O2 Nose Filters Performance & Mechanics

I. INTRODUCTION

Non-electrostatically charged filters (mechanical filters) rely on physical phenomena like inertia, velocity, and collision to capture airborne particles. Particles in the air have to "run into" filter fibers on a one-dimensional surface to become successfully tethered to the filter fibers. When tested against electrostatically charged filters, known as "electret media", these factors can lead to a decrease in mechanical filters' performance.[1] Electrostatic filtration technology is analogous to how a magnet attracts iron particles. Somewhat surprisingly, due to principles of electrostatics, electret filter performance is enhanced as its mechanical properties are enhanced, when particles adhere to charged filter fibers, enlarging the fibers' surface area. This enlarged "charged" surface area continues to attract particulates as they encounter the filter media.[2] Airborne particles that transport viruses and bacteria, referred to by academia as "droplet nuclei", are typically composed of the pathogen itself enveloped in sneeze or cough droplets.[3,7] Average sizes for human-produced droplet nuclei are between 0.5 to 12 microns in diameter.[4,5] O2 Nose Filters' use of 3M's patented AEMTM (Advanced Electret Media) provides users of its nasal filtration products up to 99% protection from airborne contaminants, including viruses and air pollution.[6]

II. MEASURING FILTRATION EFFICIENCY

Filter performance, or efficiency, is expressed in percentage terms and enumerates the relationship between particle size, particle concentration, and velocity. 3M filtration materials are FDA accepted and O2 Nose Filters products' filter performance is verified by LMS Technologies, Inc. *(see Graph 1)*. The ability of charged filter fibers to attract and hold sub-micron particulates offsets the necessity for dense filter construction, allowing good airflow without compromising particle capture. Hence, AEMTM filters are an appropriate use for personal nasal filter devices.

Capture Ratios:
3M's patented AEMTM (Advanced Electret Media) filter technology relies on the principles of electrostatic attraction[1], or the creating of electrical charges on filaments, to produce ionically charged filter fibers constructed in a 3-dimensional format. The high capture ratios and extended breathability attributed to 3M's AEMTM filtration materials are due to the fibers' high charge, uneven charge distribution, and less dense media construction, allowing airborne particles to be captured within the filter throughout several layers of media. Because the charged filter fibers act as "magnets" and not merely "walls" to attract and secure airborne particulates, the less dense format of fiber filters does not adversely impact the filter's ability to retain particulates—especially in the <5-micron size range. The O2 Nose Filters design is the first and only personal nasal insert available with 3M AEMTM filtration technology.

III. PARTICULATES IN THE AIR

Man-made and natural contaminants in the air we breathe range from subatomic particles to particles easily visible to the naked eye. The size of contaminants and particles are usually described in microns (μm), a metric unit of measure where one micron is one-millionth of a meter. The distribution of particles by size and type can be highly variable, even from one cubic meter of air to the next.

The primary particle definitions of concern are:

Hazardous Dust Particles:
Smaller dust particles can be hazardous for humans. In many jurisdictions, dust fractions at specified particle sizes in working environments are required to be measured.

Inhalable Dust:
Airborne particles can enter the nose and mouth during normal breathing. Particles of 100 microns diameter or less.

Thoracic Dust:
Particles that will pass through the nose and throat, reaching the lungs. Particles of 10 microns diameter and less. Commonly referred to as PM10.

Respirable Dust:
Particles that will penetrate into the gas exchange region of the lungs. A hazardous particulate size less than 5 microns. Particle sizes of 2.5 microns, commonly PM2.5.

Pollens:
These particles are a very common nasal irritant and cause secondary health problems. Particles are 5 microns and larger when dry, 9 microns and larger when wet.

IV. PRACTICAL / INTENDED USE

Filtration efficiency experienced by each individual user is dependent on a large number of uncontrollable variables associated with environmental conditions and human activity. The O2 nasal dilator with a 3M filter insert is not intended to replace any personal full-face breathing filtration device required or specified for hazardous environmental conditions.

