Cascade Impactor Study Comparing the Amsino OneMask™ Oxygen Mask and Predicate Mask from Hudson RCI on a Human Model

Abstract

This in vitro study compares drug delivery efficiencies of a new mask device to that of a predicate mask device when placed on a human model using an Anderson Cascade Impactor. The objective is to compare the mask deposition mass, coarse particle mass, respirable mass, fine particle mass, Mass Median Aerodynamic Diameter (MMAD) and Geometric Standard Deviation (GSD) of the Adult Amsino OneMask™ Oxygen Mask (Amsino International, Inc., Pomona, CA) and the Adult Hudson RCI Neb-U-Mask System (Teleflex Inc., Research Triangle Park, NC).

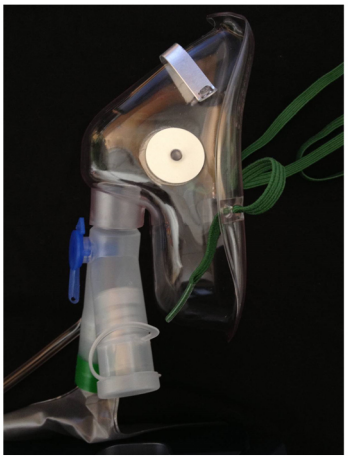
The predicate was chosen based on similar design features which include the ability to administer drug therapeutics via a nebulizer or Metered Dose Inhalers (MDIs). The masks were tested using three different therapeutic drugs: Albuterol Sulfate (beta-agonist bronchodilator), Ipratropium Bromide (anti-cholinergic bronchodilator), and Budesonide (anti-inflammatory).

Each mask was tested on a human model, using an Anderson Cascade Impactor, for each drug, administered both by nebulizer and MDI in triplicate for a total of 36 separate cascade impactor trials. The study design utilized a modified Prestan Adult CPR-AED Manikin (PP-AM-100M-MS) for the representative patient model connected to an Anderson Cascade Impactor with a constant flow of 28.3 lpm. The nebulizer trials used commercially available off-the-shelf jet nebulizer, the Hudson RCI Micro-Mist nebulizer (Research Triangle Park, NC). In each trial the nebulizer was powered with medical grade oxygen at 8 L/min for a treatment time of 3-5 minutes, depending on the drug. MDI trials used commercially available MDIs with oxygen delivered to the masks at 8 lpm during MDI actuation. MDIs were actuated a total of 10 times for each trial.

Analysis of cascade impactor stage drug content was performed by HPLC on a Dionex Ultimate 3000 nano HPLC, equipped with Dionex UVD-3000 UV/VIS detector (Thermo Scientific, Sunnyvale, CA).

Introduction

Both the Amsino OneMask™ Adult Oxygen Mask and the Neb-U-Mask System are combination devices that allow for the delivery of aerosolized medication via nebulizer or Metered Dose Inhalers, MDI's, while providing oxygen therapy. Each mask features an over the nose enclosed design with elastic straps to hold the masks in position on the patients face. The Amsino OneMask™ Adult Oxygen Mask is equipped with a single opening near the mouth to allow patients to imbibe food or drink during oxygen or nebulization therapy. The Neb-U-Mask System does not have this feature. The purpose of the present study was to determine the total inhaled drug mass, mask deposition mass, coarse particle mass, respirable mass, fine particle mass, Mass Median Aerodynamic Diameter (MMAD) and Geometric Standard Deviation (GSD) using an Anderson Cascade Impactor for aerosol particle size characterization. The masks were tested using three different therapeutic drugs: Albuterol Sulfate (beta-agonist bronchodilator), Ipratropium Bromide (anti-cholinergic bronchodilator), and Budesonide (anti-inflammatory) each delivered via nebulizer and MDI. Table 1 shows pictures of each mask and some key features of each mask design.

Masks		
	New Proposed - OneMask™	Predicate - Neb-U-Mask
Picture		
Mask Features		
Manufacturer	Amsino	Hudson RCI
Model	OneMask™ Oxygen Mask	Neb-U-Mask
Length (cm)*	12.7	13.2
Width (cm)*	7.9	8.2
Mask Volume (ml)**	115	143
Surafce Area of Openings (cm^2)*	7.2 (port near mouth)	1.15 (two valved side ports)

* Mask dimensions and openings are approximate due to irregular design

** Mask volume measured by filling mask w ith w ater

Table 1: *General Features of the Aerosol Mask.*

Study Design

The study was designed to evaluate device performance utilizing a jet nebulizer and metered dose inhalers on a simulated patient model via Anderson Cascade impactor.

The testing platform utilizes an eight stage non-viable Anderson Cascade Impactor (Thermo Fisher Scientific; Waltham, MA) integrated to a CPR mannequin to serve as the patient model. A Gast rotary-vane vacuum pump, calibrated to 28.3 lpm, was used to drive the Anderson Cascade Impactor. The mask was placed onto the mannequin and secured via the equipped elastic strap.

For the nebulizer trials, a Hudson RCI MicroMist nebulizer was filled, depending on the trial, using one of the following: Ventolin Nebules (GlaxoSmithKline), 2.5mg / 2.5 ml salbutamol sulfate IP (total volume 5 ml per trial), Atrovent Nebules (Boehringer Ingelheim), 500µg / 2.5 ml ipratropium bromide IP (total volume 5ml per trial), or Pulmicort Respules (AstraZeneca), 500µg / 2.5 ml Budesonide IP (total volume 5ml per trial). The jet nebulizer was weighed before fill, after fill and post-test to determine overall mass balance of the system. First, the filled nebulizer was fitted into the mask. Then the vacuum pump powering the cascade impactor was turned on and the oxygen feed to the jet nebulizer was initiated (8 L/min) and run for 3-5 minutes. Next, the mask (including valve body), throat, and all stages of the cascade impactor were rinsed with a quantity of appropriate solvent (HPLC mobile phase). Finally, the samples were then analyzed for drug content via HPLC with UV detection.

For the MDI trials, one of three different MDI's were used: Ventolin Evohaler (GlaxoSmithKline), 100µg / actuation salbutamol sulfate IP (total of 10 actuations per trial), Atrovent HFA (Boehringer Ingelheim), 20µg / actuation ipratropium bromide IP (total of 10 actuations per trial), or Pulmicort HFA (AstraZeneca), 200µg / actuation budesonide IP (total of 10 actuations per trial). The MDI was

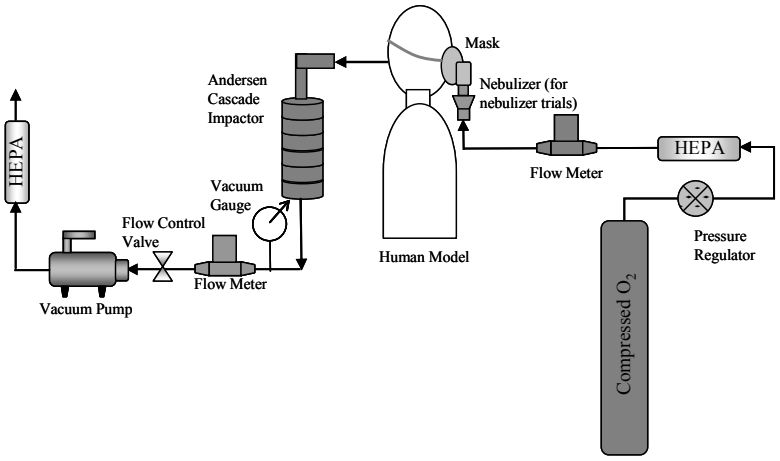


Figure 1: *Flow Diagram for Cascade Impactor Testing*

weighed before and after each trail. The vacuum pump powering the cascade impactor was turned on and the oxygen feed to the mask was initiated (8 lpm). The MDI was shaken well between each actuation and actuated a total of 10 times for each trial. The mask (including valve body), throat, and all stages of the cascade impactor were rinsed with a quantity of appropriate solvent (HPLC mobile phase).

All sample extractions were placed in labeled 12x32mm glass HPLC auto-sampler vials and analyzed for drug content via HPLC. Samples were stored refrigerated (approximately 2°C) until HPLC analysis. Figure 1 shows the flow diagram for the testing.

The test matrix for the study consists of a total of 36 independent trials. Each mask was tested in triplicate for each of three drugs for nebulizer delivery and metered dose inhaler delivery. Table 2 shows the complete test matrix for all trials for both the Amsino OneMask™ Oxygen Mask and the Neb-U-Mask System.

Nebulizer Testing Matrix

Test	Mask	Nebulizer	Nebulizer Flow (lpm)	Dose	Drug	Time	Trials
1	Amsino OneMask™	Hudson Micro Mist	8	5ml	Albuterol Sulfate (2.5mg/2.5ml)	3 min	triplicate
2	Neb-U-Mask	Hudson Micro Mist	8	5ml	Albuterol Sulfate (2.5mg/2.5ml)	3 min	triplicate
3	Amsino OneMask™	Hudson Micro Mist	8	5ml	Ipratropium Bromide (0.5mg/2.5ml)	5 min	triplicate
4	Neb-U-Mask	Hudson Micro Mist	8	5ml	Ipratropium Bromide (0.5mg/2.5ml)	5 min	triplicate
5	Amsino OneMask™	Hudson Micro Mist	8	5ml	Budesonide (0.5mg/2.5ml)	5 min	triplicate
6	Neb-U-Mask	Hudson Micro Mist	8	5ml	Budesonide (0.5mg/2.5ml)	5 min	triplicate

MDI Testing Matrix

Test	Mask	MDI	Oxygen Flow (lpm)	Drug	Acctuations	Trials
1	Amsino OneMask™	Ventolin Evohaler	8	Albuterol Sulfate (100µg/actuation)	10	triplicate
2	Neb-U-Mask	Ventolin Evohaler	8	Albuterol Sulfate (100µg/actuation)	10	triplicate
3	Amsino OneMask™	Atrovent HFA	8	Ipratropium Bromide (20µg/actuation)	10	triplicate
4	Neb-U-Mask	Atrovent HFA	8	Ipratropium Bromide (20µg/actuation)	10	triplicate
5	Amsino OneMask™	Pulmicort HFA	8	Budesonide (200µg/actuation)	10	triplicate
6	Neb-U-Mask	Pulmicort HFA	8	Budesonide (200µg/actuation)	10	triplicate

Table 2: *Test Matrices for all trials.*

Patient Model

The test bed utilized a modified Prestan Adult CPR-AED Manikin (PP-AM-100M-MS) for the representative patient model connected to an Anderson Cascade Impactor. The mannequin was modified by manufacturing a custom molded PVC throat tube (1/2" ID x 5.5") and fitting it inside the head of the mannequin. The throat tube is then press-fit into the Anderson USP throat. Figure 3 below shows the human model with the Amsino OneMask™ Adult Oxygen Mask and Anderson Cascade Impactor attached.

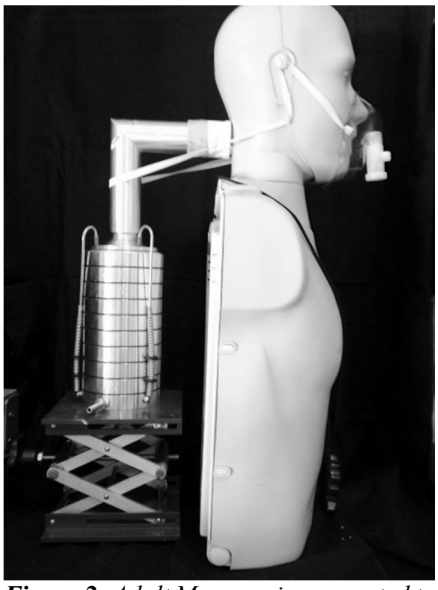


Figure 2: *Adult Mannequin connected to Anderson Cascade Impactor.*

Sample Collection

Samples were collected from the mask, throat and each stage of the cascade impactor for all runs. Nebulizer samples were also collected for the nebulizer trails. Samples were recovered in the appropriate mobile phase of a set volume. The rinse fluid volumes used was based on observance of the linearity of the calibration curve and extraction technique. Nebulizer samples were diluted with mobile phase at a 1:9 dilution before being analyzed. Cascade impactor filters were rinsed in mobile phase and filtered through 0.45um nylon syringe filters before being analyzed. All samples were archived refrigerated until analysis.

Drug Analysis

All drug content analysis was performed using a Dionex Ultimate 3000 nano-HPLC equipped with a Dionex UVD-3000 multi-wavelength UV/VIS Detector using a micro flow cell (75um x 10mm path length, total analytical volume 44.2 nl).

The column used for the albuterol sulfate and budesonide analysis was a Vydac 238DE5.315 (0.3mm ID x 150mm) C18 monomeric, 100A (USP L1) column with a column flow rate of 10µl/min at a nominal pressure of 206 bar. Total HPLC run time was 10 minute per sample with approximately 5 minutes flush between each sample. Sample injection was performed with a 1 µl sample loop in full loop injection mode. Detection was with UV at 276nm for albuterol sulfate and 254nm for Budesonide.

A Thermo Electron Beta-Basic-18 (0.32mm ID x 100mm) C18 monomeric, 100A (USP L1) column with a flow rate of 15µl/min at a nominal pressure of 202 bar was used for ipratropium bromide analysis. Total HPLC run time was 6 min per sample with approximately 5 minutes flush between each sample. Sample injection was performed with a 1 µl sample loop in full loop injection mode. Detection was with UV at 220nm.

Data acquisition and analysis were performed using Chromeleon 6.8 SR11 Build 3161 with GLP compliance client features installed.

HPLC Method and Standards

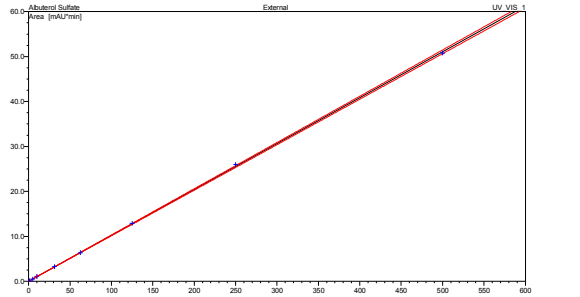
US Pharmacopeial monograph USP29nf24s_m1218 was followed as a reference method for analysis of albuterol sulfate. Briefly, the method involved dilution of an appropriate formulation of albuterol sulfate in mobile phase; 60% buffer and 40% HPLC grade methanol (Acros Organics, lot# 1154574). Buffer formulation contains reverse-osmosis filtered deionized water with 1.13gr of sodium 1-hexanesulfonate (Alfa Aesar, lot# 10159201) in 1200 ml of water, with 2 ml glacial acetic acid (Acros Organics, lot# A0317484) added. The mobile phase solution was mixed and filtered through a 0.45um filter membrane. The final mobile phase is a 60:40 dilution of Buffer:MEOH.

US Pharmacopeial monograph USP31nf26s1_m42380 was followed as a reference method for analysis of ipratropium bromide. Briefly,

the method involved dilution of an appropriate formulation of ipratropium bromide in mobile phase; 87% buffer and 13% methanol. Buffer formulation contains reverse osmosis filtered deionized water with 14.3g of monobasic sodium phosphate dihydrate (MP, lot # MR28909) and 2.0g tetra-n-propylammonium chloride (Alfa Aesar, lot# L21W016) in 1,000 ml of water, adjust pH to 5.5 with solution containing 8.9g / 100ml dibasic sodium phosphate (Acros Organics, lot# A0312739).The mobile phase solution was mixed and filtered through a 0.45um filter membrane. The final mobile phase is a 87:13 dilution of Buffer:MEOH.

