APPLICATION NOTE

CHARACTERISATION OF FACE MASKS WITH THE POROLUX™ 100

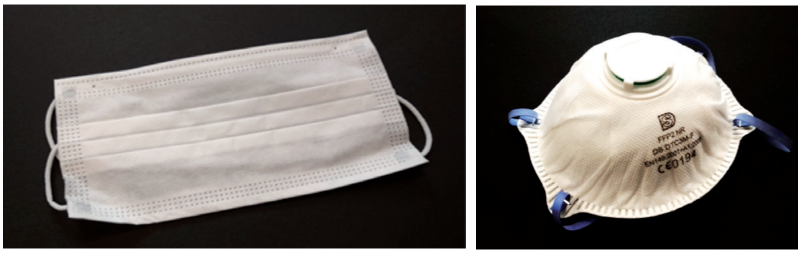
TEST SCOPE

This document briefly explains how the pore size distribution of surgical face masks and respirators can be measured using the ‘pressure scan’ method, as provided by the POROLUX™ 100 gas liquid porometer.

SURGICAL MASK VERSUS RESPIRATOR

A surgical mask is a loose fitting mask, covering the nose and mouth. It is intended to be worn by healthcare professionals, in order to catch bacteria shed in liquid droplets and aerosols from the wearer’s mouth and nose. This way, the patient is protected when the healthcare professional coughs or sneezes.

Contrary to common belief, surgical masks are not designed to protect the wearer from inhaling airborne bacteria or virus particles. Surgical masks are rated, amongst others, by ASTM (US), EN (Europe) and YY (Chinese) standards.



Surgical mask (left) and respirator (right)

A respirator is a tight fitting mask, designed to create a facial seal. Respirators are intended to provide the wearer protection against inhalation of hazardous airborne particles. The respirator which was used for this test is an FFP2 rated filtering facepiece respirator (also referred to as a ‘disposable respirator’).

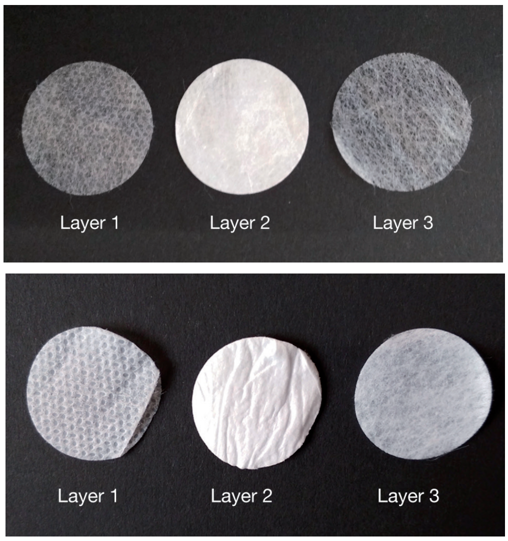
Commonly used respirator classifications are N95, N99 and N100 (NIOSH, US), FFP1, FFP2 and FFP3 (CEN, Europe) and KN95 (GB, China).

COMPOSITION OF FACE MASKS

Surgical masks are typically made of nonwoven polypropylene fabric and mostly consist of three layers. The first and third layer are generally spunbond, while the middle layer is melt-blown. This composition is commonly referred to as SMS technology (Spunbond / Meltblown / Spunbond).

The density of the first and third layer is usually 20 gsm (gram per m^2), while the middle layer is 25 gsm. The reason for using nonwoven fabric is mostly because of the higher air permeability, the higher bacterial filtration efficiency and the lower manufacturing cost compared to woven fabrics.

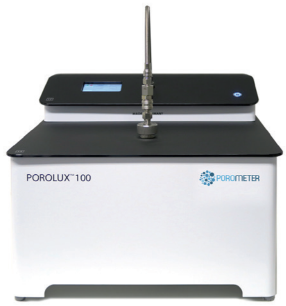
The same goes for the respirator, where it’s common to have three or four layers. As with the surgical masks, the outer layers are made of nonwoven polypropylene, while the middle layer is made of melt-blown nonwoven polypropylene. Together, the fibers form a multi-layered web where the spaces between the fibers allow for breathability.



