

# HUMIDIFICATION OF A VENTILATOR CIRCUIT USING CAPILLARY FORCE VAPORIZATION (C-Force™)

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## INTRODUCTION

As water undergoes phase transition from liquid to gas, a one hundred fold plus expansion in volume may occur. Capillary force vaporization (CFV) utilizes phase transition to generate heated water vapor from liquid<sup>1</sup>. The device consists of two porous layers (Figure 1 inset). The bottom layer is an insulated, large pore material that wicks liquid upward. As the liquid reaches the top layer, applied heat causes vaporization. Water vapor generated by this method can be used to condition inspired gases in a respiratory circuit.

## OBJECTIVE

To compare a device using CFV (C-Force™; Pari Respiratory Equipment, Midlothian, VA) to conventional humidification systems during mechanical ventilation.

## METHODS

The C-Force™ device was integrated into a modified ventilator circuit to measure water vapor delivery (Figure 1). The device consists of a water pump and a heater plate designed to sit at the Y-piece. The heater plate was set at 130°C. The water pump rate was adjusted to achieve a Y-piece temperature of 35°C, as measured by a thermocouple from a conventional humidification system. A condenser tube was used to condense and measure some of the water vapor generated.

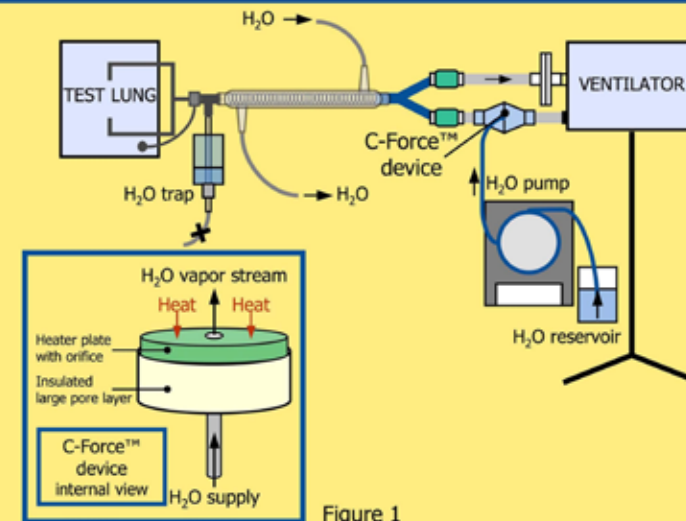


Figure 1

Hygrometric measurements were made and used to determine the absolute humidity (AH) of the gas, which escaped the condenser. Using the AH, the amount of water vapor which escaped the condenser was calculated. This allowed us to determine the amount of water delivered. In addition, we measured the amount of water each device consumed from its water reservoir in order to determine device efficiency (H<sub>2</sub>O delivered/H<sub>2</sub>O consumed). The same was done for a non-heated wire (NHHW) and heated wire humidifier (HWH). Experiments were performed using three different ventilators (Drager 4 NeoFlow, Puritan Bennett 7200, T-Bird AVS III) and two different breathing patterns (V<sub>T</sub>=750, RR=15 and V<sub>T</sub>=400, RR=15).

## RESULTS

As shown in figure 2, C-Force™ delivered 15.0±2.0, 15.7±0.8, and 8.7±0.5 mL water/hr at V<sub>T</sub>=400, and 30.7±0.3, 28.9±1.0, and 16.9±1.2 mL water/hr at V<sub>T</sub>=750 using the Drager, PB7200 and T-Bird ventilators respectively.

Figure 3 shows the efficiency for each device. HWH and C-Force™ had similar efficiencies while using the Drager and PB7200 ventilators. Both were more efficient than NHHW. Efficiency was reduced when using the T-Bird and C-Force™ in combination.

## DISCUSSION

Using the PB7200 and Drager ventilators, C-Force™ provided a greater amount of water delivery than NHHW and HWH, with similar efficiency to HWH, and greater efficiency than NHHW. The device provided gas under alveolar conditions at 37°C, carrying 44 mg H<sub>2</sub>O/L air (29.7 mL H<sub>2</sub>O/hr for V<sub>T</sub>=750, RR=15, and 15.8 mL/hr for V<sub>T</sub>=400, RR=15).