Albuterol Sulfate Standards Calibration Curve

Sample Name:	**Albuterol Sulfate**	**Injection Volume:**	**1**
Vial Number:	**RA1**	**Channel:**	**UV_VIS_1**
Sample Type:	**Standard**	**Wavelength:**	**276**
Control Program:	**Vydack 315 column**	**Bandwidth:**	**n.a.**
Quantif. Method:	**default**	**Dilution Factor:**	**1**
Run Time (min):	**5**	**Sample Amount:**	**1 ul**



No.	Peak Name	Cal.Mode	Cal.Type	Offset	Slope	RF-Value	Std.Dev.	R-Square %
1	Albuterol Sulfate	Total	Lin	0	0.09300	10.709	0.074	99.998

No.	Name	Sample Type	Pos	Inj.Vol. µl	Ref. Amount Set (ug/ml)	Concentration ug/ml UV_VIS_1	Peak Start Code UV_VIS_1	Signal:Noise UV_VIS_1
1	Albuterol, 0.001 mg/ml	standard	RA1	1.0	1	1.0275	B	3.2
2	Albuterol, 0.005 mg/ml	standard	RA2	1.0	5	5.1268	B	14.7
3	Albuterol, 0.01 mg/ml	standard	RA3	1.0	10	10.6717	B	41.9
4	Albuterol, 0.03125 mg/ml	standard	RA4	1.0	31.25	31.8349	B	94.9
5	Albuterol, 0.0625 mg/ml	standard	RA5	1.0	62.5	62.3909	B	188.7
6	Albuterol, 0.125 mg/ml	standard	RA6	1.0	125	126.3855	B	283.5
7	Albuterol, 0.25 mg/ml	standard	RA7	1.0	250	254.3209	B	466.5
8	Albuterol, 0.5 mg/ml	standard	RA8	1.0	500	500.2844	B	762.8

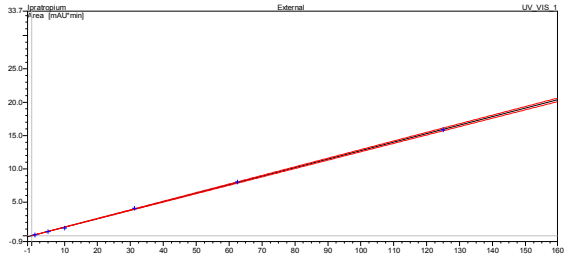
Table 3: *Albuterol Sulfate Calibration Standards and Linear Regression showing 95% confidence levels (red).*

US Pharmacopeial monograph for budesonide was used as a reference method for analysis of budesonide. Briefly, the method involved dilution of an appropriate formulation of budesonide in mobile phase; 68% buffer and 32% HPLC grade acetonitrile (Acros Organics, lot# B00M1129). Aqueous buffer includes 3.17 mg/ml monobasic sodium phosphate (MP Biomedical, Lot# MR28909) and 0.23 mg/ml of phosphoric acid (Across Organics, lot# A0305025). pH is 3.2 ±0.1. All US Pharmacopeial monographs were followed without deviation.

Standard preparation includes making a stock concentration of 500µg/ml of albuterol sulfate, 250µg/ml of ipratropium bromide and 250µg/ml of budesonide in it respective mobile phase. These stock concentrations were diluted to make a 7-point serial dilution for use as calibration standards for each drug.

Ipratropium Bromide Standards Calibration Curve

Sample Name:	**Ipratropium Bromide**	**Injection Volume:**	**1**
Vial Number:	**RA1**	**Channel:**	**UV_VIS_1**
Sample Type:	**Standard**	**Wavelength:**	**276**
Control Program:	**BioBasic 18**	**Bandwidth:**	**n.a.**
Quantif. Method:	**default**	**Dilution Factor:**	**1**
Run Time (min):	**5**	**Sample Amount:**	**1 ul**



No.	Peak Name	Cal.Mode	Cal.Type	Offset	Slope	RF-Value	Std.Dev.	R-Square %
1	Ipratropium	Total	Lin	0	0.127	7.849	0.093	99.977

No.	Name	Sample Type	Pos	Inj.Vol. µl	Ref. Amount Set (ug/ml)	Concentration ug/ml UV_VIS_1	Peak Start Code UV_VIS_1	Signal:Noise UV_VIS_1
1	Ipratropium 1ug/ml	standard	RC1	1.0	1	0.941	B	10.2
2	Ipratropium 5ug/ml	standard	RC2	1.0	5	5.0719	B	60.4
3	Ipratropium 10ug/ml	standard	RC3	1.0	10	10.1674	B	81.7
4	Ipratropium 31.25 ug/m	standard	RC4	1.0	31.25	32.2562	B	310.9
5	Ipratropium 62.5 ug/ml	standard	RC5	1.0	62.5	63.4498	B	599.2
6	Ipratropium 125 ug/ml	standard	RC6	1.0	125	125.3126	B	1247.9
7	Ipratropium 250 ug/ml	standard	RC7	1.0	250	249.4726	B	2406.9

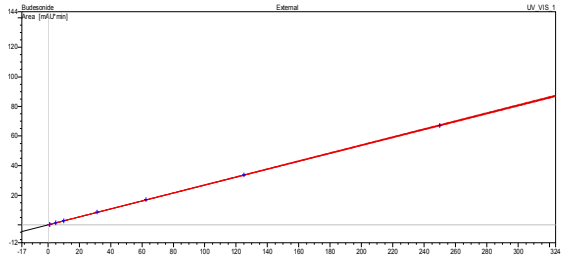
Table 4: Ipratropium Bromide *Calibration Standards and Linear Regression showing 95% confidence levels (red).*

The concentrations of the standards used are: 1, 5, 10, 31.25, 62.5, 125 and 250 µg/ml concentrations. The calibration curve was plotted for peak area of the analyte against the corresponding concentrations. Linear regression (with forced zero intercept) analysis within Chromeleon 6.8 was used for all standards curve fit. The correlation coefficient (R-squared) for each albuterol sulfate, ipratropium bromide and budesonide were 0.99998, 0.99977 and 0.99995 respectively.

The calibration curves showed excellent linearity across the entire calibration standard range for all drugs. Table 3, 4 and 5 show the linear calibration curve generated in Chromeleon with 95% confidence levels in red for each drug.

Budesonide Standards Calibration Curve

Sample Name:	Budesonide	**Injection Volume:**	1
Vial Number:	RA1	**Channel:**	UV_VIS_1
Sample Type:	Standard	**Wavelength:**	254
Control Program:	Vydack 315 column 10ul 32ACN 68Buff	**Bandwidth:**	n.a.
Quantif. Method:	default	**Dilution Factor:**	1
Run Time (min):	10	**Sample Amount:**	



No.	Peak Name	Cal.Mode	Cal.Type	Offset	Slope	RF-Value	Std.Dev.	R-Square %
1	Budesonide	Total	Lin	0	0.26900	3.717	0.168	99.995

No.	Name	Sample Type	Pos	Inj.Vol. µl	Ref. Amount Set (ug/ml)	Concentration ug/ml UV_VIS_1	Peak Start Code UV_VIS_1	Signal:Noise UV_VIS_1
1	Budesonide 1ug/ml	standard	RA1	1.0	1	0.941	B	3.3
2	Budesonide 5ug/ml	standard	RA2	1.0	5	5.0719	B	12.5
3	Budesonide 10ug/ml	standard	RA3	1.0	10	10.1674	B	20
4	Budesonide 31.25ug/ml	standard	RA4	1.0	31.25	32.2562	B	52.2
5	Budesonide 62.5ug/ml	standard	RA5	1.0	62.5	63.4498	B	56.9
6	Budesonide 125ug/ml	standard	RA6	1.0	125	125.3126	B	196.8
7	Budesonide 250ug/ml	standard	RA7	1.0	250	249.4726	B	361.1

Table 5: *Budesonide Calibration Standards and Linear Regression showing 95% confidence levels (red).*

Limit of Detection and Limit of Quantification

The sensitivity of the method was determined by estimating the Limits Of Detection (LOD) and of Quantification (LOQ) for each drug.

A routine and accepted method to determine LOD and LOQ is based on signal-to-noise ratios of the peaks. Samples with signal-to-noise ratios corresponding to 3 are accepted as LOD and samples with signal-to-noise ratio values of 10 are accepted as LOQ values.

	Albuterol	Ipratropium	Budesonide
LOD (µg/ml)	1.0	0.5	1.0
LOQ (µg/ml)	<5	1.0	<5

Table 6: *LOD and LOQ Estimation based on S:N Ratios.*

Prepared samples with 1 µg/ml of each drug were analyzed. The signal-to-noise, S/N, ratio for albuterol sulfate, ipratropium bromide and budesonide were 3.2, 10.2 and 3.3 respectively. Prepared samples with 5µg/ml of each drug were analyzed. The signal-to-noise ratio for albuterol sulfate, ipratropium bromide and budesonide were 14.7, 60.4 and 12.5 respectively. Table 6 below shows the Estimated LOD and LOQ values for each drug based on S/N ratios obtained from Chromeleon. S/N ratios can be found in figure 3, 4 and 5.

Statistical Analysis

Mean and standard deviation were calculated for all triplicate trial sets for each component of: nebulizer drug fill, total delivered dose, mask deposition, course particle dose, course particle fraction, respirable particle dose, respirable particle fraction, fine particle dose, fine particle fraction, aerosol MMAD and GSD

Results: Nebulizer Trials

Results show that the new Amsino OneMask™ Adult Oxygen Mask outperformed the Neb-U-Mask System for delivered respirable particle dose for albuterol sulfate and ipratropium bromide trials.

The Amsino OneMask™ Oxygen Mask and Neb-U-Mask system had a mean ± standard deviation respirable particle dose of 651.2 ± 29.2 µg and 598.2 ±34.5 µg respectively for albuterol sulfate. The Amsino OneMask™ Oxygen mask and Neb-U-Mask system had a respirable particle dose of 120.2 ± 2.7 µg and 108.0 ± 5.5 µg respectively for ipratropium bromide. Respirable particle dose for budesonide was 234.3 ± 5.4 µg and 248.9 ± 22.0 µg for the Amsino OneMask™ Oxygen Mask and Neb-U-mask system respectively.

The Amsino OneMask™ delivered a mean respirable particle dose of 108.9% for albuterol sulfate and 111.3% for Ipratropium bromide when compared to the Neb-U-mask system. The Rollin7 delivered 94.1% of the budesonide respirable particle dose when compared to the Neb-U-mask system. Figure 3 below shows the mean respirable particle dose for all trials.

The slight performance difference seems to be linked to the MMAD of the specific aerosol. Although both masks are substantially equivalent concerning respirable particle delivered dose, it is interesting to note that aerosols with a smaller MMAD appear to have slightly higher delivery efficiency on the Amsino OneMask™ Oxygen Mask than on the Neb-U-Mask system.

All other features are comparable with only two notable differences: Mask deposition and coarse particle dose. Mask deposition differences appear to be to due to the fact that the Neb-U-Mask system employs a spring loaded valve in-between the nebulizer and the mask. This valve collects nebulized fluid due to increased impaction of the larger aerosol particles.

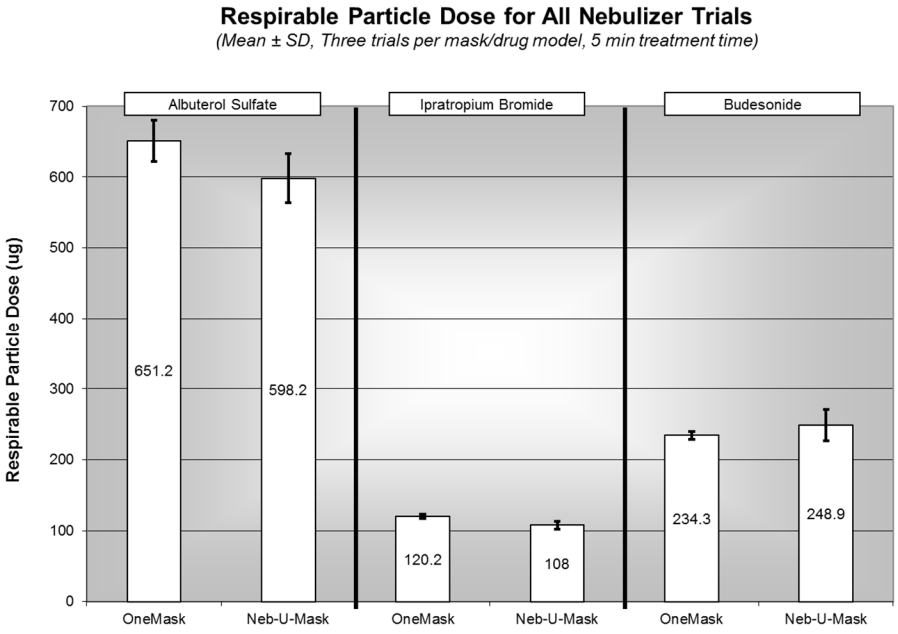


Figure 3: *Respirable Particle Dose for All Nebulizer Trials, mean ± SD.*

The rinse of the mask includes this spring loaded valve assembly into fluid which increases the mask deposition values. Additionally, the coarse particle dose and fraction are lower in the Neb-U-Mask system when compared to the Amsino OneMask™ Oxygen Mask. This appears to verify that the valve in the Neb-U-Mask system is acting as an impaction surface to remove some of the larger particles. It is also evident that since the Amsino OneMask™ Oxygen Mask has a higher respirable particle dose than that of the Neb-U-Mask, we can assume that the Neb-U-Mask valve is also collecting a small fraction of the respirable particles as well.

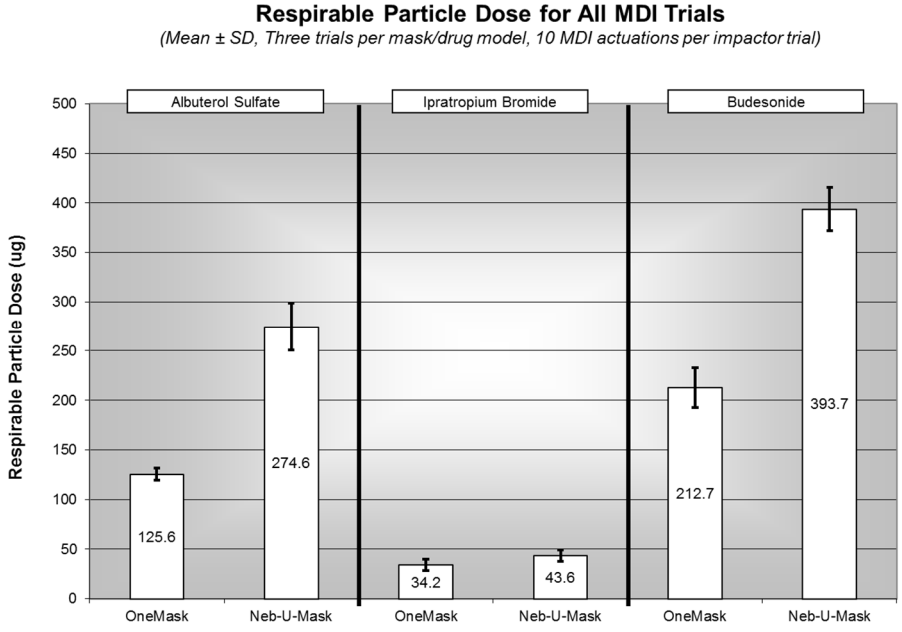


Figure 4: *Respirable Particle Dose for All MDI Trials, mean ± SD*

Overall, the Amsino OneMask™ delivers a substantially equivalent respirable dose to the patient for all drugs tested. Table 7 shows results for nebulizer drug fill, total delivered dose, mask deposition, course particle dose, course particle fraction, respirable particle dose, respirable particle fraction, fine particle dose, fine particle fraction, aerosol MMAD and GSD for all trials.

Results: MDI Trials

Results show that the new Amsino OneMask™ Adult Oxygen Mask underperformed the Neb-U-Mask System for respirable particle delivered dose for all MDI drug trials.

The Amsino OneMask™ Oxygen Mask and Neb-U-Mask system had a mean ± standard deviation respirable dose of 125.6 ± 5.8 µg and 274.6 ± 24.0 µg respectively for albuterol sulfate. The Amsino OneMask™ Oxygen mask and Neb-U-Mask system had a respirable dose of 34.2 ± 5.7 µg and 43.6 ± 5.5 µg respectively for ipratropium bromide. Respirable dose for budesonide was 212.7 ± 20.0 µg and 394.7 ± 22.0 µg for the Amsino OneMask™ Oxygen Mask and Neb-U-mask system respectively when using a metered dose inhaler.