The three layers of a surgical mask (top) and a respirator (bottom)

MEASUREMENT METHODOLOGY USING THE POROLUX™ 100

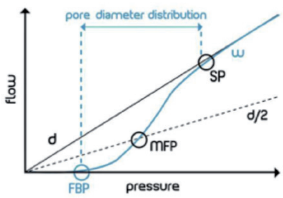
The POROLUX™ 100 is a gas liquid porometer, based on the 'pressure scan' method. This is a fast, yet reproducible method whereby air pressure is continually increased while the resulting flow rates are recorded simultaneously. The pressure scan method is preferred for environments where simplicity, speed and reproducibility are the main requirements. Therefore, the POROLUX™ 100 is the right choice for quality control and assurance.



POROLUX™ 100 porometer

First, the sample is impregnated with an inert, nontoxic wetting liquid. Next, the sample is secured in the POROLUX™ 100 where an inert gas (e.g. nitrogen) is used to displace the liquid out of the porous fiber network. This 'wet run' results in a 'wet curve' which represents the measured gas flow through the sample against the applied pressure (inversely proportional to the pore size).

Apart from the impregnation with liquid, the same method as above is used for a dry sample ('dry run') measurement. The 'half-dry curve' is obtained by dividing the flow values of the dry curve by 2. This curve is also plotted against the applied pressure in the same graphic. From the wet curve, dry curve and the half-dry curve data, information about the porous network can be obtained.



The maximum operating pressure of the POROLUX™ 100 is 1.5 bars (22 psi), which permits measuring pore sizes down to 0.4 µm. The determination of the first bubble point (or maximum pore size) – hereafter referred to as "FBP" – is based on the test method described in the ASTM F316-03 standard.

RESULTS SHOWING THE DISTINCTION BETWEEN THE SURGICAL MASK AND THE RESPIRATOR WE MEASURED

SURGICAL MASK (1)			
Material	**Maximum pore size FBP (µm)**	**Mean flow pore size MFP (µm)**	**Smallest pore size SP (µm)**
Layer 1	585.0	95.1	48.9
Layer 2	34.6	12.8	12.5
Layer 3	510.9	118.7	49.6

RESPIRATOR(1)			
Material	**Maximum pore size FBP (µm)**	**Mean flow pore size MFP (µm)**	**Smallest pore size SP (µm)**
Layer 1	202.9	76.16	46.2
Layer 2	19.5	10.7	10.3
Layer 3	128.8	52.0	36.3

(1) Measured with POREFIL™, using shape factor 1.00

WET & DRY CURVES OF THE SURGICAL MASK AND THE RESPIRATOR WE MEASURED

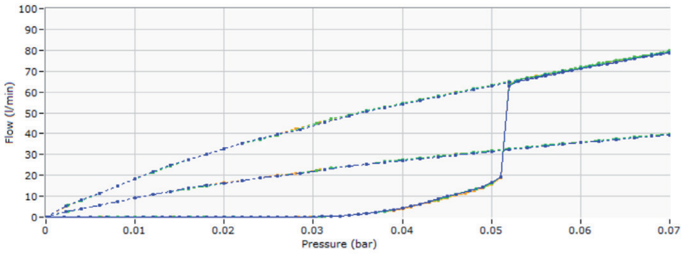


Figure 1 - Overlay of wet, half dry and dry curves of three measurements of the surgical mask (all layers)

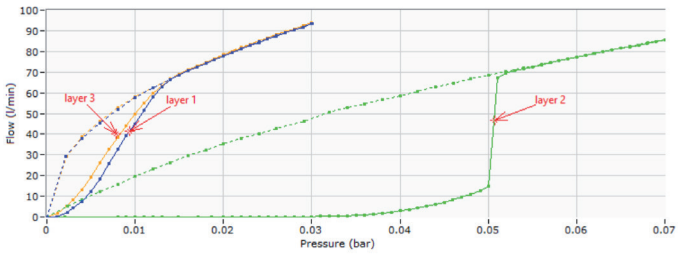


Figure 2 - Wet and dry measurements from the three layers of a surgical mask (for better readability the half dry curve is not shown)

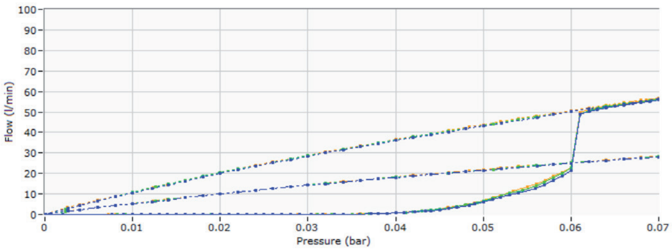


Figure 3 - Overlay of wet, half dry and dry curves of three measurements of the respirator (middle layer)

