



A Report

to

tensARC

on

Filtration Efficiency of One Facemask Sample

from

Textile Protection and Comfort Center (TPACC)
Wilson College of Textiles
North Carolina State University
Raleigh, North Carolina 27695-8301

12 February 2021

Filtration Efficiency of One Facemask Sample

tensARC submitted one gaiter to the Textile Protection and Comfort Center (TPACC) in the Wilson College of Textiles at North Carolina State University, for characterization of the filtration efficiency using a manikin head form test method. This report describes the test method used to characterize the gaiter and presents the results of the tests.

Test Material

We tested the gaiter as received, the sample was labeled as:

FG: facegaiter, light blue and white

Test Method

We used a novel animatronic breathing head form test method to measure the filtration efficiency for each mask (Figure 1). The breathing head form provides a consistent testing platform, including repeatable movements and a realistic fit of the mask to the face. It uses a composite skeleton base covered with a compressible silicone “skin” to mimic the bone structure and skin compressibility of a human, It breathes through its mouth at a rate of 15 breaths per minute.

Two particle counters measure the filtration efficiency of the mask. One counter measures particles suspended in ambient air outside the mask. The other measures particles that penetrate inside the mask. This testing protocol measures particles in 0.3 μm size range. This is the particle size considered most penetrating for characterizing facemask filtration efficiency. We calculate mask filtration efficiency for each minute of the test as:

$$\% FE_{mask} = 100 - (C_i/C_o) * 100$$

C_i – Count of 0.3 μm particles measured inside the mask

C_o - Count of 0.3 μm particles in the ambient air outside the mask

$\% FE_{mask}$ - % Mask Filtration Efficiency



Figure 1. Animatronic Breathing Head Form

Prior to testing, we used particle counters to verify that sufficient particles were present in the ambient air to ensure adequate particle count. We confirm that the particle counters read zero when measuring air filtered through a HEPA filter.

Head form Testing Protocol

During test, the head form executes a 2-minute clearing period followed by a 7-minute dynamic testing protocol. For the first two minutes, the head form is static and breathes normally. We take no measurements during this time to allow clearing of particles in the mask prior to the start of the test. Following the clearing phase, data collection begins and the following programmed head movements occur:

- Two (2) minutes- normal breathing, no movement
- One (1) minute-normal breathing, Head nod up and down
- One (1) minute-normal breathing, Head shaking from right to left
- One (1) minute-normal breathing, Jaw moving up and down (replicating talking)
- One (1) minute-normal breathing, Head wobble from shoulder to shoulder
- One (1) minute- normal breathing, no movement

We calculated filtration efficiency for each minute of the 7-minute protocol. We calculate an overall filtration efficiency by averaging the one-minute efficiency values. To provide a comparative benchmark, we also test a NIOSH certified N95 mask during the same test session. We have tested the N95 with this apparatus. Based on testing over time, we expect the N95 mask to provide a filtration efficiency between 91 and 97% filtration efficiency against $0.3 \mu\text{m}$ size particles. N95 test results are included in the report to facilitate comparison with test masks.

Test Results

Table 1 shows the average % filtration efficiency for the test sample based on three replicate tests on the same gaiter. The gaiter was removed and repositioned between tests. Table 1 also shows the percent filtration efficiency of the N95 control mask. Detailed results obtained for each minute of collected data are in Appendix A. A picture of the test gaiter was taken (Figure 2).

Table 1: Summary of Percent FE_{mask} Values

Mask Sample	Filtration Efficiency % (0.3 μm)
Control (N95)	92.8
Disposable Surgical Mask	
FG-1	88.0
FG-2	86.6
FG-3	87.9
Average	87.5

Caveat

These data characterize the particulate filtration efficiency values of facemasks as measured on an anemometric, mouth breathing head form while breathing particles suspended in ambient air of a specific size (0.3 μm). They do not assesses filtration against particles of larger or smaller sizes. They were generated using a developmental prototypic apparatus following a repeatable, but still unstandardized testing methodology.

These data were obtained under specific laboratory conditions. They should not be used to assess or to certify the protective performance of facemasks intended to provide protection against airborne infectious diseases, including COVID-19. They should not be used to appraise the safety benefits or risks of the materials, products, or assemblies in use conditions. The relationships between laboratory tests and field performance are not simple, and many things must be considered when making practical translations. The protection provided by masks are determined by many factors including the hazard, individual, materials used, design, fit, activity level, and the environmental conditions of use. These results do not address the full range of these issues. It is not our intention to recommend, exclude, or predict the suitability of any commercial product for a particular end use.

Appendix A: FE_{mask} results for each minute of testing

Sample – N95 Control

Motion	Filtration Efficiency % (0.3 μ m)
Still	94.5
Still	94.3
Head Nod	93.5
Head Shake	93.5
Jaw up and down	92.9
Head Wobble	90.8
Still	89.9
AVG	92.8



Figure 2 – FG

FG-1

Motion	Filtration Efficiency % (0.3 μm)
Still	92.8
Still	92.5
Head Nod	88.0
Head Shake	85.5
Jaw up and down	86.5
Head Wobble	84.7
Still	85.9
AVG	88.0

FG -2

Motion	Filtration Efficiency % (0.3 μ m)
Still	93.8
Still	93.3
Head Nod	86.9
Head Shake	82.8
Jaw up and down	84.7
Head Wobble	81.3
Still	83.5
AVG	86.6

FG-3

Motion	Filtration Efficiency % (0.3 μ m)
Still	91.6
Still	91.5
Head Nod	86.9
Head Shake	85.3
Jaw up and down	88.4
Head Wobble	85.1
Still	86.6
AVG	87.9