Nebulizer Testing Summary

Features	Drug	New OneMask Adult	Predicate Neb-U-Mask
Nebulizer Fill (ug)	Albuterol	2510.7 +/- 24.0	2472.1 +/- 40.7
	Ipratropium	947.5 +/- 3.0	927.3 +/- 20.9
	Budesonide	2039.8 +/- 18.6	2032.6 +/- 27.8
Total Delivered Dose (ug)	Albuterol	877.3 +/- 42.8	988.1 +/- 40.4
	Ipratropium	162.0 +/- 1.4	145.9 +/- 5.9
	Budesonide	385.3 +/- 7.7	435.3 +/- 65
Mask Deposistion (ug)	Albuterol	42.3 +/- 16.9	300.7 +/- 67.6
	Ipratropium	13.8 +/- 1.7	145.9 +/- 5.9
	Budesonide	11.4 +/- 1.6	65.3 +/- 15.2
Coarse Particle Dose (ug) *(>4.7um)*	Albuterol	128.1 +/- 33.2	11.9 +/- 2.5
	Ipratropium	17.2 +/- 0.5	3.3 +/- 0.6
	Budesonide	83.6 +/- 10.4	54.2 +/- 31.2
Coarse Particle Frac (%) *(>4.7um)*	Albuterol	15.8% +/- 3.6%	1.9% +/- 0.5%
	Ipratropium	11.7% +/- 0.2%	2.7 +/- 0.5%
	Budesonide	26% +/- 2.9%	17% +/- 8.2%
Respirable Particle Dose (ug) *(0.4-4.7 um)*	Albuterol	651.2 +/- 29.4	598.2 +/- 34.5
	Ipratropium	120.2 +/- 2.7	108.0 +/- 5.5
	Budesonide	234.3 +/- 5.4	248.9 +/- 22
Respirable Particle Frac (%) *(0.4-4.7 um)*	Albuterol	80.7% +/- 3.2%	93.1% +/- 1.1%
	Ipratropium	81.8% +/- 0.2%	90.4 +/- 0.5%
	Budesonide	73% +/- 2.8%	81.4% +/- 7.8%
Fine Particle Dose (ug) *(<0.4um)*	Albuterol	28.6 +/- 12.1	32.4 +/- 7.6
	Ipratropium	9.6 +/- 0.4	8.1 +/- 0.2
	Budesonide	3.2 +/- 0.5	4.8 +/- 1
Fine Particle Frac (%) *(<0.4um)*	Albuterol	3.5% +/- 1.4%	5% +/- 1.1%
	Ipratropium	6.5% +/- 0.3%	6.8 +/- 0.1%
	Budesonide	1.0% +/- 0.2%	1.6% +/- 0.6%
MMAD (um)	Albuterol	2.06 +/- 0.13	1.64 +/- 0.08
	Ipratropium	1.87 +/- 0.07	1.65 +/- 0.07
	Budesonide	3.03 +/- 0.12	2.97 +/- 0.31
GSD (um)	Albuterol	2.66 +/- 0.14	1.98 +/- 0.05
	Ipratropium	2.54 +/- 0.05	2.06 +/- 0.02
	Budesonide	2.10 +/- 0.04	2.14 +/- 0.14
Confidence level of testing		The test and number of samples (3) tested provide 95% confidence level	

All values Mean +/- SD

MDI Testing Summary

Features	Drug	New OneMask Adult	Predicate Neb-U-Mask
Total Delivered Dose (ug)	Albuterol	245.2 +/- 26.5	486.2 +/- 35.6
	Ipratropium	143.2 +/- 6.2	158.9 +/- 6
	Budesonide	389.4 +/- 43.5	732.2 +/- 36.2
Mask Deposistion (ug)	Albuterol	99.3 +/- 17.4	176.1 +/- 10.6
	Ipratropium	37.2 +/- 0.6	40.3 +/- 2.8
	Budesonide	119.1 +/- 9	198 +/- 33.8
Coarse Particle Dose (ug) *(>4.7um)*	Albuterol	12.7 +/- 3.8	19.1 +/- 8.7
	Ipratropium	27.3 +/- 3.5	33.7 +/- 2.1
	Budesonide	61.3 +/- 10.9	126.3 +/- 11
Coarse Particle Frac (%) *(>4.7um)*	Albuterol	8.7% +/- 2.1%	6.2% +/- 2.5%
	Ipratropium	33.7% +/- 5.8%	28.7% +/- 3.8%
	Budesonide	21.6% +/- 1.8%	23.9% +/- 2.0%
Respirable Particle Dose (ug) *(0.4-4.7 um)*	Albuterol	125.6 +/- 5.8	274.6 +/- 24.0
	Ipratropium	34.2 +/- 5.7	43.6 +/- 5.5
	Budesonide	212.7 +/- 20.2	393.7 +/- 21.9
Respirable Particle Frac (%) *(0.4-4.7 um)*	Albuterol	87.1% +/- 1.4%	91.6% +/- 1.5%
	Ipratropium	41.8% +/- 3.5%	37.1% +/- 5.4%
	Budesonide	75.4% +/- 1.3.0%	74.3% +/- 2.1%
Fine Particle Dose (ug) *(<0.4um)*	Albuterol	6.0 +/- 0.8	6.3 +/- 2.6
	Ipratropium	20.1 +/- 4.1	40.6 +/- 11.5
	Budesonide	8.3 +/- 1.5	9.7 +/- 0.8
Fine Particle Frac (%) *(<0.4um)*	Albuterol	4.2% +/- 0.7%	2.2% +/- 1.1%
	Ipratropium	24.6% +/- 4.2%	34.2% +/- 7.8%
	Budesonide	3% +/- 0.6%	1.8% +/- 0.1%
MMAD (um)	Albuterol	2.50 +/- 0.13	2.51 +/- 0.08
	Ipratropium	1.30 +/- 0.18	1.36 +/- 0.30
	Budesonide	3.12 +/- 0.06	3.45 +/- 0.06
GSD (um)	Albuterol	2.01 +/- 0.05	1.88 +/- 0.09
	Ipratropium	6.54 +/- 0.67	5.06 +/- 0.48
	Budesonide	2.12 +/- 0.15	1.97 +/- 0.04
Confidence level of testing		The test and number of samples (3) tested provide 95% confidence level	

All values Mean +/- SD

Table 5: *Testing Results for all trials (Mean ± SD), N=3.*

The Amsino OneMask™ delivered 45.7% of albuterol sulfate and 54.0% of Ipratropium bromide of the respirable dose when compared to the Neb-U-mask system when using the MDI. The Amsino OneMask™ delivered 78.4% of the budesonide respirable dose when compared to the Neb-U-mask system when using the MDI. Figure 4 shows the mean respirable particle dose for all MDI trials.

Conclusions: *Nebulizer Performance*

Results show that the newly proposed Amsino OneMask™ Adult Oxygen Mask outperformed the Southmedic OxyMulti Mask for two of the three drugs when considering the respirable delivered dose to the patient. The Amsino OneMask™ mask slightly under performed the Neb-U-Mask system for ipratropium bromide respirable dose using a nebulizer. Overall, the new proposed mask's respirable dose delivery is substantially equivalent to the predicate mask. Table 7 lists all results for both mask's nebulizer performance.

Conclusions: *MDI Performance*

Results show that the newly proposed Amsino OneMask™ Adult Oxygen Mask had a patient respirable dose of about 50% compared to the Neb-U-Mask system for albuterol sulfate and budesonide when administered by MDIs. The Amsino OneMask™ Oxygen mask performed better with the ipratropium bromide MDI, having a patient delivered respirable dose of 78.4% that of the Neb-U-Mask system. Using two actuations from the MDI would alleviate the underperformance and deliver substantially equivalent respirable dose to the patient.

Table 7 list all results for both mask's MDI performance.

Document Revision

December 2016 – Updated manufacture data from original report

References

Aerosol Research and Engineering Laboratories Inc. *Analytical Report for Cascade Impactor Analysis Certificate of Analysis and GLP Statement for project #10766.1*

Reviewer Guidance for Nebulizers, Metered Dose Inhalers, Spacers and Actuators. FDA Office of Device Evaluation. 1993.

William C. Hinds. *Aerosol technology: Properties, Behavior, and Measurement of Airborne Particles*. John Wiley & Sons. 1999. pg 243.

Appendix A

Individual Cascade Reduction Data for Each Nebulizer Trial

Amsino OneMask™ Oxygen Mask, Nebulizer Performance, Albuterol Sulfate

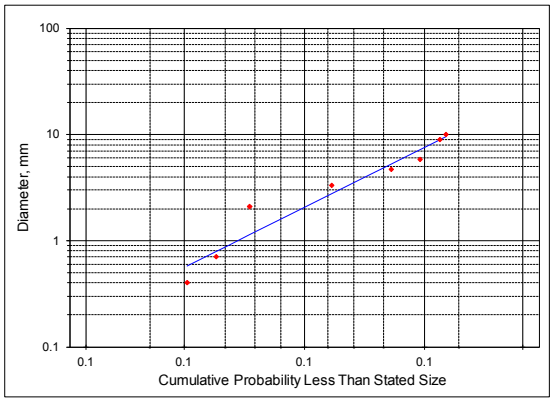
8-STAGE ANDERSON IMPACTOR DATA REDUCTION

Trial Name: Albuterol - OneMask - Nebulizer - 1 Test Date: 06/21/12

Mask: OneMask
Nebulizer: Hudson Micro-Mist Nebulizer
Drug: Albuterol

Neb Flow: 8 lpm
Anderson Flow: 28.3 lpm
Calibrated: 06/18/12
Nebulized Fluid: 1.1232 ml
Drug Concentration: 1,000 ug/ml
Nebulizer Time: 3.25 min

STAGE NO.	Cut Diam. µm	Recovery Mass, µg	Mass/Stage %	Cum. % >	Cum. % <
0	10	*45.45*	6.00	6.00	94.00
1	9	*55.10*	7.27	7.27	92.73
2	5.8	*21.17*	2.79	10.07	89.93
3	4.7	*45.68*	6.03	16.10	83.90
4	3.3	*151.94*	20.06	36.15	63.85
5	2.1	*261.14*	34.47	70.62	29.38
6	0.7	*91.95*	12.14	82.76	17.24
7	0.4	*69.75*	9.21	91.97	8.03
FILTER	0	*15.39*	2.03	94.00	6.00
	Total	***757.6***	µg		



Total Delivered Dose = 757.6 µg

MMAD = 2.06 µm
Geometric Std.Dev. = 2.66 µm

Coarse Particles (>4.7um) = 121.7 µg
Coarse particle Fraction (>4.7um) = 16.07 %

Respirable Dose (0.4-4.7um) = 620.5 µg
Respirable Frac (0.4-4.7um) = 81.90 %

Fine Particle (<0.4um) = 15.4 µg
Fine Particle Fraction (<0.4um) = 2.03 %

Mask and Throat Deposistion = 39.1 µg

Respiratory Delivery Rate (0.4-4.7um) = 190.9 µg/min

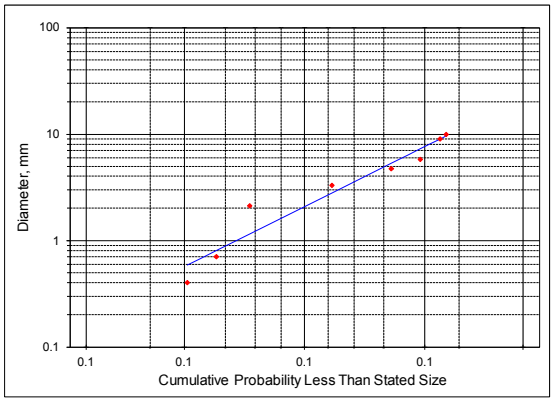
8-STAGE ANDERSON IMPACTOR DATA REDUCTION

Trial Name: **Albuterol - OneMask - Nebulizer - 2** Test Date: 10/17/12

Mask: OneMask
Nebulizer: Hudson Micro-Mist Nebulizer
Drug: Albuterol

Neb Flow: 8 lpm
Anderson Flow R: 28.3 lpm
Calibrated: 10/04/12
Nebulized Fluid: 0.9397 ml
Drug Concentration: 1,000 ug/ml
Nebulizer Time: 3.00 min

STAGE NO.	Cut Diam. µm	Recovery Mass, µg	Mass/Stage %	Cum. % >	Cum. % <
0	10	*41.58*	5.09	5.09	94.91
1	9	*42.82*	5.24	5.24	94.76
2	5.8	*14.08*	1.72	6.97	93.03
3	4.7	*39.44*	4.83	11.80	88.20
4	3.3	*188.03*	23.02	34.82	65.18
5	2.1	*299.07*	36.62	71.44	28.56
6	0.7	*93.97*	11.51	82.94	17.06
7	0.4	*58.49*	7.16	90.10	9.90
FILTER	0	*39.25*	4.81	94.91	5.09
	Total	***816.7***	µg		



Total Delivered Dose = 816.7 µg

MMAD = 1.92 µm
Geometric Std.Dev. = 2.52 µm

Coarse Particles (>4.7um) = 98.5 µg
Coarse particle Fraction (>4.7um) = 12.06 %

Respirable Dose (0.4-4.7um) = 679.0 µg
Respirable Frac (0.4-4.7um) = 83.14 %

Fine Particle (<0.4um) = 39.2 µg
Fine Particle Fraction (<0.4um) = 4.81 %

Mask and Throat Deposistion = 59.5 µg

Respiratory Delivery Rate (0.4-4.7um) = 226.3 µg/min

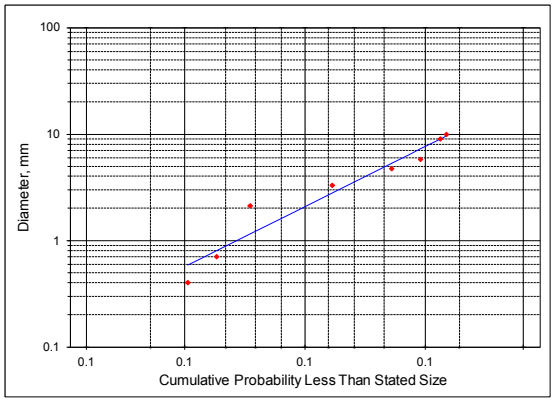
8-STAGE ANDERSON IMPACTOR DATA REDUCTION

Trial Name: **Albuterol - OneMask - Nebulizer - 3** Test Date: 10/17/12

Mask: OneMask
Nebulizer: Hudson Micro-Mist Nebulizer
Drug: Albuterol

Neb Flow: 8 lpm
Anderson Flow R: 28.3 lpm
Calibrated: 10/04/12
Nebulized Fluid: 0.9876 ml
Drug Concentration: 1,000 ug/ml
Nebulizer Time: 3.00 min

STAGE NO.	Cut Diam. µm	Recovery Mass, µg	Mass/Stage %	Cum. % >	Cum. % <
0	10	*60.93*	7.17	7.17	92.83
1	9	*70.33*	8.28	8.28	91.72
2	5.8	*32.77*	3.86	12.14	87.86
3	4.7	*70.75*	8.33	20.46	79.54
4	3.3	*197.32*	23.23	43.69	56.31
5	2.1	*257.89*	30.36	74.05	25.95
6	0.7	*77.63*	9.14	83.19	16.81
7	0.4	*50.64*	5.96	89.15	10.85
FILTER	0	*31.24*	3.68	92.83	7.17
	Total	***849.5***	µg		