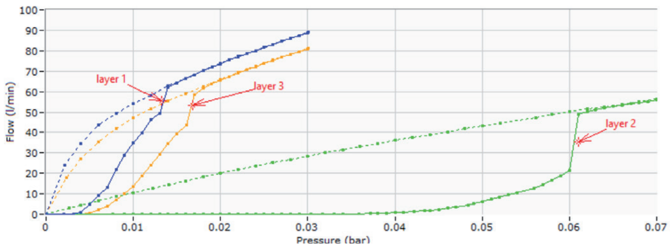


Figure 4 - Wet and dry measurements from the three layers of a respirator (for better readability the half dry curve is not shown)

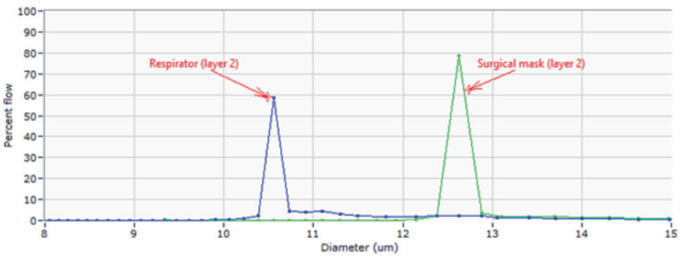


Figure 5 - Surgical mask vs respirator: flow based pore size distribution of the middle layer

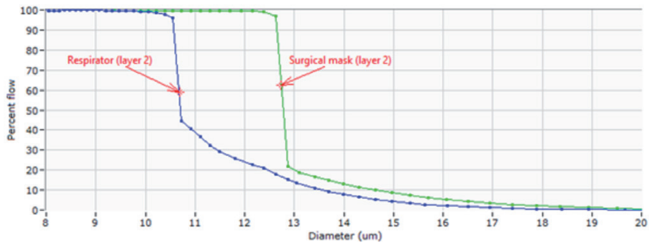


Figure 6 - Surgical mask vs respirator: flow characteristic of the middle layer

The POROLUX™ 100 also allows fast and easy measurements of the air permeability. Air permeability – describing the air flow rate through a porous material – is one of the most important properties of nonwoven fabrics used in face masks.

Due to the random arrangement of fibres in nonwovens, pores of all geometrical shapes are possible. Generally, air permeability of nonwovens is related to the fibre diameter, pore size, porosity and thickness of the samples.

Underneath, the measurement results of the air permeability tests (20 mbar pressure) are shown.

Material	Sample thickness (μm)	Permeation flux[(2)] (l/cm²/min)
Surgical mask	330	10.4
Respirator	1020	5.1

[(2)] *The permeation flux is defined as the air volume flowing through the sample per unit area per unit time.*

SUMMARY

Based on the measurements with the POROLUX™ 100, we can summarize as follows:

1) As seen in figures 2 and 4, both masks' outside layers have considerably larger pores compared to their middle layers. The middle layer is hence often called the filtration layer. In both masks, the middle layer has a more narrow pore size distribution compared to the other layers.

2) When measuring the complete mask, we measure - conform the theory of porometry - the pores in the layer with the smallest pores (layer 2, the middle layer).

3) Figure 5 and 6 show the differences between the middle layers of the surgical mask and the respirator, in terms of diameter and flow, respectively. The middle layer of the respirator has smaller pores than the middle layer of the surgical mask. Figure 6 shows that the mean flow pore size (50% of the flow is through pores larger than the mean flow pore size) is smaller for the respirator (10.7 μm) than for the surgical mask (12.8 μm).

4) As is demonstrated in figures 1 and 3, the measurements are highly reproducible. This proves the value of the POROLUX™ 100 for quality control purposes.

5) The POROLUX™ 100 also allows fast and easy measurements of the air permeability. Air permeability – describing the air flow rate through a porous material – is one of the most important properties of nonwoven fabrics used in face masks.

CONCLUSION

These measurements show that the pore sizes and air permeability of the surgical mask and the respirator are easy to measure with the POROLUX™ 100 porometer. The measurements are fast (under 5 minutes) and very reproducible. We can see clear differences between the surgical mask and the respirator. The data obtained with the POROLUX™ 100 can provide valuable input for research & development and/or be a good indicator for quality control.

Please contact us at info@porometer.com if you need further information.

Disclaimer
The purpose of measuring these masks with the POROLUX™ 100 is not to validate the masks against the norms mentioned in the section 'Surgical masks versus respirators'. Insights into pore sizes and pore size distribution is only part of determining the filter's efficiency, and the results should not be compared to the reported size of viruses, etc.