In determining expected efficiency, the following should be considered:

The Condensation Effect:
All airborne particles can be expected to, dependent on condition, take on some water vapor. This condensation effect, more prevalent at high humidity, can continue until contaminates trapped in the water, now a fog, mist or larger droplets, fall to the earth. The very smallest particulates, when trapped in water, take on H_2O increasing their perceived size by minimally 80% and as much as 1000% or even more dependent on conditions; as an example, a 2.5 µm size particle dry will be filtered wet at approximately 4.5 µm minimum in size or larger. The amount of water that condenses on any one or group of particles is dependent on size and is as variable as the weather conditions. This process significantly increases the effectiveness of the 3M filtration material by enlarging the size of particles that otherwise would pass through more easily.

Moreover, airborne viruses and bacteria (2 µm and larger wet) need moisture to live; airborne infection is dependent on moisture. Viruses and bacteria are released into the air in water droplets, normally in groups larger than a single virus (droplet sizes as described above) and either quickly fall to the ground, take on more water, or begin to dry, dependent on conditions.

The Laboratory Environment:
The process of comparing the laboratory data presented here to real world application highlights a large set of interacting variables. There are several measurement techniques that have been implemented in measuring contaminates in the air; the number of particles of specific sizes in a cubic meter of air. To say that statistically there are a number of particles that are 2.5 µm or smaller in the volume, and a number of particles at 10 µm or smaller (which obviously include the 2.5 µm particles), etc. does not tell the whole story when we consider all the particles and their constant changing position in and out of a specific chosen volume or as they are trapped or measured in air quality testing equipment. Along with the constantly changing particle distribution, humans are constantly moving in and out of these varying distributions. The best we can do is capture the condition at a moment in time, a snapshot.

V. FILTER MEDIA TEST IN NASAL DILATOR

Experiments were conducted at LMS Technologies, Inc., an independent 3rd party testing lab.

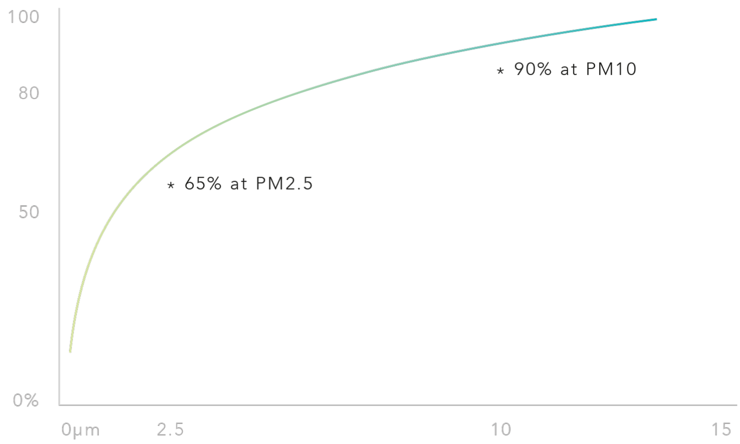
Testing of 3M's AEMTM filtration material set in the nasal dilator design demonstrated 65% filtration efficiency for particles measuring 2.5 µm and 90% for particles measuring 10 µm *(See Graph 1).*

Expected efficiency of O2 Nose Filters in a variety of applications are as follows:

APPLICATION	DRY PARTICLE SIZE PARTICLE (microns, µm)	FILTRATION EFFICIENCY
POLLEN	*10-100*	*90-100%*
PET DANDER	*1-9*	*45-90%*
MOLD SPORES	*10-30*	*90-100%*
DUST MITES	*100-300*	*100%*
VIRUSES / BACTERIA	*0.1-10*	*25-90%*
SMOG	*0.01-10*	*15-90%*
DIESEL EXHAUSTS	*0.05-1*	*25-40%*
SAW DUST	*30-600*	*99-100%*

** See The Condensation Effect*

VI. GRAPHS:



GRAPH 1: *Filter Efficiency (%) vs. Particle Size (micrometers), LMS Technology, Inc.*
(Data extrapolated above 8 microns)

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