EVALUATION OF FABRIC PERFORMANCES FOR THEIR POTENTIAL USE AS FACE MASK DURING COVID19 CRISIS

Sebastien Jacquinot[1], Cécile Philippot[1], Sebastien Artous[1], Bastien Pellegrin[1], Arnaud Guiot[1], Simon Clavaguera[1], Joséphine Steck[1], Hervé Giraud[1], Samir Derrough[1]

[1]Univ. Grenoble Alpes, F-38000, Grenoble, France – CEA, Liten, DTNM, F-38054, Grenoble, France

Context :

During the Covid19 crisis, an unprecedented need arose for protective masks to supply the entire population. To this end, a new category of alternative masks has been created in France in addition to Surgical masks and Filtering Face Pieces (FFP). The Nanosafety Platform (PNS) staff rallied and adapted its facilities and devices to respond to the different demands of local SMEs for filter media characterization.
In this context, two different experimental setups to measure the filtration efficiency were developed and implemented in addition to a permeability bench.

Key Parameters

Two key parameters to qualify facemask fabrics were assessed:

- **the air permeability (or Breathability)**
- **the particle collection efficiency η (%)**

Collection efficiency:

Represents the particle retention ratio of a filter for given challenge conditions :

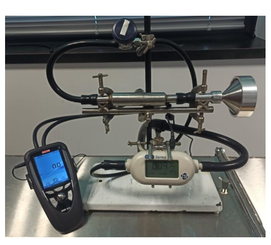
$$\eta = 1 - \frac{C_{downstream}}{C_{upstream}}$$

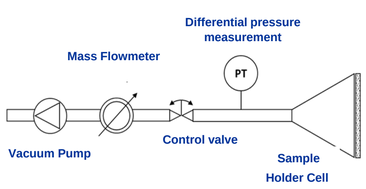
Collection efficiency is a function of challenge aerosol (particle size, charging stage…) and test parameters (filtration velocity).

Air permeability:

Measurement of the air flow through a given surface sample for a pressure drop of 100 Pa

→ Permeability in $L.m^{-2}.s^{-1}$ @ 100 Pa (according to ISO 9237: 1995)





Mask Classification

Exisiting standards versus face mask categories for non-sanitary use :

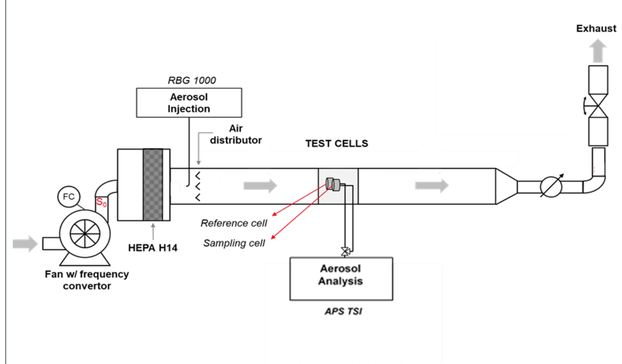
	Personal Protective Equipment PPE		Masks for Medical use (Surgical masks)			Alternative masks (masks for non-sanitary use, barrier masks, masks for the general public)	
	FFP2	FFP1	Type IIR[e]	Type II	Type I	Category 1	Category 2
French Standards	NF EN 149:2001	NF EN 149:2001	NF EN 14683:2019	NF EN 14683:2019	NF EN 14683:2019	According to DGA + ISO 16170 protocol	According to DGA + ISO 16170 protocol
Minimum Filtration Efficiency	94%	80%	98%	98%	95%	90%	70%
Average aerosol size tested (µm)	0,6µm	3µm	3µm	3µm	3µm	3µm	3µm
Aerosol Type	Sodium chloride aerosol or paraffin oil mist	Sodium chloride aerosol or paraffin oil mist	Bacterial (Staphylococcus aureus)	Bacterial (Staphylococcus aureus)	Bacterial (Staphylococcus aureus)	Calcium Carbonate Aerosol	Calcium Carbonate Aerosol
Minimum Air Perméability (MAP)(en L/m2.s@100Pa)/ Differential Pressure(DP) (Pa.cm-2 @ 8 L.min-1)	several expiratory/inspiratory resistance values (mb) at different flow rates, before/after clogging	several expiratory/inspiratory resistance values (mb) at different flow rates, before/after clogging	DP<40	DP<40	DP<60	MAP>96	MAP>96
Observations	Correspondence with different international standards	Correspondence with different international standards	Correspondence with an american standard		Correspondence with some american and chinese standards	New class. for France - Correspondence with some chinese standards	New classification for France

Ventilated tunnel for micron-sized testing

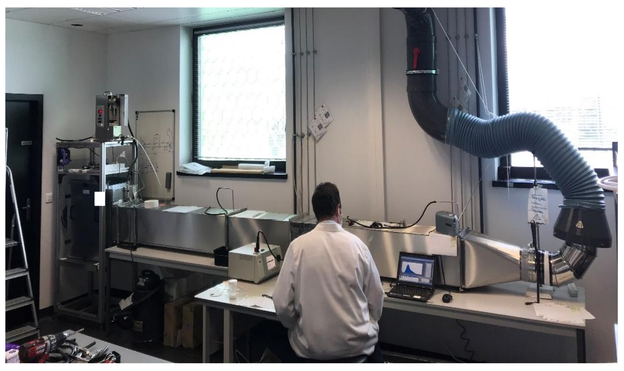
Objective

Evaluation of collection efficiency for **3µm challenge particles.**
Most of the media / fabrics tested are intended for alternative masks manufacturing. The bench can also be used as a first response for quality control of surgical masks / FFP.