Total Delivered Dose = 849.5 µg

MMAD = 2.18 µm
Geometric Std.Dev. = 2.79 µm

Coarse Particles (>4.7um) = 164.0 µg
Coarse particle Fraction (>4.7um) = 19.31 %

Respirable Dose (0.4-4.7um) = 654.2 µg
Respirable Frac (0.4-4.7um) = 77.01 %

Fine Particle (<0.4um) = 31.2 µg
Fine Particle Fraction (<0.4um) = 3.68 %

Mask and Throat Deposistion = 71.1 µg

Respiratory Delivery Rate (0.4-4.7um) = 218.1 µg/min

Neb-U-Mask System, Nebulizer Performance, Albuterol Sulfate

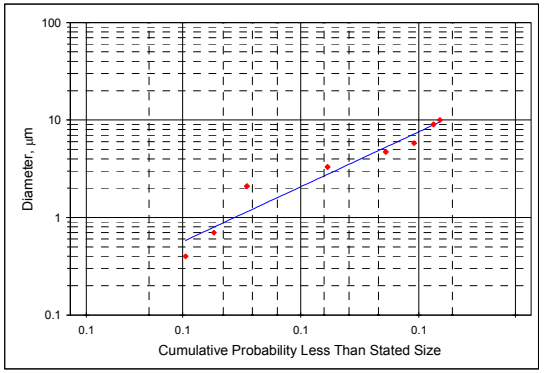
8-STAGE ANDERSON IMPACTOR DATA REDUCTION

Trial Name: Albuterol - Neb-U-Mask - Nebulizer - 1 Test Date: 06/21/12

Mask: Neb-U-Mask
Nebulizer: Hudson Micro-Mist Nebulizer
Drug: Albuterol

Neb Flow: 8 lpm
Anderson Flow Ra: 1 lpm
Calibrated: 06/18/12
Nebulized Fluid: 1.2188 ml
Drug Concentration: 1,000 ug/ml
Nebulizer Time: 3.00 min

STAGE NO.	Cut Diam. µm	Recovery Mass, µg	Mass/Stage %	Cum. % >	Cum. % <
0	10	6.565	1.09	1.09	98.91
1	9	5.497	0.91	0.91	99.09
2	5.8	2.720	0.45	1.36	98.64
3	4.7	23.300	3.87	5.23	94.77
4	3.3	129.447	21.48	26.71	73.29
5	2.1	243.809	40.46	67.18	32.82
6	0.7	112.987	18.75	85.93	14.07
7	0.4	49.324	8.19	94.11	5.89
FILTER	0	28.913	4.80	98.91	1.09
		602.6 µg			



Total Delivered Dose = 602.6 µg

MMAD = 1.69 µm
Geometric Std.Dev. = 2.03 µm

Coarse Particles (>4.7um) = 14.8 µg
Coarse particle Fraction (>4.7um) = 2.45 %

Respirable Dose (0.4-4.7um) = 558.9 µg
Respirable Frac (0.4-4.7um) = 92.75 %

Fine Particle (<0.4um) = 28.9 µg
Fine Particle Fraction (<0.4um) = 4.80 %

Mask and Throat Deposistion = 378.9 µg

Respiratory Delivery Rate (0.4-4.7um) = 186.3 µg/min

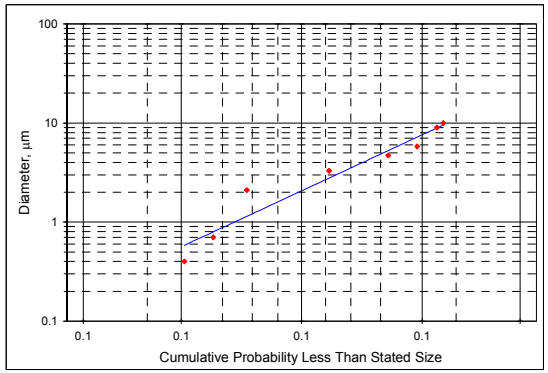
8-STAGE ANDERSON IMPACTOR DATA REDUCTION

Trial Name: Albuterol - Neb-U-Mask - Nebulizer - 2 Test Date: 06/21/12

Mask: Neb-U-Mask
Nebulizer: Hudson Micro-Mist Nebulizer
Drug: Albuterol

Neb Flow: 8 lpm
Anderson Flow Ra: 28.3 lpm
Calibrated: 06/18/12
Nebulized Fluid: 1.1517 ml
Drug Concentration: 1,000 ug/ml
Nebulizer Time: 3.00 min

STAGE NO.	Cut Diam. µm	Recovery Mass, µg	Mass/Stage %	Cum. % >	Cum. % <
0	10	3.881	0.59	0.59	99.41
1	9	5.104	0.77	0.77	99.23
2	5.8	1.610	0.24	1.02	98.98
3	4.7	12.599	1.91	2.92	97.08
4	3.3	140.786	21.29	24.21	75.79
5	2.1	306.339	46.32	70.53	29.47
6	0.7	100.083	15.13	85.67	14.33
7	0.4	63.693	9.63	95.30	4.70
FILTER	0	27.207	4.11	99.41	0.59
		661.3 µg			



Total Delivered Dose = 661.3 µg

MMAD = 1.68 µm
Geometric Std.Dev. = 1.93 µm

Coarse Particles (>4.7um) = 10.6 µg
Coarse particle Fraction (>4.7um) = 1.60 %

Respirable Dose (0.4-4.7um) = 623.5 µg
Respirable Frac (0.4-4.7um) = 94.28 %

Fine Particle (<0.4um) = 27.2 µg
Fine Particle Fraction (<0.4um) = 4.11 %

Mask and Throat Deposistion = 243.2 µg

Respiratory Delivery Rate (0.4-4.7um) = 207.8 µg/min

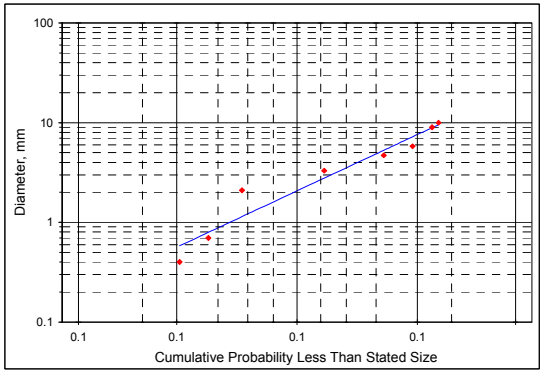
8-STAGE ANDERSON IMPACTOR DATA REDUCTION

Trial Name: Albuterol - Neb-U-Mask - Nebulizer - 3 Test Date: 06/21/12

Mask: Neb-U-Mask
Nebulizer: Hudson Micro-Mist Nebulizer
Drug: Albuterol

Neb Flow: 8 lpm
Anderson Flow Ra: 28.3 lpm
Calibrated: 06/18/12
Nebulized Fluid: 1.1578 ml
Drug Concentration: 1,000 ug/ml
Nebulizer Time: 3.00 min

STAGE NO.	Cut Diam. µm	Recovery Mass, µg	Mass/Stage %	Cum. % >	Cum. % <
0	10	3.015	0.45	0.45	99.55
1	9	5.100	0.77	0.77	99.23
2	5.8	2.257	0.34	1.11	98.89
3	4.7	8.640	1.30	2.41	97.59
4	3.3	114.385	17.23	19.64	80.36
5	2.1	307.979	46.40	66.04	33.96
6	0.7	109.741	16.53	82.58	17.42
7	0.4	71.396	10.76	93.34	6.66
FILTER	0	41.219	6.21	99.55	0.45
		663.7 µg			



Total Delivered Dose = 663.7 µg

MMAD = 1.55 µm
Geometric Std.Dev. = 1.98 µm

Coarse Particles (>4.7um) = 10.4 µg
Coarse particle Fraction (>4.7um) = 1.56 %

Respirable Dose (0.4-4.7um) = 612.1 µg
Respirable Frac (0.4-4.7um) = 92.23 %

Fine Particle (<0.4um) = 41.2 µg
Fine Particle Fraction (<0.4um) = 6.21 %

Mask and Throat Deposistion = 294.1 µg

Respiratory Delivery Rate (0.4-4.7um) = 204.0 µg/min

Amsino OneMask™ Oxygen Mask, Nebulizer Performance, Ipratropium Bromide

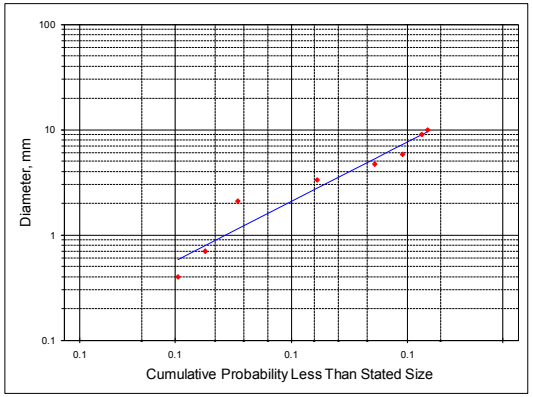
8-STAGE ANDERSON IMPACTOR DATA REDUCTION

Trial Name: **Ipratropium - OneMask - Nebulizer - 1** Test Date: 10/28/12

Mask: OneMask
Nebulizer: Hudson Micro-Mist Nebulizer
Drug: Ipratropium

Neb Flow: 8 lpm
Anderson Flow Ra: 28.3 lpm
Calibrated: 10/16/12
Nebulized Fluid: 1.5858 ml
Drug Concentration: 250 ug/ml
Nebulizer Time: 5.02 min

STAGE NO.	Cut Diam. µm	Recovery Mass, µg	Mass/Stage %	Cum. % >	Cum. % <
0	10	7.074	4.92	4.92	95.08
1	9	6.913	4.81	4.81	95.19
2	5.8	2.677	1.86	6.68	93.32
3	4.7	6.681	4.65	11.33	88.67
4	3.3	30.656	21.34	32.67	67.33
5	2.1	50.509	35.17	67.84	32.16
6	0.7	18.801	13.09	80.93	19.07
7	0.4	10.581	7.37	88.29	11.71
FILTER	0	9.741	6.78	95.08	4.92
	TOTAL	143.6	µg		



Total Delivered Dose = 143.6 µg

MMAD = 1.80 µm
Geometric Std.Dev. = 2.59 µm

Coarse Particles (>4.7um) = 16.7 µg
Coarse particle Fraction (>4.7um) = 11.60 %

Respirable Dose (0.4-4.7um) = 117.2 µg
Respirable Frac (0.4-4.7um) = 81.62 %

Fine Particle (<0.4um) = 9.7 µg
Fine Particle Fraction (<0.4um) = 6.78 %

Mask and Throat Deposistion = 16.7 µg

Respiratory Delivery Rate (0.4-4.7um) = 23.3 µg/min

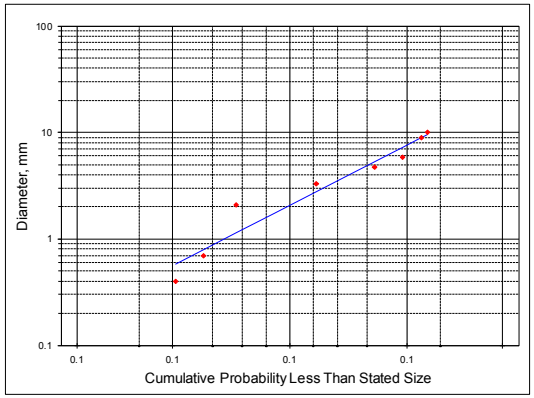
8-STAGE ANDERSON IMPACTOR DATA REDUCTION

Trial Name: **Ipratropium - OneMask - Nebulizer - 2** Test Date: 10/28/12

Mask: OneMask
Nebulizer: Hudson Micro-Mist Nebulizer
Drug: Ipratropium

Neb Flow: 8 lpm
Anderson Flow Ra: 28.3 lpm
Calibrated: 10/16/12
Nebulized Fluid: 1.6602 ml
Drug Concentration: 250 ug/ml
Nebulizer Time: 5.01 min

STAGE NO.	Cut Diam. µm	Recovery Mass, µg	Mass/Stage %	Cum. % >	Cum. % <
0	10	7.668	5.19	5.19	94.81
1	9	6.741	4.56	4.56	95.44
2	5.8	3.179	2.15	6.71	93.29
3	4.7	7.730	5.23	11.94	88.06
4	3.3	32.207	21.79	33.73	66.27
5	2.1	53.889	36.46	70.19	29.81
6	0.7	18.324	12.40	82.58	17.42
7	0.4	8.955	6.06	88.64	11.36
FILTER	0	9.123	6.17	94.81	5.19
	TOTAL	147.8	µg		



Total Delivered Dose = 147.8 µg

MMAD = 1.86 µm
Geometric Std.Dev. = 2.54 µm

Coarse Particles (>4.7um) = 17.6 µg
Coarse particle Fraction (>4.7um) = 11.90 %

Respirable Dose (0.4-4.7um) = 121.1 µg
Respirable Frac (0.4-4.7um) = 81.93 %

Fine Particle (<0.4um) = 9.1 µg
Fine Particle Fraction (<0.4um) = 6.17 %

Mask and Throat Deposistion = 15.0 µg

Respiratory Delivery Rate (0.4-4.7um) = 24.1 µg/min

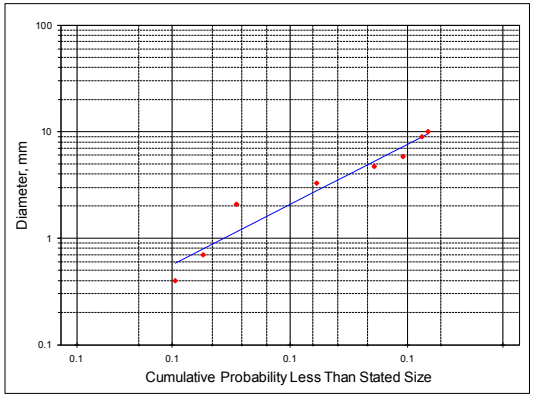
8-STAGE ANDERSON IMPACTOR DATA REDUCTION

Trial Name: **Budesonide-OneMask-Neb-1** Test Date: 10/28/12

Mask: OneMask
Nebulizer: Hudson Micro-Mist Nebulizer
Drug: Ipratropium

Neb Flow: 8 lpm
Anderson Flow R: 28.3 lpm
Calibrated: 10/16/12
Nebulized Fluid: 1.8241 ml
Drug Concentration: 250 ug/ml
Nebulizer Time: 5.02 min

STAGE NO.	Cut Diam. µm	Recovery Mass, µg	Mass/Stage %	Cum. % >	Cum. % <
0	10	5.940	3.97	3.97	96.03
1	9	7.413	4.96	4.96	95.04
2	5.8	3.870	2.59	7.55	92.45
3	4.7	8.472	5.67	13.22	86.78
4	3.3	32.760	21.92	35.14	64.86
5	2.1	55.870	37.38	72.52	27.48
6	0.7	17.262	11.55	84.07	15.93
7	0.4	8.049	5.39	89.46	10.54
FILTER	0	9.815	6.57	96.03	3.97
	TOTAL	149.5	µg		



Total Delivered Dose = 149.5 µg

MMAD = 1.93 µm
Geometric Std.Dev. = 2.50 µm

Coarse Particles (>4.7um) = 17.2 µg
Coarse particle Fraction (>4.7um) = 11.52 %

Respirable Dose (0.4-4.7um) = 122.4 µg
Respirable Frac (0.4-4.7um) = 81.91 %

Fine Particle (<0.4um) = 9.8 µg
Fine Particle Fraction (<0.4um) = 6.57 %

Mask and Throat Deposistion = 13.3 µg

Respiratory Delivery Rate (0.4-4.7um) = 24.4 µg/min

Neb-U-Mask System, Nebulizer Performance, Ipratropium Bromide

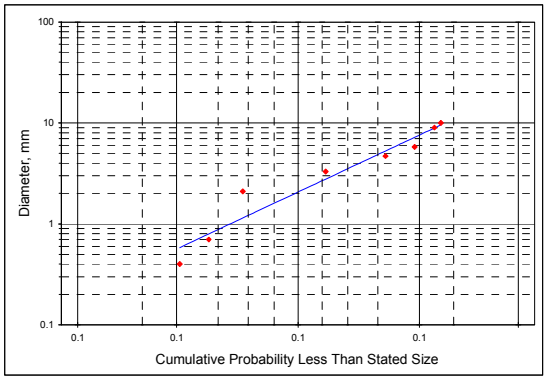
8-STAGE ANDERSON IMPACTOR DATA REDUCTION

