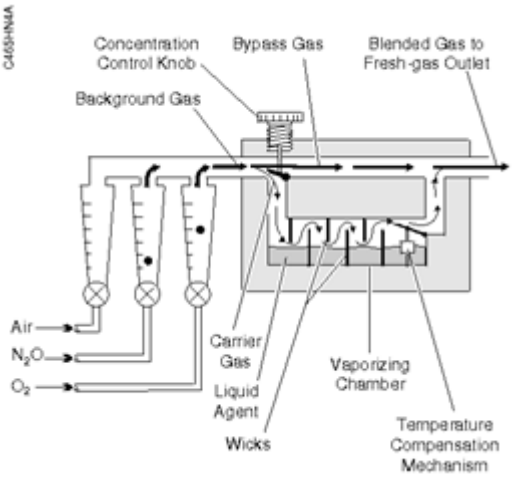

Figure1. Schematic illustrating the basic elements of a variable-bypass vaporizer

Desflurane (heated-blender) vaporizers.Desflurane, a volatile inhalation anesthetic marketed by Baxter Pharmaceutical Products Division under the trade name Suprane, has characteristics that allow rapid induction of and emergence from anesthesia.

The boiling point of desflurane—22.9°C at 760 mm Hg—is just above room temperature; therefore, small increases in ambient temperature or decreases in atmospheric pressure can cause it to boil. Also, because of desflurane's high minimum alveolar concentration (i.e., its low potency), evaporation of sufficient agent to achieve a given anesthetic effect would require much more heat absorption from the vaporizer than occurs with other agents. Furthermore, the change in vapor pressure of desflurane per change in temperature is as much as three times that for the other volatile agents at sea-level atmospheric pressure. These profound effects of temperature and ambient pressure on the vapor pressure of desflurane make stabilizing the delivered concentration at a set point extremely difficult in a passive mechanical system, such as a variable-bypass vaporizer. As a result, the variable-bypass design was abandoned for desflurane, and Datex-Ohmeda developed the Tec 6 vaporizer, based on a heated-blender design. Figure 2 shows a schematic of this vaporizer. Datex-Ohmeda has since released the Tec 6 Plus, which is similar in design.

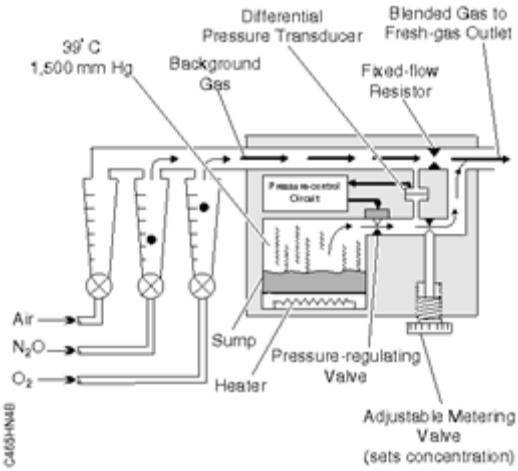

Figure 2. Schematic illustrating the basic elements of the Datex-Ohmeda Tec 6 vaporizer

Datascope, Drager, Medical, and Penlon have not developed an equivalent desflurane vaporizer. A version of the Tec 6 has been adapted for Drager machines and is compatible with Drager's triple-exclusion interlock system.
A desflurane vaporizer requires electrical power to heat the agent to a thermostatically controlled 39°C, producing a stable, saturated vapor pressure of 1,500 mm Hg. No wick is used, and no carrier gas enters the sump chamber. Instead, a stream of vapor under pressure flows out of the sump; this stream blends with the background gas stream, which originates from the anesthesia machine's flowmeters, to achieve the desired concentration.
The background gas stream passes through a fixed-flow resistor, producing a back pressure upstream of this resistor that is proportional to the background gas flow. The desired desflurane concentration is set on the dial of the adjustable metering valve in the vapor stream; this setting produces a predetermined aperture. The pressure in the vapor upstream of the aperture and the back pressure in the background gas stream are continually sensed by a differential pressure transducer. The transducer controls a pressure-regulating valve in the vapor stream between the sump and the adjustable metering valve. The pressure-regulating valve permits only that flow from the sump necessary to cause the pressure upstream of the adjustable metering valve to equal the back pressure in the background gas stream. In this way, the ratio of the adjustable metering valve's resistance to the resistance of the fixed-flow resistor determines the ratio of the flows in each stream, and therefore, the concentration of vapor in the blended output. If the flow from the anesthesia machine's flowmeters through the vaporizer is altered, the flow of vapor from the sump is automatically adjusted so that the pressures at the two monitored points remain equal, the flow ratio does not change, and the output concentration continues to match its setting.
The control circuits and heating elements in the vaporizer are turned on by the act of connecting the vaporizer to electrical power. The unit then heats to and remains at operating temperature as long as it receives power, whether it is delivering agent or is in the standby mode. Consequently, it is warm to the touch while plugged into a live socket.

Test Apparatus and Supplies:

- Electrical safety analyzer (line powered vaporizers)
- Halogenated anesthetics analyzer

Special Precautions:

Do not fill a vaporizer with an inhalation agent unless you are qualified to do so. Always use a scavenging system or appropriate ventilation when inspecting vaporizers. For personal safety, when inspecting vaporizers alone, notify other personnel of your location. Be sure that filler ports are tightly capped before passing gas through the vaporizer.
As a general precaution, older vaporizers containing an anesthetic agent should not be tipped. If such tipping occurs, notify the user and follow the manufacturer's recommended procedures for airing or drying the vaporizer.