Bench Description



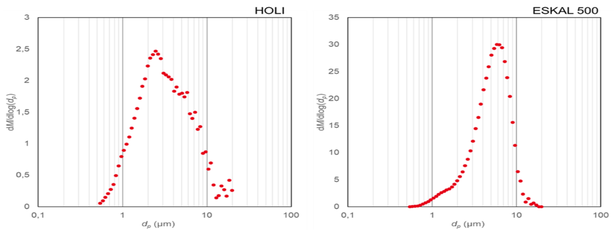
Flow diagram of the ventilated tunnel



Ventilated tunnel illustration

Aerosol Type and Description

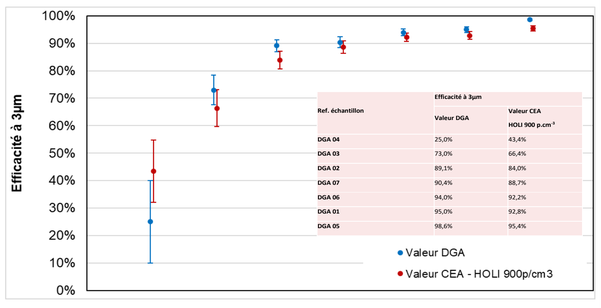
- A polydisperse aerosol is produced from $CaCO_3$ powders, using a rotary brush aerosol generator (PALAS, RBG)
- The Efficiency calculation is based on 3µm concentration values, extracted from optical particle classifier (APS, TSI) reading



Examples of mass distributions of aerosols produced from HOLI and ESKAL 500 powders

Results

- **Experimental setup approved by DGA***
  - **Over 500 fabrics reference tested**



Ref. échantillon	Efficacité à 3µm Valeur DGA	Valeur CEA HOLI 900 p.cm⁻³
DGA 04	25,0%	43,4%
DGA 03	73,0%	66,4%
DGA 02	89,1%	84,0%
DGA 07	90,4%	88,7%
DGA 06	94,0%	92,2%
DGA 01	95,0%	92,8%
DGA 05	98,6%	95,4%

Comparison of CEA & DGA test benches for various efficiency samples

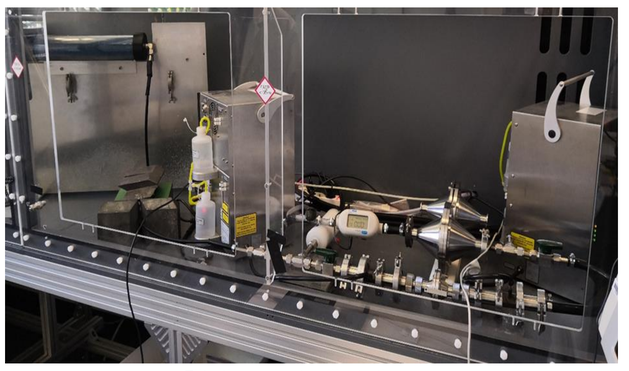
*DGA: Direction Générale des armés (General Direction of the Armed forces).This institute has been choosen by French government as reference organism for the alternatives mask's qualification during COVID crisis.

Filtration cell for sub-micron testing

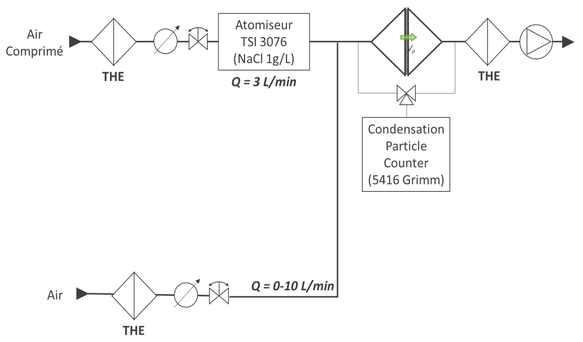
Objective

Evaluation of collection efficiency for **< 0.6µm challenge particles.**
This experimental setup was mounted and made available to SMEs during COVID crisis to screen for promising candidates for chirurgical / FFP masks

Bench Description



Filtration cell setup illustration

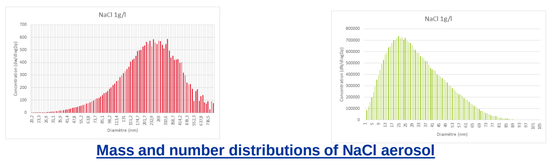


Flow diagram of the filtration cell setup

Aerosol Type and Description

- A NaCl aerosol is produced by atomization (TSI 3076) of a $1g.L^{-1}$ NaCl solution
- Mass median diameter of NaCl aerosol : 0.3 µm
  → close to MPPS
- The Efficiency calculation is based on concentration values reading for a condensation particle counter (CPC 5416 Grimm)

**MPPS: Most Penetrating Particle, usually 0.1-0.25 µm



Mass and number distributions of NaCl aerosol

Results

- **Hundreds of medias tested for various SMEs**
- **Joint development with OUVRY of a commercially available solution: the OCOV mask (20x washable P1 type mask)**

OCOV mask – OUVRY-CEA collaboration

Conclusions and perspectives:

These test benches, which did not exist a few months ago, have made it possible to respond quickly to the explosion in demand for the qualification of fabrics intended for alternative and FFP masks manufacturing during COVID crisis. They relied on expertise and equipment present in most laboratories working with aerosols.
Apart from qualification of new candidates as filtration media, the Nanosafety Platform also took part in studies on mask reusability (washing impact on collection efficiency, re-charging processes)

PLATE-FORME NANO SÉCURITÉ