Trial Name: Budesonide - Neb-U-Mask - Nebulizer - 1 Test Date: 06/21/12

Mask: Neb-U-Mask
Nebulizer: Hudson Micro-Mist Nebulizer
Drug: Budesonide

Neb Flow: 8 lpm
Anderson Flow Ra: 28.3 lpm
Calibrated: 06/18/12
Nebulized Fluid Drug Concentration: 1.7235 ml, 250 ug/ml
Nebulizer Time: 5.01 min

STAGE NO.	Cut Diam. µm	Recovery Mass, µg	Mass/Stage %	Cum. % >	Cum. % <
0	10	1.143	0.99	0.99	99.01
1	9	0.909	0.79	0.79	99.21
2	5.8	0.557	0.48	1.27	98.73
3	4.7	2.496	2.16	3.44	96.56
4	3.3	20.843	18.08	21.52	78.48
5	2.1	51.470	44.65	66.16	33.84
6	0.7	20.195	17.52	83.68	16.32
7	0.4	9.632	8.36	92.04	7.96
FILTER	0	8.034	6.97	99.01	0.99
	TOTAL	115.3	µg		



Total Delivered Dose = 115.3 µg

MMAD = 1.58 µm
Geometric Std.Dev. = 2.04 µm

Coarse Particles (>4.7um) = 2.6 µg
Coarse particle Fraction (>4.7um) = 2.26 %

Respirable Dose (0.4-4.7um) = 104.6 µg
Respirable Frac (0.4-4.7um) = 90.77 %

Fine Particle (<0.4um) = 8.0 µg
Fine Particle Fraction (<0.4um) = 6.97 %

Mask and Throat Deposistion = 27.3 µg

Respiratory Delivery Rate (0.4-4.7um) = 20.9 µg/min

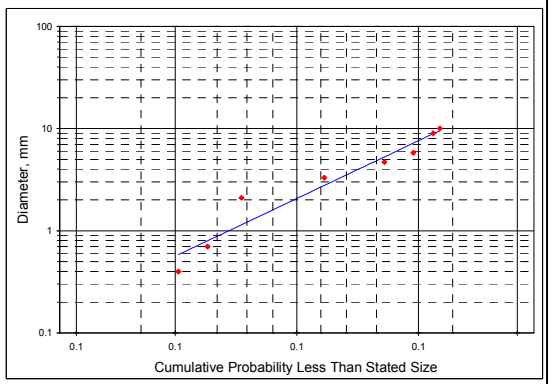
8-STAGE ANDERSON IMPACTOR DATA REDUCTION

Trial Name: Budesonide - Neb-U-Mask - Nebulizer - 2 Test Date: 06/21/12

Mask: Neb-U-Mask
Nebulizer: Hudson Micro-Mist Nebulizer
Drug: Budesonide

Neb Flow: 8 lpm
Anderson Flow Ra: 28.3 lpm
Calibrated: 06/18/12
Nebulized Fluid Drug Concentration: 1.5125 ml, 250 ug/ml
Nebulizer Time: 5.02 min

STAGE NO.	Cut Diam. µm	Recovery Mass, µg	Mass/Stage %	Cum. % >	Cum. % <
0	10	1.095	0.94	0.94	99.06
1	9	1.607	1.38	1.38	98.62
2	5.8	1.093	0.94	2.31	97.69
3	4.7	4.835	4.14	6.46	93.54
4	3.3	25.944	22.23	28.68	71.32
5	2.1	49.744	42.62	71.30	28.70
6	0.7	16.013	13.72	85.02	14.98
7	0.4	8.410	7.20	92.22	7.78
FILTER	0	7.983	6.84	99.06	0.94
	TOTAL	116.7	µg		



Total Delivered Dose = 116.7 µg

MMAD = 1.72 µm
Geometric Std.Dev. = 2.09 µm

Coarse Particles (>4.7um) = 3.8 µg
Coarse particle Fraction (>4.7um) = 3.25 %

Respirable Dose (0.4-4.7um) = 104.9 µg
Respirable Frac (0.4-4.7um) = 89.91 %

Fine Particle (<0.4um) = 8.0 µg
Fine Particle Fraction (<0.4um) = 6.84 %

Mask and Throat Deposistion = 36.0 µg

Respiratory Delivery Rate (0.4-4.7um) = 20.9 µg/min

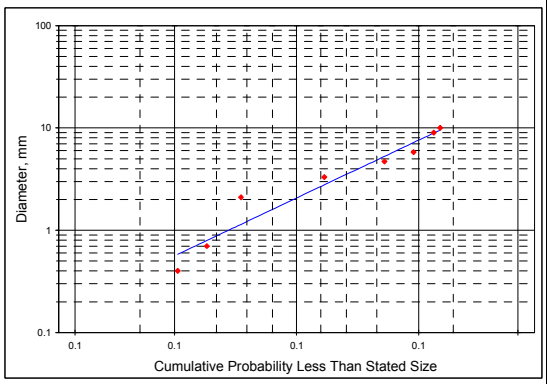
8-STAGE ANDERSON IMPACTOR DATA REDUCTION

Trial Name: Budesonide - Neb-U-Mask - Nebulizer - 3 Test Date: 06/21/12

Mask: Neb-U-Mask
Nebulizer: Hudson Micro-Mist Nebulizer
Drug: Budesonide

Neb Flow: 8 lpm
Anderson Flow Ra: 28.3 lpm
Calibrated: 06/18/12
Nebulized Fluid Drug Concentration: 1.6628 ml, 250 ug/ml
Nebulizer Time: 5.02 min

STAGE NO.	Cut Diam. µm	Recovery Mass, µg	Mass/Stage %	Cum. % >	Cum. % <
0	10	1.241	0.98	0.98	99.02
1	9	1.346	1.07	1.07	98.93
2	5.8	0.762	0.60	1.67	98.33
3	4.7	3.194	2.53	4.21	95.79
4	3.3	23.371	18.54	22.75	77.25
5	2.1	58.995	46.80	69.55	30.45
6	0.7	19.788	15.70	85.25	14.75
7	0.4	8.936	7.09	92.34	7.66
FILTER	0	8.414	6.68	99.02	0.98
	TOTAL	126.0	µg		



Total Delivered Dose = 126.0 µg

MMAD = 1.65 µm
Geometric Std.Dev. = 2.05 µm

Coarse Particles (>4.7um) = 3.3 µg
Coarse particle Fraction (>4.7um) = 2.66 %

Respirable Dose (0.4-4.7um) = 114.3 µg
Respirable Frac (0.4-4.7um) = 90.67 %

Fine Particle (<0.4um) = 8.4 µg
Fine Particle Fraction (<0.4um) = 6.68 %

Mask and Throat Deposistion = 16.3 µg

Respiratory Delivery Rate (0.4-4.7um) = 22.8 µg/min

Amsino OneMask™ Oxygen Mask, Nebulizer Performance, Budesonide

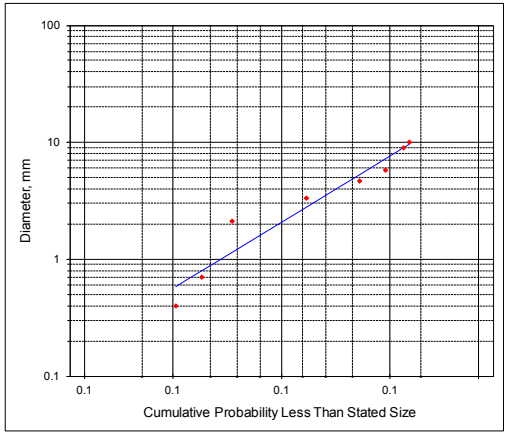
8-STAGE ANDERSON IMPACTOR DATA REDUCTION

Trial Name: Budesonide - OneMask - Nebulizer - 1 Test Date: 06/22/12

Mask OneMask
Nebulizer Hudson Micro-Mist Nebulizer
Drug Budesonide

Neb Flow 8 lpm
Anderson Flow : 28.3 lpm
Calibrated: 06/18/12
Nebulized Fluid Drug Concentration 2.744 ml 500 ug/ml
Nebulizer Time: 7.00 min

STAGE NO.	Cut Diam. µm	Recovery Mass, µg	Mass/Stage %	Cum. % >	Cum. % <
0	10	3.003	0.93	0.93	99.07
1	9	51.537	15.89	15.89	84.11
2	5.8	33.477	10.32	26.21	73.79
3	4.7	30.551	9.42	35.63	64.37
4	3.3	70.144	21.63	57.26	42.74
5	2.1	91.752	28.29	85.55	14.45
6	0.7	33.487	10.33	95.88	4.12
7	0.4	6.637	2.05	97.93	2.07
FILTER	0	3.720	1.15	99.07	0.93
	TOTAL	324.3	µg		



Total Delivered Dose = 324.3 µg

MMAD = 3.07 µm
Geometric Std.Dev. = 2.11 µm

Coarse Particles (>4.7um) = 88.0 µg
Coarse particle Fraction (>4.7um) = 27.14 %

Respirable Dose (0.4-4.7um) = 232.6 µg
Respirable Frac (0.4-4.7um) = 71.71 %

Fine Particle (<0.4um) = 3.7 µg
Fine Particle Fraction (<0.4um) = 1.15 %

Mask and Throat Deposistion = 15.2 µg

Respiratory Delivery Rate (0.4-4.7um) = 33.2 µg/min

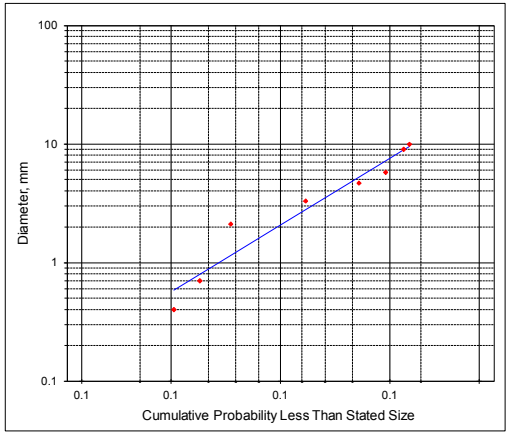
8-STAGE ANDERSON IMPACTOR DATA REDUCTION

Trial Name: Budesonide - OneMask - Nebulizer - 2 Test Date: 06/21/12

Mask OneMask
Nebulizer Hudson Micro-Mist Nebulizer
Drug Budesonide

Neb Flow 8 lpm
Anderson Flow : 28.3 lpm
Calibrated: 06/18/12
Nebulized Fluid Drug Concentration 2.9948 ml 500 ug/ml
Nebulizer Time: 6.50 min

STAGE NO.	Cut Diam. µm	Recovery Mass, µg	Mass/Stage %	Cum. % >	Cum. % <
0	10	3.621	1.12	1.12	98.88
1	9	40.742	12.58	12.58	87.42
2	5.8	46.721	14.43	27.02	72.98
3	4.7	47.544	14.69	41.70	58.30
4	3.3	80.182	24.77	66.47	33.53
5	2.1	60.040	18.54	85.01	14.99
6	0.7	30.802	9.51	94.53	5.47
7	0.4	11.381	3.52	98.04	1.96
FILTER	0	2.722	0.84	98.88	1.12
	TOTAL	323.8	µg		



Total Delivered Dose = 323.8 µg

MMAD = 3.13 µm
Geometric Std.Dev. = 2.13 µm

Coarse Particles (>4.7um) = 91.1 µg
Coarse particle Fraction (>4.7um) = 28.13 %

Respirable Dose (0.4-4.7um) = 229.9 µg
Respirable Frac (0.4-4.7um) = 71.03 %

Fine Particle (<0.4um) = 2.7 µg
Fine Particle Fraction (<0.4um) = 0.84 %

Mask and Throat Deposistion = 16.1 µg

Respiratory Delivery Rate (0.4-4.7um) = 35.4 µg/min

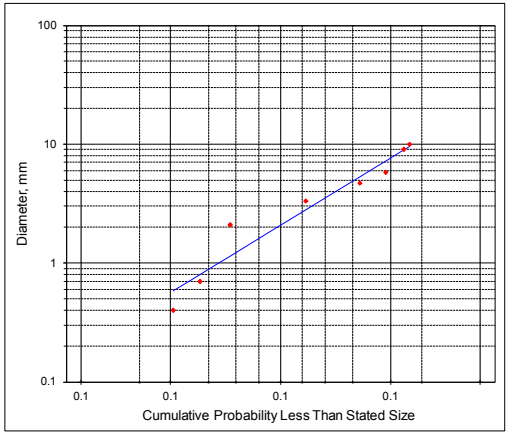
8-STAGE ANDERSON IMPACTOR DATA REDUCTION

Trial Name: Budesonide - OneMask - Nebulizer - 3 Test Date: 06/21/12

Mask OneMask
Nebulizer Neb-U-Mask Nebulizer
Drug Budesonide

Neb Flow 8 lpm
Anderson Flow : 28.3 lpm
Calibrated: 06/18/12
Nebulized Fluid Drug Concentration 2.7776 ml 500 ug/ml
Nebulizer Time: 6.25 min

STAGE NO.	Cut Diam. µm	Recovery Mass, µg	Mass/Stage %	Cum. % >	Cum. % <
0	10	2.473	0.78	0.78	99.22
1	9	31.233	9.91	9.91	90.09
2	5.8	37.999	12.06	21.97	78.03
3	4.7	29.707	9.43	31.40	68.60
4	3.3	72.774	23.09	54.49	45.51
5	2.1	95.583	30.33	84.82	15.18
6	0.7	36.172	11.48	96.30	3.70
7	0.4	6.040	1.92	98.22	1.78
FILTER	0	3.151	1.00	99.22	0.78
	TOTAL	315.1	µg		



Total Delivered Dose = 315.1 µg

MMAD = 2.90 µm
Geometric Std.Dev. = 2.05 µm

Coarse Particles (>4.7um) = 71.7 µg
Coarse particle Fraction (>4.7um) = 22.75 %

Respirable Dose (0.4-4.7um) = 240.3 µg
Respirable Frac (0.4-4.7um) = 76.25 %

Fine Particle (<0.4um) = 3.2 µg
Fine Particle Fraction (<0.4um) = 1.00 %

Mask and Throat Deposistion = 12.1 µg

Respiratory Delivery Rate (0.4-4.7um) = 38.4 µg/min

Neb-U-Mask System, Nebulizer Performance, Budesonide

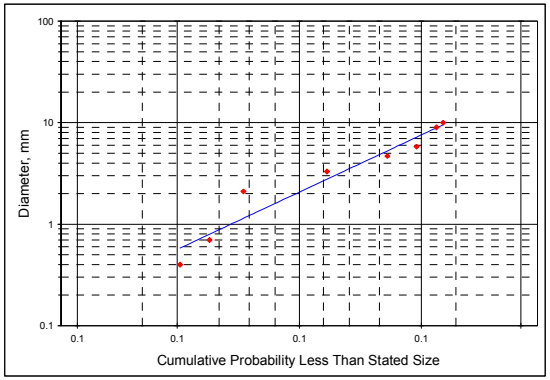
8-STAGE ANDERSON IMPACTOR DATA REDUCTION

Trial Name: Budesonide - Neb-U-Mask - Nebulizer - 1 Test Date: ######

Mask: Neb-U-Mask
Nebulizer: Hudson Micro-Mist Nebulizer
Drug: Budesonide

Neb Flow: 8 lpm
Anderson Flow Ra: 28.3 lpm
Calibrated: 06/18/12
Nebulized Fluid: 3.0103 ml
Drug Concentration: 500 ug/ml
Nebulizer Time: 7.00 min