Procedure:

Be sure that you understand how to operate the equipment, the significance of each control and indicator, and the alarm capabilities. Before beginning an inspection, carefully read this procedure, the operators manual, and the inspection and preventive maintenance procedures recommended by the manufacturer (typically included in the service manual). Use the BiomedicalBenchmark Support Assessment Form to document a maintenance decision that reflects past experience with this type of equipment and the environment where it is used. Then use the IPM Procedure Customization Tool to modify this procedure as needed; the program will generate a documentation form with the corresponding changes.
Note:This procedure should be performed simultaneously with Anesthesia Units Procedure 400, where leak testing of the vaporizer has been included with the anesthesia unit.

Qualitative tasks: Chassis/Housing.

Examine the exterior of the vaporizer for cleanliness and general physical condition. Be sure that housings are intact, that all assembly hardware is present and tight, and that there are no signs of spilled liquids or other serious abuse.

AC Plug .

If the vaporizer has an AC plug, examine it for damage. Attempt to wiggle the blades to determine that they are secure. Shake the plug and listen for rattles that could indicate loose screws. If any damage is suspected, open the plug and inspect it.

Line Cord.

Inspect the cord, if so equipped, for signs of damage. If damaged, replace the entire cord, or if the damage is near one end, cut out the defective portion.

Strain Reliefs.

Examine the strain reliefs at both ends of the line cord, if so equipped. Be sure that they hold the cord securely.

Fittings/Connectors.

Examine all gas and liquid fittings and connectors for general condition. Be sure all fittings are tight.

Controls.

Examine all controls for physical condition, secure mounting, and correct motion. Where a control should operate against fixed-limit stops, check for proper alignment, as well as positive stopping. During the course of the inspection, be sure to check that each control performs its proper function. Return all controls to the off position following the test.

Battery .

If so equipped and readily accessible inspect the physical condition of the battery and battery connectors. Operate the battery-powered functions of the vaporizer for several minutes to check that the battery has an adequate charge. Check remaining battery capacity by activating the battery test function or measuring the output voltage. If it is necessary to replace a battery, label it with the date.

Indicators/Displays .

Confirm the operation of all indicators and visual displays on the vaporizer, if so equipped.

Self-Test.

For units with a self-test mode, activate it and determine if the expected response is produced.

Time/Date Settings.

Verify that the time and date settings on the unit are correct.

Network/Wireless Interfaces.

Review measures taken to ensure protection against the potential risks and vulnerabilities to the confidentiality, integrity, and availability of electronic information stored or transmitted by the device or system and verify that preventive measures are still active. For example, are passwords being applied correctly, have operating system and virus protection patches and upgrades been installed, is the device still operating on a VPN (virtual private network) and are wireless security measures still in place. Verify that data backup processes are activated and that data can be retrieved from backups.

Alarms.

If the vaporizer has alarms, operated it in such a way as to activate each audible and visual alarm. If the vaporizer has an alarm-silence feature, check the method of reset (i.e., manual or automatic) against the manufacturer's specifications.

Audible Signals.

If the vaporizer has audible signals, operate it in such a way as to activate the signals. Confirm appropriate volume, as well as the operation of a volume control, if so equipped.

Interlocks.

Check that the vaporizer interlock allows activation of only one vaporizer at a time.

Labeling.

Check that all necessary placards, labels, conversion charts, and instruction cards are present and legible.

Site Glass, O-Rings, Keyed Filler Mechanism .

Examine the physical condition of the site glass, O-rings, and keyed filler mechanism, if so equipped.

Accessories.

Verify that all necessary features and accessories have been supplied with the vaporizer. A copy of the operators and service manuals (electronic or hard copy), including schematics, should be shipped with the

equipment. Manuals should be filed in the central equipment file and clinical instructions should be kept in the patient care area for easy access by clinicians.

Quantitative tasks: Grounding Resistance.

Measure the resistance between the grounding pin of the power cord (if so equipped) and exposed (unpainted and not anodized) metal on the chassis. Grounding resistance should not exceed 0.5 Ω. If the unit is double insulated, grounding resistance need not be measured.

Concentration Check.

Record the type and control number of each vaporizer. Because there are various types of halogenated anesthetic analyzers, follow the manufacturer's procedure for setup and use of the analyzer.
Vaporizers should usually be tested with an oxygen flow of 4 to 5 L/min (nitrous oxide may affect the readings of some vapor analyzers). Test the vaporizers at low, medium, and high concentration settings in the normal clinical use range (e.g., 0.5%, 1.0%, and 3.0% for halothane). At one concentration setting (e.g., 1.0% for halothane, 10% for desflurane), test the vaporizer at another flow (e.g., 1 L/min). The concentration should be ±0.3% vapor or ±10% of the selected value, whichever is greater. [If errors in concentration are observed, allow the vaporizer to operate for a minute or two and recheck the unit. Some units may require a short stabilization period.]

Preventive Maintenance: Clean.

Clean the exterior.

Replace.

Replace the battery, if indicated.

Change.

Change CO2 absorbent if the procedure or investigation results in excessive gas flow through the carbon dioxide absorber.