With the T-Bird ventilator, the C-Force™ had a reduced capacity to humidify inspired gas. This may be due to bias flow, which for the T-Bird was set at 10 L/minute. Bias flow consists of volume flow in addition to the minute ventilation which will take up water vapor provided by a humidification device, therefore impairing device performance and efficiency. Similar results were obtained for conventional systems during ventilation with bias flow, however, C-Force™ was affected to a greater degree.

Because C-Force™ uses sterile water more efficiently than conventional devices, it may be more cost effective. In addition, its position in the inspiratory line prevents inspiratory line condensation, or "rain out", which requires labor intensive draining and may act as a reservoir for infection.

## CONCLUSIONS

C-Force™:

- ✓ is an effective method for generating water vapor to condition inspiratory gases
- ✓ provides adequate humidification, while eliminating inspiratory line condensation
- ✓ uses sterile water more efficiently, making it more cost effective compared to NHHW and HWH
- ✓ is sensitive to bias flow which impairs humidification device performance

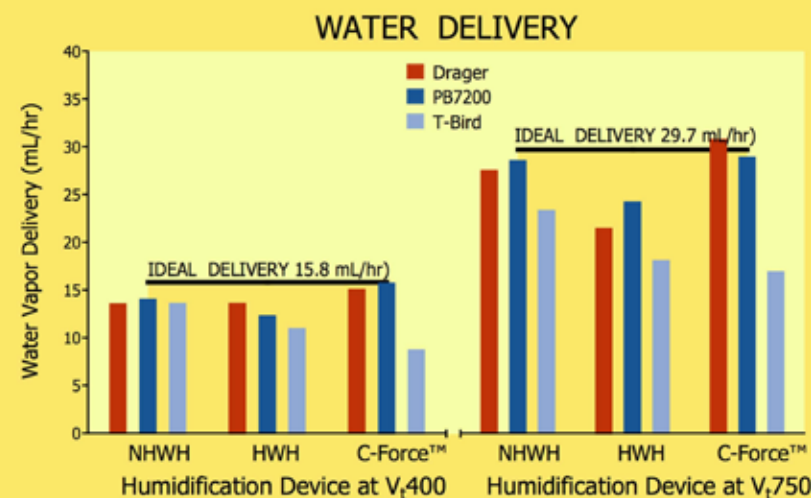


Figure 2

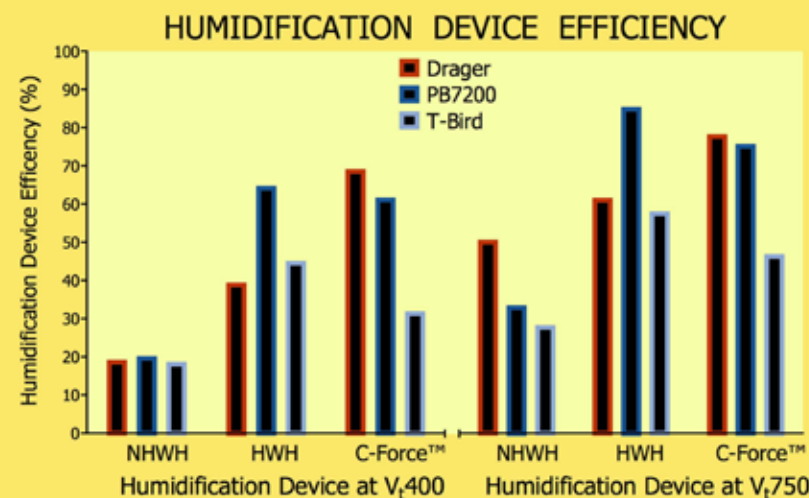


Figure 3

### REFERENCES:

<sup>1</sup>RDD Europe 2005, Vol 1, (2005): pp 229-232

<sup>2</sup>Proc Am Thorac Soc. 2006; 3:A143

SUPPORTED IN PART BY:

Pari Respiratory Equipment, Midlothian, VA