STAGE NO.	Cut Diam. µm	Recovery Mass, µg	Mass/Stage %	Cum. % >	Cum. % <
0	10	5.052	1.95	1.95	98.05
1	9	9.379	3.62	3.62	96.38
2	5.8	10.185	3.94	7.56	92.44
3	4.7	56.245	21.73	29.29	70.71
4	3.3	101.416	39.19	68.48	31.52
5	2.1	55.766	21.55	90.03	9.97
6	0.7	9.522	3.68	93.71	6.29
7	0.4	5.415	2.09	95.80	4.20
FILTER	0	5.820	2.25	98.05	1.95
	TOTAL	258.8 µg			



Total Delivered Dose = 258.8 µg

MMAD = 2.68 µm
Geometric Std.Dev. = 2.01 µm

Coarse Particles (>4.7um) = 24.6 µg
Coarse particle Fraction (>4.7um) = 9.51 %

Respirable Dose (0.4-4.7um) = 228.4 µg
Respirable Frac (0.4-4.7um) = 88.24 %

Fine Particle (<0.4um) = 5.8 µg
Fine Particle Fraction (<0.4um) = 2.25 %

Mask and Throat Deposistion = 51.4 µg

Respiratory Delivery Rate (0.4-4.7um) = 32.6 µg/min

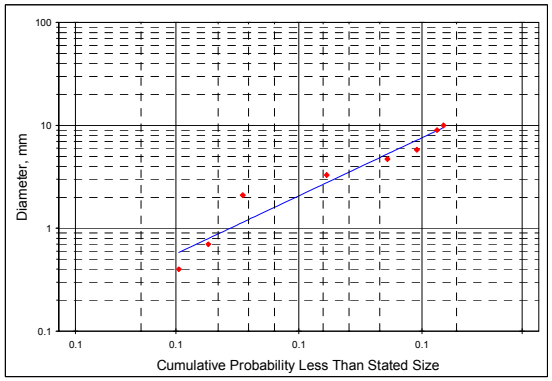
8-STAGE ANDERSON IMPACTOR DATA REDUCTION

Trial Name: Budesonide - Neb-U-Mask - Nebulizer - 2 Test Date: 06/21/12

Mask: Neb-U-Mask
Nebulizer: Hudson Micro-Mist Nebulizer
Drug: Budesonide

Neb Flow: Bud respule lpm
Anderson Flow Ra: 2 lpm
Calibrated: 06/18/12
Nebulized Fluid: 3.2778 ml
Drug Concentration: 500 ug/ml
Nebulizer Time: 6.50 min

STAGE NO.	Cut Diam. µm	Recovery Mass, µg	Mass/Stage %	Cum. % >	Cum. % <
0	10	14.398	4.26	4.26	95.74
1	9	41.065	12.16	12.16	87.84
2	5.8	31.352	9.28	21.44	78.56
3	4.7	88.792	26.29	47.74	52.26
4	3.3	95.403	28.25	75.99	24.01
5	2.1	48.607	14.39	90.38	9.62
6	0.7	8.142	2.41	92.79	7.21
7	0.4	5.203	1.54	94.33	5.67
FILTER	0	4.747	1.41	95.74	4.26
	TOTAL	337.7 µg			



Total Delivered Dose = 337.7 µg

MMAD = 3.30 µm
Geometric Std.Dev. = 2.28 µm

Coarse Particles (>4.7um) = 86.8 µg
Coarse particle Fraction (>4.7um) = 25.71 %

Respirable Dose (0.4-4.7um) = 246.1 µg
Respirable Frac (0.4-4.7um) = 72.89 %

Fine Particle (<0.4um) = 4.7 µg
Fine Particle Fraction (<0.4um) = 1.41 %

Mask and Throat Deposistion = 66.5 µg

Respiratory Delivery Rate (0.4-4.7um) = 37.9 µg/min

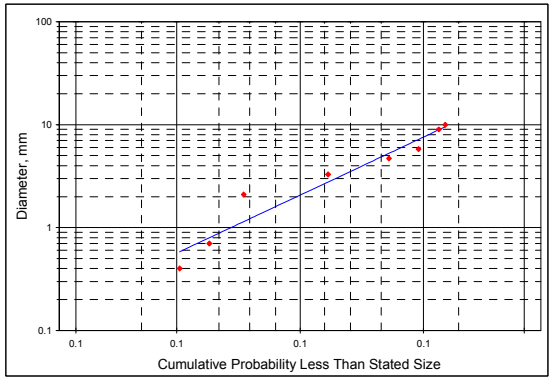
8-STAGE ANDERSON IMPACTOR DATA REDUCTION

Trial Name: Budesonide - Neb-U-Mask - Nebulizer - 3 Test Date: 06/21/12

Mask: Neb-U-Mask
Nebulizer: Hudson Micro-Mist Nebulizer
Drug: Budesonide

Neb Flow: 8 lpm
Anderson Flow Ra: 28.3 lpm
Calibrated: 06/18/12
Nebulized Fluid: 3.2378 ml
Drug Concentration: 500 ug/ml
Nebulizer Time: 7.00 min

STAGE NO.	Cut Diam. µm	Recovery Mass, µg	Mass/Stage %	Cum. % >	Cum. % <
0	10	11.927	3.64	3.64	96.36
1	9	21.034	6.43	6.43	93.57
2	5.8	18.298	5.59	12.02	87.98
3	4.7	74.184	22.67	34.69	65.31
4	3.3	117.818	36.00	70.69	29.31
5	2.1	65.555	20.03	90.72	9.28
6	0.7	9.046	2.76	93.48	6.52
7	0.4	5.541	1.69	95.17	4.83
FILTER	0	3.870	1.18	96.36	3.64
	TOTAL	327.3 µg			



Total Delivered Dose = 327.3 µg

MMAD = 2.93 µm
Geometric Std.Dev. = 2.14 µm

Coarse Particles (>4.7um) = 51.3 µg
Coarse particle Fraction (>4.7um) = 15.66 %

Respirable Dose (0.4-4.7um) = 272.1 µg
Respirable Frac (0.4-4.7um) = 83.16 %

Fine Particle (<0.4um) = 3.9 µg
Fine Particle Fraction (<0.4um) = 1.18 %

Mask and Throat Deposistion = 82.1 µg

Respiratory Delivery Rate (0.4-4.7um) = 38.9 µg/min

Appendix B

Individual Cascade Reduction Data for Each Metered Dose Inhaler Trial

Amsino OneMask™ Oxygen Mask, MDI Performance, Albuterol Sulfate

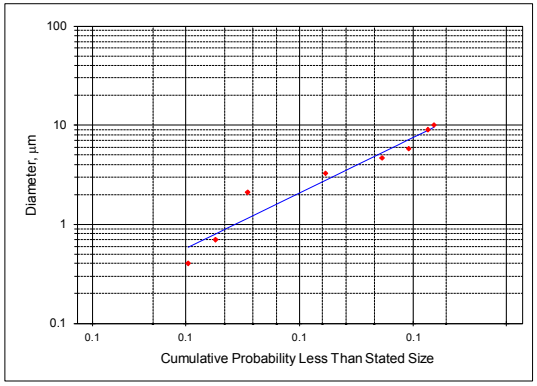
8-STAGE ANDERSON IMPACTOR DATA REDUCTION

Trial Name: Albuterol - OneMask - MDI - 1 Test Date: 10/22/12

Mask: OneMask
Device: MDI
Drug: Albuterol

Oxygen Flow: 8 lpm
Anderson Flow: 28.3 lpm
MDI Actuations: 10
Drug Concentration: 100 ug/Ac
Calibrated: 10/20/12

STAGE NO.	Cut Diam. µm	Recovery Mass, µg	Mass/Stage %	Cum. % >	Cum. % <
0	10	3.179	2.20	2.20	97.80
1	9	5.050	3.50	3.50	96.50
2	5.8	4.008	2.77	6.27	93.73
3	4.7	17.954	12.43	18.70	81.30
4	3.3	56.113	38.84	57.54	42.46
5	2.1	45.681	31.62	89.16	10.84
6	0.7	4.780	3.31	92.47	7.53
7	0.4	1.182	0.82	93.29	6.71
FILTER	0	6.515	4.51	97.80	2.20
	TOTAL	144.5	µg		



Total Delivered Dose = 144.5 µg

MMAD = 2.4 µm
Geometric Std.Dev. = 2.05 µm

Coarse Particles (>4.7um) = 12.2 µg
Coarse particle Fraction (>4.7um) = 8.47 %

Respirable Dose (0.4-4.7um) = 125.7 µg
Respirable Frac (0.4-4.7um) = 87.02 %

Fine Particle (<0.4um) = 6.5 µg
Fine Particle Fraction (<0.4um) = 4.51 %

Mask and Throat Deposistion = 95.5 µg

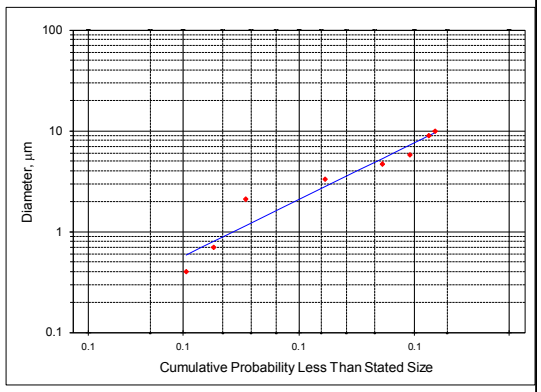
8-STAGE ANDERSON IMPACTOR DATA REDUCTION

Trial Name: Albuterol - OneMask - MDI - 2 Test Date: 10/22/12

Mask: OneMask
Device: MDI
Drug: Albuterol

Oxygen Flow: 8 lpm
Anderson Flow: 28.3 lpm
MDI Actuations: 10
Drug Concentration: 100 ug/Ac
Calibrated: 10/20/12

STAGE NO.	Cut Diam. µm	Recovery Mass, µg	Mass/Stage %	Cum. % >	Cum. % <
0	10	1.944	1.44	1.44	98.56
1	9	2.893	2.14	2.14	97.86
2	5.8	4.295	3.18	5.31	94.69
3	4.7	20.582	15.22	20.53	79.47
4	3.3	55.301	40.89	61.42	38.58
5	2.1	38.177	28.23	89.65	10.35
6	0.7	4.542	3.36	93.00	7.00
7	0.4	1.124	0.83	93.84	6.16
FILTER	0	6.394	4.73	98.56	1.44
	TOTAL	135.3	µg		



Total Delivered Dose = 135.3 µg

MMAD = 2.4 µm
Geometric Std.Dev. = 1.96 µm

Coarse Particles (>4.7um) = 9.1 µg
Coarse particle Fraction (>4.7um) = 6.75 %

Respirable Dose (0.4-4.7um) = 119.7 µg
Respirable Frac (0.4-4.7um) = 88.52 %

Fine Particle (<0.4um) = 6.4 µg
Fine Particle Fraction (<0.4um) = 4.73 %

Mask and Throat Deposistion = 86.5 µg

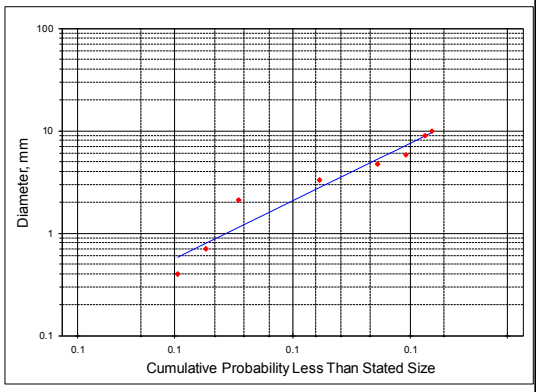
8-STAGE ANDERSON IMPACTOR DATA REDUCTION

Trial Name: Albuterol - OneMask - MDI - 3 Test Date: 10/22/12

Mask: OneMask
Device: MDI
Drug: Albuterol

Oxygen Flow: 8 lpm
Anderson Flow: 28.3 lpm
MDI Actuations: 10
Drug Concentration: 100 ug/Ac
Calibrated: 10/20/12

STAGE NO.	Cut Diam. µm	Recovery Mass, µg	Mass/Stage %	Cum. % >	Cum. % <
0	10	3.698	2.42	2.42	97.58
1	9	4.821	3.15	3.15	96.85
2	5.8	8.103	5.30	8.45	91.55
3	4.7	30.654	20.03	28.48	71.52
4	3.3	56.979	37.24	65.72	34.28
5	2.1	38.761	25.33	91.05	8.95
6	0.7	4.047	2.65	93.70	6.30
7	0.4	0.838	0.55	94.25	5.75
FILTER	0	5.105	3.34	97.58	2.42
	TOTAL	153.0	µg		



Total Delivered Dose = 153.0 µg

MMAD = 2.7 µm
Geometric Std.Dev. = 2.02 µm

Coarse Particles (>4.7um) = 16.6 µg
Coarse particle Fraction (>4.7um) = 10.86 %

Respirable Dose (0.4-4.7um) = 131.3 µg
Respirable Frac (0.4-4.7um) = 85.80 %

Fine Particle (<0.4um) = 5.1 µg
Fine Particle Fraction (<0.4um) = 3.34 %

Mask and Throat Deposistion = 120.9 µg

Neb-U-Mask System, MDI Performance, Albuterol Sulfate

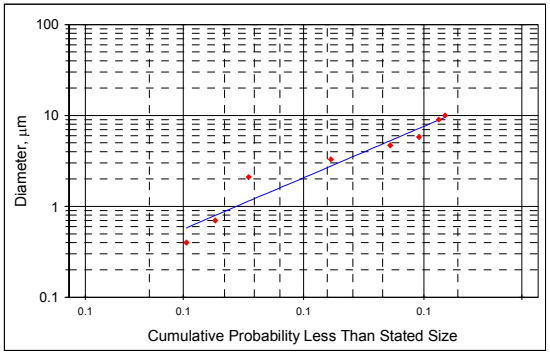
8-STAGE ANDERSON IMPACTOR DATA REDUCTION

Trial Name: **Albuterol - Neb-U-Mask - MDI - 1** Test Date: 06/24/12

Mask: Neb-U-Mask
Device: MDI
Drug: Albuterol

Oxygen Flow: 8 lpm
Anderson Flow: 28.3 lpm
Calibrated: 06/18/12
MDI Actuations: 10
Drug Concentration: 100.00 ug/Act

STAGE NO.	Cut Diam. µm	Recovery Mass, µg	Mass/Stage %	Cum. % >	Cum. % <
0	10	*1.874*	0.70	0.70	99.30
1	9	*5.286*	1.98	1.98	98.02
2	5.8	*2.023*	0.76	2.74	97.26
3	4.7	*55.106*	20.65	23.39	76.61
4	3.3	*127.140*	47.65	71.04	28.96
5	2.1	*58.290*	21.85	92.89	7.11
6	0.7	*4.732*	1.77	94.66	5.34
7	0.4	*3.169*	1.19	95.85	4.15
FILTER	0	*9.195*	3.45	99.30	0.70
	TOTAL	***266.8***	**µg**		



Total Delivered Dose = 266.8 µg

MMAD = 2.52 µm
Geometric Std.Dev. = 1.81 µm

Coarse Particles (>4.7um) = 9.2 µg
Coarse particle Fraction (>4.7um) = 3.44 %

Respirable Dose (0.4-4.7um) = 248.4 µg
Respirable Frac (0.4-4.7um) = 93.11 %

Fine Particle (<0.4um) = 9.2 µg
Fine Particle Fraction (<0.4um) = 3.45 %

Mask and Throat Deposistion = 182.3 µg

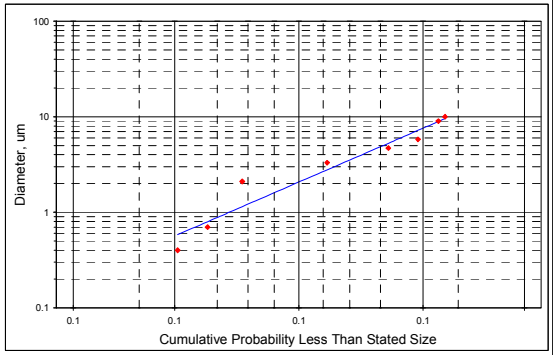
8-STAGE ANDERSON IMPACTOR DATA REDUCTION

