Ventilators

1. Preventive Maintenance Qualitative Tests

a. Chassis/Housing: Examine the exterior of the unit for cleanliness and general physical condition. Be sure that plastic housings are intact, that all hardware is present and tight, and that there are no signs of spilled liquids or serious abuse.

b. Mount/Fasteners: If the device is mounted on a stand or cart, examine the condition of the mount. If it attached to the wall, or rests on a shelf, check the security of the attachment.

c. Casters/Brakes: If the device moves on casters, check their condition. Look for accumulations of lint and thread around the casters, and be sure that they turn and swivel, as appropriate. Check the operation of brakes and swivel locks, if the unit is so equipped.

d. AC Plug/Receptacles: Examine the AC power plug for damage. Attempt to wiggle the blades to check 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. Should the equipment be placed on a cart that has extra electrical receptacles for other equipment, insert AC plugs into each and verify they are firmly held. Verify that no damage is present in the cart receptacles.

e. Line Cord: Inspect the cord for signs of damage. If damaged, replace the entire cord or if the damage is near one end, cut out the defective portion. Wire a new power cord or plug on the same polarity. Check the line cords of battery chargers.

f. Strain Reliefs: Examine the strain reliefs at both ends of the line cord. Be sure that they hold the cord securely. If the line cord is detachable, we recommend that the cord be affixed to the unit so that it cannot be removed by the operator.

g. Circuit Breaker/Fuse: If the device has a switch-type circuit breaker, check that it moves freely. If the device is protected by an external fuse, check its value and type against that marked on the chassis and ensure that a spare is provided.

h. Tubes / Hoses / Bulbs: Check the condition of all tubing, cuff, hoses, and bulbs (if present). Be sure that are not cracked, kinked or dirty. Inspect all oxygen orifices to make sure that they are clear and free of foreign matter.

i. Cables: Inspect the cables of sensors, electrodes, remote control and their strain reliefs and general conditions. Carefully examine cables to detect breaks in the insulation and to ensure that they are gripped securely in the connectors at each end to prevent rotation or other strain.

j. Fittings / Connectors: Examine all fittings and electrical cable connectors for general condition. Electrical contact pins or surfaces should be straight and clean. Fittings should be tight and should not leak. If keyed connectors are used, make sure that the keying is correct.

k. Electrodes/Probes: Confirm that special paddles and electrodes are available if appropriate for the area of use. Examine all paddles and probes for physical conditions and cleanliness. Should the equipment have fluids, dried electrode gel or debris on it, inform the clinical staff. Clean paddles and electrode surfaces if needed and ensure they are completely dry before testing.

Ensure that probe labels clearly identify the associated units. Improperly interchanged probes of different types or from different manufacturers may adversely affect temperature control. Confirm that any necessary transducers (if applicable) are on hand and check their physical condition.

l. **Filters**: If the device has a switch-type circuit breaker, check that it moves freely. If the device is protected by an external fuse, check its value and type against that marked on the chassis and ensure that a spare is provided. Clean filter.

m. **Controls/ Switches:** Before changing any controls or alarm limits, check their position any settings appear inordinate (e.g., alarm limits at the ends of their range), consider the possibility of inappropriate clinical use or of incipient device failure. Record the settings of those controls that should be returned to their original positions following the inspection. Examine all controls and switches for physical condition, secure mounting, and correct motion. Check that control knobs have not slipped on their shafts. Where a control should operate against fixed-limit stops, check for proper alignment, as well as positive stopping. Check membrane switches for membrane damage (e.g., from fingernails, pens). During the course of the inspection, be sure to check that each control and switch performs its proper function.

n. **Water Traps:** Verify or replace filter of the water trap and o rings.
*Make sure that the filter is correctly installed.

o. **Motor/Fan/Pump**: Inspect fan blades for deterioration and damage. Ensure fan is securely attached to drive shaft and that the coupling is present and intact. Check that clearance between the fans and housing are adequate by looking for signs of rubbing. In some cases, an improperly inserted control module and heater assembly in the incubator base has bent and disabled fan. Verify whether if fan requires lubrication or not. Observe the fan in operation to determine if there are excessive vibrations or wobbling.

p. **Compressor:** Verify the hours of use if the compressor is available.

q. **Battery / Charger:** Inspect the physical condition of batteries and battery connectors, if readily accessible. Check operation of battery-operated power-loss alarms, if so equipped. Operate the unit on battery power for several minutes to check that the battery is charged and can hold a charge. (The inspection can be carried out on battery power to help confirm adequate battery capacity.) Check battery condition by activating the battery test function or measuring the output voltage. Check the condition of the battery charger and, to the extent possible, confirm that it does, in fact, charge the battery. Be sure that the battery is recharged or charging when the inspection is complete. Some batteries require periodic deep discharges and recharging to maintain a maximum battery capacity. If this is recommended by the manufacturer, verify that it is being performed on schedule.

r. **Indicators/Displays:** During the course of the inspection, confirm the operation of all lights, indicators, and visual displays on the unit and charger, if so equipped. Be sure that all segments of a digital display function properly.

s. **User Calibration/Self-Test**: Verify operation of these features, if applicable.

t. **Alarms**: Operate the device in a way that activates all the alarms. Check that any associated interlocks function. Check action of disconnected-probe alarm, if unit so equipped. If the device has an alarm-silence feature, check the reset method.

u. **Audible Signals:** Operate the device to activate any audible signals. Confirm appropriate volume, as well as the operation of a volume control, if so equipped. If audible alarms have been silenced or the volume set too low, alert clinical staff to the importance of keeping alarms at the appropriate level.

v. **Labeling:** Check that all necessary labels, conversion charts, and instruction cards are present and legible.

w. **Accessories:** Confirm the presence and condition of accessories. Check for the proper type of accessory.

