

# Aerosol Density

Density is the mass of a substance per unit volume. Concentration is the amount (numerical value) of a component in a given area or volume. When delivering an aerosolized medication there is a linear relationship between density and concentration. A denser aerosol delivers a higher concentration of a drug. Simply put, more drug is available in a dense aerosol, because a higher volume of medication is delivered. This assumes that the denser aerosol is generated with a larger percentage of its particles in the respirable range. In aerosol medicine, density is a function of; (1) the rate at which particles are generated; (2) the size and shape of the device in which they are generated; (3) the flowrate at which particles are evacuated; and (4) the rate of evaporation which is immeasurable.

The mechanics of breathing dictate that the denser an aerosol is in the first one-third of inspiration the higher the concentration of a drug will reach the area of the lung where it can be most effective. This is true because in the initial one-third portion of inspiration the change in flow rates are greatest and the largest volume of gas is recruited to fill the lungs.

When breathing an aerosol from a nebulizer, as the inspiratory phase progresses, the flow rate often overcomes the atomizer's ability to generate particles and maintain density. Most medical nebulizers have some reservoir function by design and will therefore have a higher density in the aerosol delivered at the onset of inspiration. As inspiration continues the bulk of particles are drawn off and density tapers down as a function of the flow rate and the rate of particle generation.

Given the dynamics of breathing and particle generation, it is obvious that drug delivery is a product of the density of the aerosol, the rate, depth and flow of inspiration, particle size and nebulizer output. Thus, the measurement of density is an integral component of assessing a nebulizer's performance. It is important to remember that nebulizer output does not have a linear correlation to aerosol density. Output may increase at the expense of density unless particle generation can accelerate in response to outflow.

## Method Rationale

Since drug delivery is a function of density, the most direct assessment of density is the measurement of the concentration of drug delivered per unit time. In order to quantify density we used Sodium Fluoride (NaF) as a tag in a diluent of normal saline. NaF was used because it disperses evenly in the saline solution and its ionic charge can be quantified by an ion/pH meter. Because we use a set volume and number of breaths, we know the total inspired volume of air through the filter. Since we know the starting concentration of the ionic solution and can measure the total deposition of ions on the filter, we can extrapolate the density in grams per unit volume of the aerosol delivered. This test is a qualitative test, not a quantitative test. Its accuracy is dependent upon the efficiency of the filter, the volume and flow rate of the aerosol through the tube, and the size range of the particles being tested. It is a good method for assessing total aerosol delivery, ergo density, but it cannot account for in-vivo deposition.

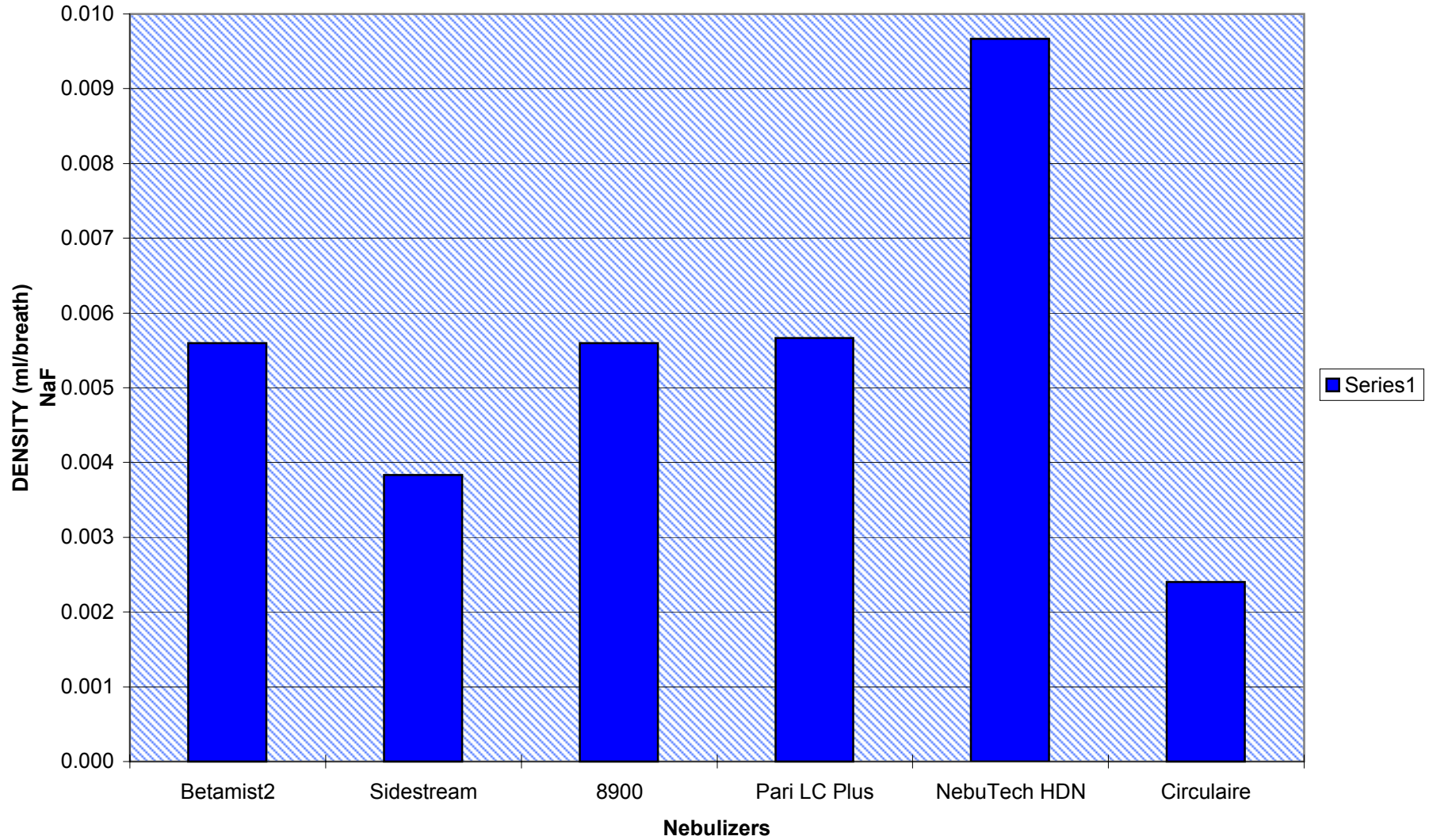
## Conclusion

If all nebulizers delivered their entire aerosol in the respirable range there would still be a difference from one device to another in actual medication output. Nebulizers which are open to the atmosphere or are unable to recycle non-respirable particles will not have the same level of drug delivery as the NebuTech<sup>®</sup> HDN<sup>®</sup>.

Furthermore, since the NebuTech HDN draws inhaled air through a reservoir of densely packed respirable particles, it creates a superior dense aerosol plume as demonstrated by the bar graph.

In this study the entire output of each device was captured in a manner which mimics the respiratory cycle, only aerosol which would have been inspired is represented by the bar graphs.

## Performance Comparison DENSITY



Test Specifications: Comparison tests were performed at 50 psi source pressure at 7 lpm flow with 0.5m NaF.