Trial Name: **Albuterol - Neb-U-Mask - MDI - 2** Test Date: 06/24/12

Mask: Neb-U-Mask
Device: MDI
Drug: Albuterol

Oxygen Flow: 8 lpm
Anderson Flow: 28.3 lpm
Calibrated: 06/18/12
MDI Actuations: 10
Drug Concentration: 100 ug/Act

STAGE NO.	Cut Diam. µm	Recovery Mass, µg	Mass/Stage %	Cum. % >	Cum. % <
0	10	*15.030*	4.66	4.66	95.34
1	9	*1.603*	0.50	0.50	99.50
2	5.8	*5.764*	1.79	2.28	97.72
3	4.7	*56.262*	17.45	19.74	80.26
4	3.3	*144.705*	44.89	64.62	35.38
5	2.1	*88.350*	27.40	92.03	7.97
6	0.7	*5.317*	1.65	93.68	6.32
7	0.4	*1.004*	0.31	93.99	6.01
FILTER	0	*4.355*	1.35	95.34	4.66
	TOTAL	***322.4***	**µg**		



Total Delivered Dose = 322.4 µg

MMAD = 2.43 µm
Geometric Std.Dev. = 1.84 µm

Coarse Particles (>4.7um) = 22.4 µg
Coarse particle Fraction (>4.7um) = 6.95 %

Respirable Dose (0.4-4.7um) = 295.6 µg
Respirable Frac (0.4-4.7um) = 91.70 %

Fine Particle (<0.4um) = 4.4 µg
Fine Particle Fraction (<0.4um) = 1.35 %

Mask and Throat Deposistion = 166.9 µg

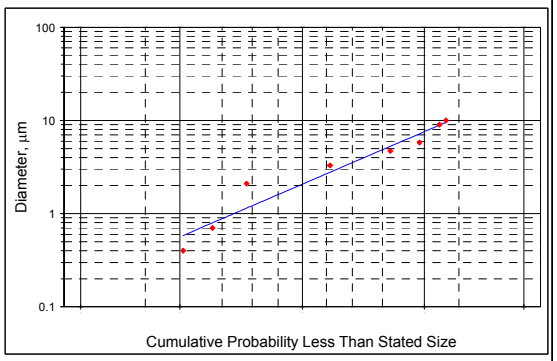
8-STAGE ANDERSON IMPACTOR DATA REDUCTION

Trial Name: **Albuterol - Neb-U-Mask - MDI - 3** Test Date: 06/24/12

Mask: Neb-U-Mask
Device: MDI
Drug: Albuterol

Oxygen Flow: 8 lpm
Anderson Flow: 28.3 lpm
Calibrated: 06/18/12
MDI Actuations: 10
Drug Concentration: 100 ug/Act

STAGE NO.	Cut Diam. µm	Recovery Mass, µg	Mass/Stage %	Cum. % >	Cum. % <
0	10	*7.069*	2.28	2.28	97.72
1	9	*10.565*	3.40	3.40	96.60
2	5.8	*7.971*	2.57	5.97	94.03
3	4.7	*40.974*	13.19	19.15	80.85
4	3.3	*116.112*	37.37	56.53	43.47
5	2.1	*109.005*	35.09	91.61	8.39
6	0.7	*11.484*	3.70	95.31	4.69
7	0.4	*2.226*	0.72	96.03	3.97
FILTER	0	*5.277*	1.70	97.72	2.28
	TOTAL	***310.7***	**µg**		



Total Delivered Dose = 310.7 µg

MMAD = 2.58 µm
Geometric Std.Dev. = 1.97 µm

Coarse Particles (>4.7um) = 25.6 µg
Coarse particle Fraction (>4.7um) = 8.24 %

Respirable Dose (0.4-4.7um) = 279.8 µg
Respirable Frac (0.4-4.7um) = 90.06 %

Fine Particle (<0.4um) = 5.3 µg
Fine Particle Fraction (<0.4um) = 1.70 %

Mask and Throat Deposistion = 209.4 µg

Amsino OneMask™ Oxygen Mask, MDI Performance, Ipratropium Bromide

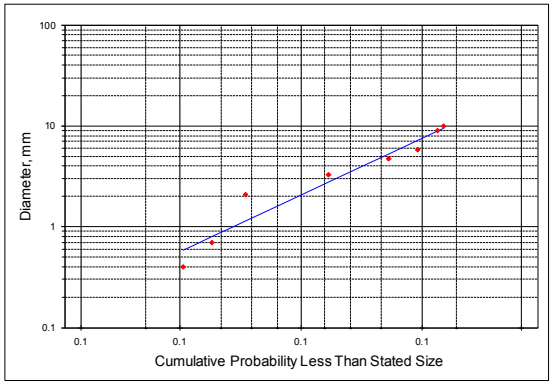
8-STAGE ANDERSON IMPACTOR DATA REDUCTION

Trial Name: **Ipratropium - OneMask - MDI - 1** Test Date: 10/30/12

Mask: OneMask
Device: MDI
Drug: Ipratropium

Oxygen Flow: 8 lpm — MDI Actuations: 10
Anderson Flow: 28.3 lpm — Drug Concentration: 20 ug/Ac
Calibrated: 10/22/12

STAGE NO.	Cut Diam. µm	Recovery Mass, µg	Mass/Stage %	Cum. % >	Cum. % <
0	10	*8.391*	9.43	9.43	90.57
1	9	*8.172*	9.19	9.19	90.81
2	5.8	*7.990*	8.98	18.17	81.83
3	4.7	*8.498*	9.55	27.72	72.28
4	3.3	*8.447*	9.49	37.21	62.79
5	2.1	*7.323*	8.23	45.44	54.56
6	0.7	*8.409*	9.45	54.89	45.11
7	0.4	*7.814*	8.78	63.68	36.32
FILTER	0	*23.927*	26.89	90.57	9.43
	TOTAL	***89.0***	µg		



Total Delivered Dose = 89.0 µg

MMAD = 1.17 µm
Geometric Std.Dev. = 5.80 µm

Coarse Particles (>4.7um) = 24.6 µg
Coarse particle Fraction (>4.7um) = 27.60 %

Respirable Dose (0.4-4.7um) = 40.5 µg
Respirable Frac (0.4-4.7um) = 45.51 %

Fine Particle (<0.4um) = 23.9 µg
Fine Particle Fraction (<0.4um) = 26.89 %

Mask and Throat Deposistion = 60.9 µg

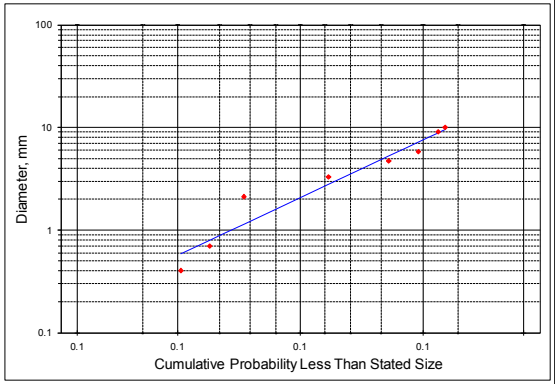
8-STAGE ANDERSON IMPACTOR DATA REDUCTION

Trial Name: **Ipratropium - OneMask - MDI - 2** Test Date: 10/30/12

Mask: OneMask
Device: MDI
Drug: Ipratropium

Oxygen Flow: 8 lpm — MDI Actuations: 10
Anderson Flow: 28.3 lpm — Drug Concentration: 20 ug/Ac
Calibrated: 10/22/12

STAGE NO.	Cut Diam. µm	Recovery Mass, µg	Mass/Stage %	Cum. % >	Cum. % <
0	10	*12.532*	15.69	15.69	84.31
1	9	*10.395*	13.02	13.02	86.98
2	5.8	*8.309*	10.41	23.42	76.58
3	4.7	*8.213*	10.28	33.71	66.29
4	3.3	*9.387*	11.76	45.46	54.54
5	2.1	*6.535*	8.18	53.65	46.35
6	0.7	*3.957*	4.96	58.60	41.40
7	0.4	*4.802*	6.01	64.62	35.38
FILTER	0	*15.723*	19.69	84.31	15.69
	TOTAL	***79.9***	µg		



Total Delivered Dose = 79.9 µg

MMAD = 1.51 µm
Geometric Std.Dev. = 6.73 µm

Coarse Particles (>4.7um) = 31.2 µg
Coarse particle Fraction (>4.7um) = 39.12 %

Respirable Dose (0.4-4.7um) = 32.9 µg
Respirable Frac (0.4-4.7um) = 41.19 %

Fine Particle (<0.4um) = 15.7 µg
Fine Particle Fraction (<0.4um) = 19.69 %

Mask and Throat Deposistion = 62.2 µg

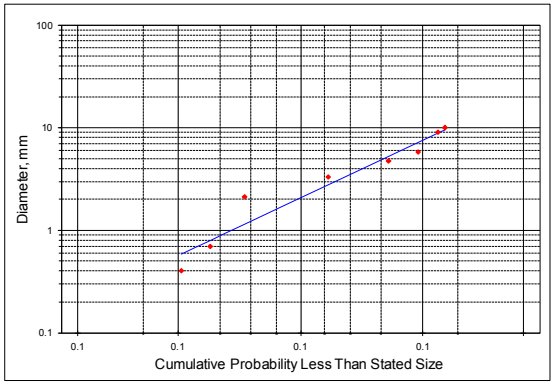
8-STAGE ANDERSON IMPACTOR DATA REDUCTION

Trial Name: **Ipratropium - OneMask - MDI - 3** Test Date: 10/30/12

Mask: OneMask
Device: MDI
Drug: Ipratropium

Oxygen Flow: 8 lpm — MDI Actuations: 10
Anderson Flow: 28.3 lpm — Drug Concentration: 20 ug/Ac
Calibrated: 10/22/12

STAGE NO.	Cut Diam. µm	Recovery Mass, µg	Mass/Stage %	Cum. % >	Cum. % <
0	10	*9.572*	12.58	12.58	87.42
1	9	*9.046*	11.89	11.89	88.11
2	5.8	*7.477*	9.82	21.71	78.29
3	4.7	*7.513*	9.87	31.58	68.42
4	3.3	*6.971*	9.16	40.74	59.26
5	2.1	*5.999*	7.88	48.63	51.37
6	0.7	*4.290*	5.64	54.26	45.74
7	0.4	*4.565*	6.00	60.26	39.74
FILTER	0	*20.671*	27.16	87.42	12.58
	TOTAL	***76.1***	µg		



Total Delivered Dose = 76.1 µg

MMAD = 1.23 µm
Geometric Std.Dev. = 7.10 µm

Coarse Particles (>4.7um) = 26.1 µg
Coarse particle Fraction (>4.7um) = 34.29 %

Respirable Dose (0.4-4.7um) = 29.3 µg
Respirable Frac (0.4-4.7um) = 38.55 %

Fine Particle (<0.4um) = 20.7 µg
Fine Particle Fraction (<0.4um) = 27.16 %

Mask and Throat Deposistion = 61.5 µg

.Neb-U-Mask Sysytem, MDI Performance, Ipratropium Bromide

8-STAGE ANDERSON IMPACTOR DATA REDUCTION

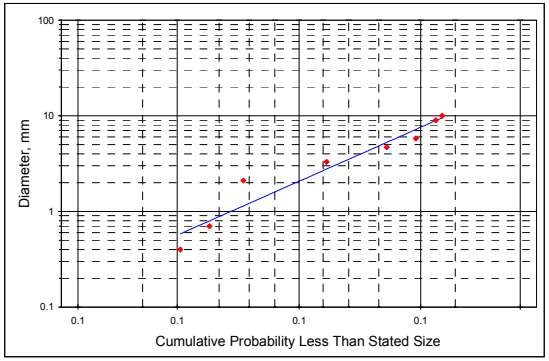
Trial Name: **Budesonide - Neb-U-Mask - MDI - 1** Test Date: 10/29/12

Mask: Neb-U-Mask
Device: MDI
Drug: Budesonide

Oxygen Flow: 8 lpm
Anderson Flow: 28.3 lpm
Calibrated: 10/22/12

MDI Actuations: 10
Drug Concentration: 20 ug/Ac

STAGE NO.	Cut Diam. µm	Recovery Mass, µg	Mass/Stage %	Cum. % >	Cum. % <
0	10	*11.962*	9.81	9.81	90.19
1	9	*10.149*	8.32	8.32	91.68
2	5.8	*9.722*	7.97	16.30	83.70
3	4.7	*17.619*	14.45	30.74	69.26
4	3.3	*11.346*	9.31	40.05	59.95
5	2.1	*12.146*	9.96	50.01	49.99
6	0.7	*3.402*	2.79	52.80	47.20
7	0.4	*4.426*	3.63	56.43	43.57
FILTER	0	*41.167*	33.76	90.19	9.81
	TOTAL	***121.9***	µg		



Total Delivered Dose = 121.9 µg

MMAD = 1.19 µm
Geometric Std.Dev. = 5.39 µm

Coarse Particles (>4.7um) = 31.8 µg
Coarse particle Fraction (>4.7um) = 26.11 %

Respirable Dose (0.4-4.7um) = 48.9 µg
Respirable Frac (0.4-4.7um) = 40.13 %

Fine Particle (<0.4um) = 41.2 µg
Fine Particle Fraction (<0.4um) = 33.76 %

Mask and Throat Deposistion = 38.1 µg

8-STAGE ANDERSON IMPACTOR DATA REDUCTION

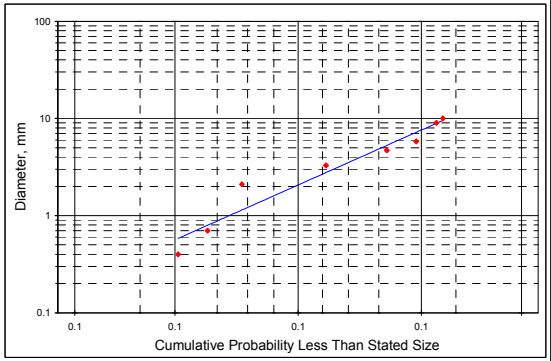
Trial Name: **Budesonide - Neb-U-Mask - MDI - 2** Test Date: 10/29/12

Mask: Neb-U-Mask
Device: MDI
Drug: Budesonide

Oxygen Flow: 8 lpm
Anderson Flow: 28.3 lpm
Calibrated: 10/22/12

MDI Actuations: 10
Drug Concentration: 20 ug/Ac

STAGE NO.	Cut Diam. µm	Recovery Mass, µg	Mass/Stage %	Cum. % >	Cum. % <
0	10	*10.006*	8.14	8.14	91.86
1	9	*11.017*	8.97	8.97	91.03
2	5.8	*12.127*	9.87	18.84	81.16
3	4.7	*18.818*	15.32	34.15	65.85
4	3.3	*11.502*	9.36	43.51	56.49
5	2.1	*4.479*	3.65	47.16	52.84
6	0.7	*2.066*	1.68	48.84	51.16
7	0.4	*1.023*	0.83	49.67	50.33
FILTER	0	*51.827*	42.18	91.86	8.14
	TOTAL	***122.9***	µg		



Total Delivered Dose = 122.9 µg

MMAD = 1.18 µm
Geometric Std.Dev. = 5.29 µm

Coarse Particles (>4.7um) = 33.2 µg
Coarse particle Fraction (>4.7um) = 26.98 %

Respirable Dose (0.4-4.7um) = 37.9 µg
Respirable Frac (0.4-4.7um) = 30.84 %

Fine Particle (<0.4um) = 51.8 µg
Fine Particle Fraction (<0.4um) = 42.18 %

Mask and Throat Deposistion = 41.5 µg

8-STAGE ANDERSON IMPACTOR DATA REDUCTION

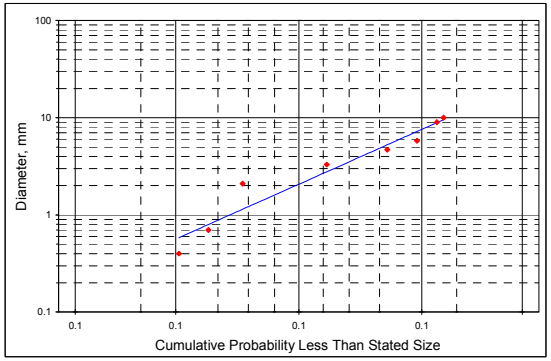
Trial Name: **Budesonide - Neb-U-Mask - MDI - 3** Test Date: 10/29/12