2. Preventive Maintenance Electrical Safety Test

a. **Grounding Resistance:** Using an ohmmeter, electrical safety analyzer, or multimeter with good resolution of fractional ohms, measure and record the resistance between the grounding pin of the power cord and exposed (unpainted and not anodized) metal on the chassis. We recommend a maximum of 0.5 Ohms.

b. **Leakage Current:** Measure chassis leakage current to ground with the grounding conductor of plug-connected equipment temporarily opened. Operate the device in all normal modes, including on, standby, and off, and record the maxi- mum leakage current. Chassis leakage current to ground should not exceed 300µA.

3. Preventive Maintenance: Components Check based on Hours Used

a. For the ventilator, after 250 hours of use clean the cooling fan filters and inspect thoroughly.

b. For the compressor, after 250 hours of use clean the cooling fan filters and inspect thoroughly.

c. For the ventilator, if 2,500 hours PM, check and/or change the various components that may apply based on ventilator's manufacturer and model. Use the 2,500 PM kit to perform this PM.

d. For the compressor, if 2,500 hours PM, check and/or change the various components that may apply based on ventilator's manufacturer and model. Use the 2,500 PM kit to perform this PM.

e. For the ventilator, if 10,000 hours PM, check and/or change the various components that may apply based on ventilator's manufacturer and model. Use the 10,000 PM kit to perform this PM.

f. For the compressor, if 10,000 hours PM, check and/or change the various components that may apply based on ventilator's manufacturer and model. Use the 10,000 PM kit to perform this PM.

4. Preventive Maintenance: Cleaning and Calibration

a. Clean the exterior and interior of the ventilator

b. Calibrate if needed

5. Quantitative Tests

a. Memory Codes: Check for error code stored in memory. Memory codes should be written in the PM form together with its dates and times.

b. EST Codes: Check for error codes that where presented during an Extended Self Test (EST). To run the EST press button and write EST codes in the PM form together with its dates and times.

c. Gas Supply System Test: This test verifies the performance of the oxygen and air supply system. Using the Gas Flow Analyzer measurements should 9.9- 11.0 PSIG. Check wall air, oxygen and compressor if available.

d. Peak Inspiratory Flow Test: This test verifies the correct inspiratory flow. Oxygen Max Flow- Using the Gas Flow analyzer the measurements should be ≥162 LPM.

Wall Air: verify the measurements that should be > 162 LPM.
Compressor Max Flow: verify the measurements that should be>110 LPM.
Compressor Min Pressure, Max Flow: verify the minimum pressure when the compressor is at Max Flow that should be > 7.4 PSIG.

e. High Pressure Alarm: verifies the High Pressure limit alarm.

Set the alarm to 95 cmH_2O and verify the pressure difference between the test instant and the ventilator's is ≤ 7cmH_2O.

Set the alarm 60cmH_2O and verify the pressure difference between the test instrument and the ventilator's is ≤ 4.5cmH_2O.

f. Gas Volume Accuracy Test: verifies the accuracy of the volume of the gas delivered to the patient.

Set oxygen volume to .25L target should be .22- 0.30L
Set oxygen volume to 1.5L target should be 1.40 – 1.75L
Set Air volume to 1.5L target should be 1.44 – 1.82L
Set Air volume to .25L target should be 0.23 – 0.30L

g. Sensitivity Accuracy Test: verifies the accuracy of the sensitivity measurement.

Set sensitivity to 10cmH_2O and the target should be -9 to -11cmH_2O on the Bar Graph.
Set sensitivity to 5cmH_2O and the target should be -4 to -6cmH_2O on the Bar Graph.
Set sensitivity to 0.5cmH_2O and the target should be -0.5cmH_2O.

h. PEEP System Test: test verifies the performance of the PEEP System. "Positive End Expiratory Pressure"

Set PEEP to 10cmH_2O and the target should be 8-12cmH_2O.
Set PEEP to 30cmH_2O and the target should be 27- 33cmH_2O.
Set PEEP to maximum and the target should be >45cmH_2O.

i. Oxygen Percentage Accuracy: this test verifies the accuracy of the percentage of oxygen delivered to the patient. The test instrument must be calibrated to measure oxygen percentage accurately.

Set the O_2 to 30% w/square wave the target should be ± 3%.
Set the O_2 to 30% w/ramp wave the target should be ± 3%.
Set the O_2 to 60% w/ramp wave the target should be ± 3%.
Set the O_2 to 60% w/square wave the target should be ± 3%.
Set the O_2 to 80% w/square wave the target should be ± 4%.
Set the O_2 to 80% w/sine wave the target should be ± 4%.

j. Control Settings: these tests are performed by attaching the ventilator to a lung

Simulator or ventilator tester and comparing measured values of:
Tidal Volume- it should be (+/- 10%) of the chosen parameter. (Tidal Volume VT is normally 500mls.
Rate- should be (+/- 1BPM) of difference of the chosen parameter.

k. I:E Ratio: these test is to verify the ratio of inspiration to expiration in relation to the rate. These tests are performed by attaching the ventilator to a lung simulator or ventilator tester.

Example:
If the machine rate = 10BPM, this would produce a total inspiratory/ expiratory time of 6 seconds. By setting the I:E Ratio to 1:1 , this equalizes the inspiration on exhalation times at 3 seconds each, by
following equation: **I/E : E/E or 3/3: 3/3 or 1:1**