Mask: Neb-U-Mask
Device: MDI
Drug: Budesonide

Oxygen Flow: 8 lpm
Anderson Flow: 28.3 lpm
Calibrated: 10/22/12

MDI Actuations: 10
Drug Concentration: 20 ug/Ac

STAGE NO.	Cut Diam. µm	Recovery Mass, µg	Mass/Stage %	Cum. % >	Cum. % <
0	10	*11.971*	11.00	11.00	89.00
1	9	*10.184*	9.36	9.36	90.64
2	5.8	*13.821*	12.70	22.06	77.94
3	4.7	*19.884*	18.27	40.33	59.67
4	3.3	*10.022*	9.21	49.54	50.46
5	2.1	*10.075*	9.26	58.80	41.20
6	0.7	*1.883*	1.73	60.53	39.47
7	0.4	*2.109*	1.94	62.47	37.53
FILTER	0	*28.867*	26.53	89.00	11.00
	TOTAL	***108.8***	µg		



Total Delivered Dose = 108.8 µg

MMAD = 1.71 µm
Geometric Std.Dev. = 4.51 µm

Coarse Particles (>4.7um) = 36.0 µg
Coarse particle Fraction (>4.7um) = 33.06 %

Respirable Dose (0.4-4.7um) = 44.0 µg
Respirable Frac (0.4-4.7um) = 40.41 %

Fine Particle (<0.4um) = 28.9 µg
Fine Particle Fraction (<0.4um) = 26.53 %

Mask and Throat Deposistion = 43.6 µg

Amsino OneMask™ Oxygen Mask, MDI Performance, Budesonide

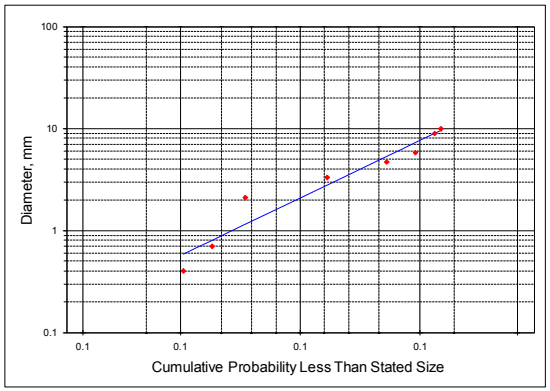
8-STAGE ANDERSON IMPACTOR DATA REDUCTION

Trial Name: **Budesonide - OneMask - MDI - 1** Test Date: 10/25/12

Mask: OneMask
Device: MDI
Drug: Budesonide

Oxygen Flow: 8 lpm
Anderson Flow: 28.3 lpm
Calibrated: 10/18/12
MDI Actuations: 10
Drug Concentration: 200 ug/Ac

STAGE NO.	Cut Diam. µm	Recovery Mass, µg	Mass/Stage %	Cum. % >	Cum. % <
0	10	*18.850*	6.09	6.09	93.91
1	9	*20.590*	6.65	6.65	93.35
2	5.8	*33.868*	10.94	17.59	82.41
3	4.7	*96.007*	31.00	48.59	51.41
4	3.3	*78.703*	25.42	74.00	26.00
5	2.1	*48.070*	15.52	89.53	10.47
6	0.7	*4.454*	1.44	90.97	9.03
7	0.4	*1.726*	0.56	91.52	8.48
FILTER	0	*7.402*	2.39	93.91	6.09
	TOTAL	***309.7***	µg		



Total Delivered Dose = 309.7 µg

MMAD = 3.06 µm
Geometric Std.Dev. = 2.29 µm

Coarse Particles (>4.7um) = 73.3 µg
Coarse particle Fraction (>4.7um) = 23.67 %

Respirable Dose (0.4-4.7um) = 229.0 µg
Respirable Frac (0.4-4.7um) = 73.94 %

Fine Particle (<0.4um) = 7.4 µg
Fine Particle Fraction (<0.4um) = 2.39 %

Mask and Throat Deposistion = 113.8 µg

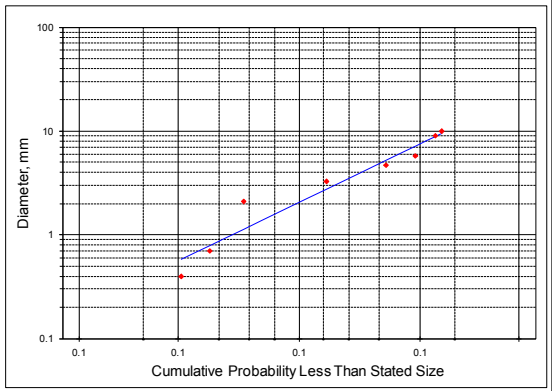
8-STAGE ANDERSON IMPACTOR DATA REDUCTION

Trial Name: **Budesonide - OneMask - MDI - 2** Test Date: 10/25/12

Mask: OneMask
Device: MDI
Drug: Budesonide

Oxygen Flow: 8 lpm
Anderson Flow: 28.3 lpm
Calibrated: 10/18/12
MDI Actuations: 10
Drug Concentration: 200 ug/Ac

STAGE NO.	Cut Diam. µm	Recovery Mass, µg	Mass/Stage %	Cum. % >	Cum. % <
0	10	*5.346*	1.86	1.86	98.14
1	9	*16.960*	5.90	5.90	94.10
2	5.8	*36.258*	12.60	18.50	81.50
3	4.7	*102.142*	35.51	54.00	46.00
4	3.3	*85.118*	29.59	83.59	16.41
5	2.1	*25.990*	9.03	92.63	7.37
6	0.7	*4.039*	1.40	94.03	5.97
7	0.4	*1.762*	0.61	94.64	5.36
FILTER	0	*10.064*	3.50	98.14	1.86
	TOTAL	***287.7***	µg		



Total Delivered Dose = 287.7 µg

MMAD = 3.18 µm
Geometric Std.Dev. = 1.99 µm

Coarse Particles (>4.7um) = 58.6 µg
Coarse particle Fraction (>4.7um) = 20.36 %

Respirable Dose (0.4-4.7um) = 219.1 µg
Respirable Frac (0.4-4.7um) = 76.14 %

Fine Particle (<0.4um) = 10.1 µg
Fine Particle Fraction (<0.4um) = 3.50 %

Mask and Throat Deposistion = 132.0 µg

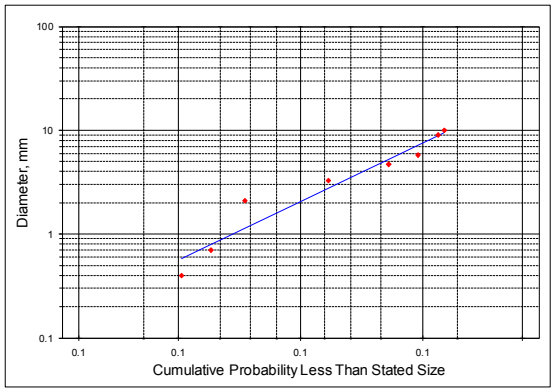
8-STAGE ANDERSON IMPACTOR DATA REDUCTION

Trial Name: **Budesonide - OneMask - MDI - 3** Test Date: 10/25/12

Mask: OneMask
Device: MDI
Drug: Budesonide

Oxygen Flow: 8 lpm
Anderson Flow: 28.3 lpm
Calibrated: 10/18/12
MDI Actuations: 10
Drug Concentration: 200 ug/Ac

STAGE NO.	Cut Diam. µm	Recovery Mass, µg	Mass/Stage %	Cum. % >	Cum. % <
0	10	*6.953*	2.79	2.79	97.21
1	9	*14.274*	5.72	5.72	94.28
2	5.8	*30.693*	12.31	18.03	81.97
3	4.7	*83.939*	33.66	51.70	48.30
4	3.3	*69.318*	27.80	79.50	20.50
5	2.1	*27.531*	11.04	90.54	9.46
6	0.7	*4.911*	1.97	92.51	7.49
7	0.4	*4.302*	1.73	94.23	5.77
FILTER	0	*7.433*	2.98	97.21	2.79
	TOTAL	***249.4***	µg		



Total Delivered Dose = 249.4 µg

MMAD = 3.10 µm
Geometric Std.Dev. = 2.09 µm

Coarse Particles (>4.7um) = 51.9 µg
Coarse particle Fraction (>4.7um) = 20.82 %

Respirable Dose (0.4-4.7um) = 190.0 µg
Respirable Frac (0.4-4.7um) = 76.20 %

Fine Particle (<0.4um) = 7.4 µg
Fine Particle Fraction (<0.4um) = 2.98 %

Mask and Throat Deposistion = 119.9 µg

Neb-U-Mask System, MDI Performance, Budesonide

8-STAGE ANDERSON IMPACTOR DATA REDUCTION

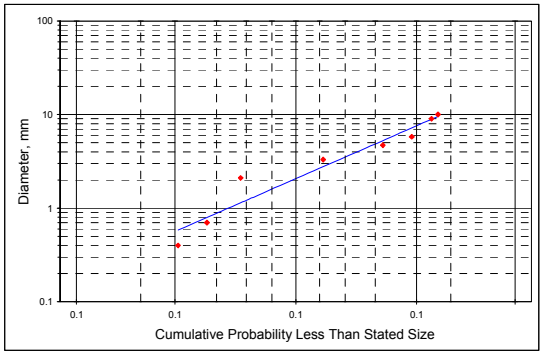
Trial Name: **Budesonide - Neb-U-Mask - MDI - 1** Test Date: 06/24/12

Mask: Neb-U-Mask
Device: MDI
Drug: Budesonide

Oxygen Flow: 8 lpm
Anderson Flow: 28.3 lpm
Calibrated: 06/18/12

MDI Actuations: 10
Drug Concentration: 200 ug/Ac

STAGE NO.	Cut Diam. µm	Recovery Mass, µg	Mass/Stage %	Cum. % >	Cum. % <
0	10	*11.445*	2.07	2.07	97.93
1	9	*32.718*	5.91	5.91	94.09
2	5.8	*91.818*	16.59	22.50	77.50
3	4.7	*209.899*	37.92	60.42	39.58
4	3.3	*152.463*	27.55	87.97	12.03
5	2.1	*38.084*	6.88	94.85	5.15
6	0.7	*4.274*	0.77	95.62	4.38
7	0.4	*2.117*	0.38	96.01	3.99
FILTER	0	*10.663*	1.93	97.93	2.07
	TOTAL	***553.5***	µg		



Total Delivered Dose = 553.5 µg

MMAD = 3.44 µm
Geometric Std.Dev. = 1.93 µm

Coarse Particles (>4.7um) = 136.0 µg
Coarse particle Fraction (>4.7um) = 24.57 %

Respirable Dose (0.4-4.7um) = 406.8 µg
Respirable Frac (0.4-4.7um) = 73.51 %

Fine Particle (<0.4um) = 10.7 µg
Fine Particle Fraction (<0.4um) = 1.93 %

Mask and Throat Deposistion = 177.5 µg

8-STAGE ANDERSON IMPACTOR DATA REDUCTION

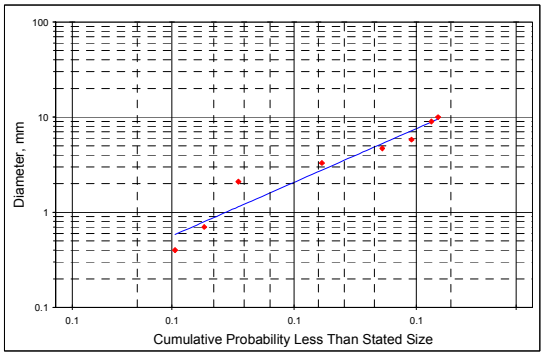
Trial Name: **Budesonide - Neb-U-Mask - MDI - 2** Test Date: 06/24/12

Mask: Neb-U-Mask
Device: MDI
Drug: Budesonide

Oxygen Flow: 8 lpm
Anderson Flow: 28.3 lpm
Calibrated: 06/18/12

MDI Actuations: 10
Drug Concentration: 200 ug/Ac

STAGE NO.	Cut Diam. µm	Recovery Mass, µg	Mass/Stage %	Cum. % >	Cum. % <
0	10	*13.399*	2.65	2.65	97.35
1	9	*44.342*	8.76	8.76	91.24
2	5.8	*70.903*	14.00	22.76	77.24
3	4.7	*183.723*	36.29	59.05	40.95
4	3.3	*144.971*	28.63	87.68	12.32
5	2.1	*32.064*	6.33	94.01	5.99
6	0.7	*5.396*	1.07	95.08	4.92
7	0.4	*2.207*	0.44	95.51	4.49
FILTER	0	*9.328*	1.84	97.35	2.65
	TOTAL	***506.3***	µg		



Total Delivered Dose = 506.3 µg

MMAD = 3.51 µm
Geometric Std.Dev. = 2.00 µm

Coarse Particles (>4.7um) = 128.6 µg
Coarse particle Fraction (>4.7um) = 25.41 %

Respirable Dose (0.4-4.7um) = 368.4 µg
Respirable Frac (0.4-4.7um) = 72.75 %

Fine Particle (<0.4um) = 9.3 µg
Fine Particle Fraction (<0.4um) = 1.84 %

Mask and Throat Deposistion = 190.3 µg

8-STAGE ANDERSON IMPACTOR DATA REDUCTION

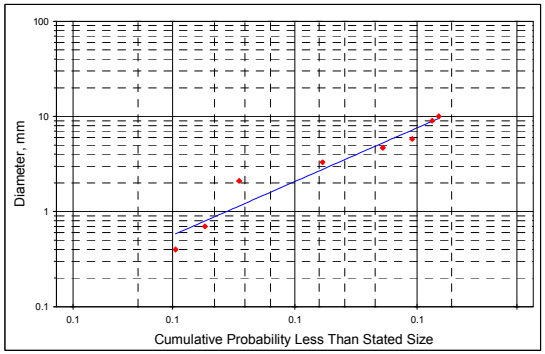
Trial Name: **Budesonide - Neb-U-Mask - MDI - 3** Test Date: 06/21/12

Mask: Neb-U-Mask
Device: MDI
Drug: Budesonide

Oxygen Flow: 8 lpm
Anderson Flow: 28.3 lpm
Calibrated: 06/18/12

MDI Actuations: 10
Drug Concentration: 200 ug/Ac

STAGE NO.	Cut Diam. µm	Recovery Mass, µg	Mass/Stage %	Cum. % >	Cum. % <
0	10	*11.847*	2.24	2.24	97.76
1	9	*37.366*	7.06	7.06	92.94
2	5.8	*65.059*	12.29	19.35	80.65
3	4.7	*193.885*	36.63	55.98	44.02
4	3.3	*162.429*	30.69	86.67	13.33
5	2.1	*39.337*	7.43	94.11	5.89
6	0.7	*5.730*	1.08	95.19	4.81
7	0.4	*4.488*	0.85	96.04	3.96
FILTER	0	*9.126*	1.72	97.76	2.24
	TOTAL	***529.3***	µg		



Total Delivered Dose = 529.3 µg

MMAD = 3.39 µm
Geometric Std.Dev. = 1.97 µm

Coarse Particles (>4.7um) = 114.3 µg
Coarse particle Fraction (>4.7um) = 21.59 %

Respirable Dose (0.4-4.7um) = 405.9 µg
Respirable Frac (0.4-4.7um) = 76.69 %

Fine Particle (<0.4um) = 9.1 µg
Fine Particle Fraction (<0.4um) = 1.72 %

Mask and Throat Deposistion = 239.8 µg