Different Specification of Filtration Medias and How They Compare

1.Project brief

How do the face mask grade and hepa filter compare by particle size filtration and will the filtered exhaust air be safe of Covid-19?

2.Background

2 main routes of transmission, respiratory droplets (coughing and sneezing) and contact.

3.Face masks

Different grades of facemasks are used, the ones that are recommended as protection against Covid-19 are N95/FFP2 and FFP3 standard or equivalent. These are recommended by World Health Organisation (WHO).

The masks are tested to a set of standardised test methods (ASTM F2100, EN 14683, or equivalent).
The Association of Perioperative Registered Nurses recommends that surgical masks filter particles of at least 0.3μm for regular use and 0.1μm for laser use (i.e. to protect the wearer against laser smoke) or have 90–95% bacterial filtration efficiency.

The US food and drug administration (FDA) standards for surgical masks are as follows.

- Fluid resistance - American Society for Testing and Materials (ASTM) F 1862–00a: standard test method for resistance of surgical mask to penetration by synthetic blood.
- Filtration Efficiency - particulate filtration efficiency (PFE) - 0.1μ polystyrene latex sphere; bacterial filtration efficiency (BFE) –ASTM F 2101–01: standard test method for evaluating the BFE of surgical masks using a biological aerosol of Staphylococcus aureus.
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3.1 N95 and FFP2 Respirator

N95 respirator blocks at least 95% of 0.3-micron test particles, regulated under CFR 878.4040 and CFR Part 84.

The N95 is the US code and FFP2 is the EU code, both of which stop 95% of particles larger than 0.3 microns. The figure below shows the comparison between each mask using NaCl as a common testing agent.

Based on this comparison, it is reasonable to consider China KN95, AS/NZ P2, Korea 1st Class, and Japan DS FFRs as "equivalent" to US NIOSH N95 and European FFP2 respirators, for filtering non-oil-based particles such as those resulting from wildfires, PM 2.5 air pollution, volcanic eruptions, or bioaerosols (e.g. viruses). However, prior to selecting a respirator, users should consult their local respiratory protection regulations and requirements or check with their local public health authorities for selection guidance.

Certification/ Class (Standard)	N95 (NIOSH-42C FR84)	FFP2 (EN 149-2001)	KN95 (GB2626-2006)	P2 (AS/NZ 1716:2012)	Korea 1st Class (KMOEL - 2017-64)	DS (Japan JMHLW-Notification 214, 2018)
Filter performance – (must be ≥ X% efficient)	≥ 95%	≥ 94%	≥ 95%	≥ 94%	≥ 94%	≥ 95%
Test agent	NaCl	NaCl and paraffin oil	NaCl	NaCl	NaCl and paraffin oil	NaCl
Flow rate	85 L/min	95 L/min	85 L/min	95 L/min	95 L/min	85 L/min
Total inward leakage (TIL)* – tested on human subjects each performing exercises	N/A	≤ 8% leakage (arithmetic mean)	≤ 8% leakage (arithmetic mean)	≤ 8% leakage (individual and arithmetic mean)	≤ 8% leakage (arithmetic mean)	Inward Leakage measured and included in User Instructions
Inhalation resistance – max pressure drop	≤ 343 Pa	≤ 70 Pa (at 30 L/min) ≤ 240 Pa (at 95 L/min) ≤ 500 Pa (clogging)	≤ 350 Pa	≤ 70 Pa (at 30 L/min) ≤ 240 Pa (at 95 L/min)	≤ 70 Pa (at 30 L/min) ≤ 240 Pa (at 95 L/min)	≤ 70 Pa (w/valve) ≤ 50 Pa (no valve)
Flow rate	85 L/min	Varied – see above	85 L/min	Varied – see above	Varied – see above	40 L/min
Exhalation resistance - max pressure drop	≤ 245 Pa	≤ 300 Pa	≤ 250 Pa	≤ 120 Pa	≤ 300 Pa	≤ 70 Pa (w/valve) ≤ 50 Pa (no valve)
Flow rate	85 L/min	160 L/min	85 L/min	85 L/min	160 L/min	40 L/min
Exhalation valve leakage requirement	Leak rate ≤ 30 mL/min	N/A	Depressurization to 0 Pa ≥ 20 sec	Leak rate ≤ 30 mL/min	visual inspection after 300 L /min for 30 sec	Depressurization to 0 Pa ≥ 15 sec
Force applied	-245 Pa	N/A	-1180 Pa	-250 Pa	N/A	-1,470 Pa
CO_2 clearance requirement	N/A	≤ 1%	≤ 1%	≤ 1%	≤ 1%	≤ 1%

Figure 1

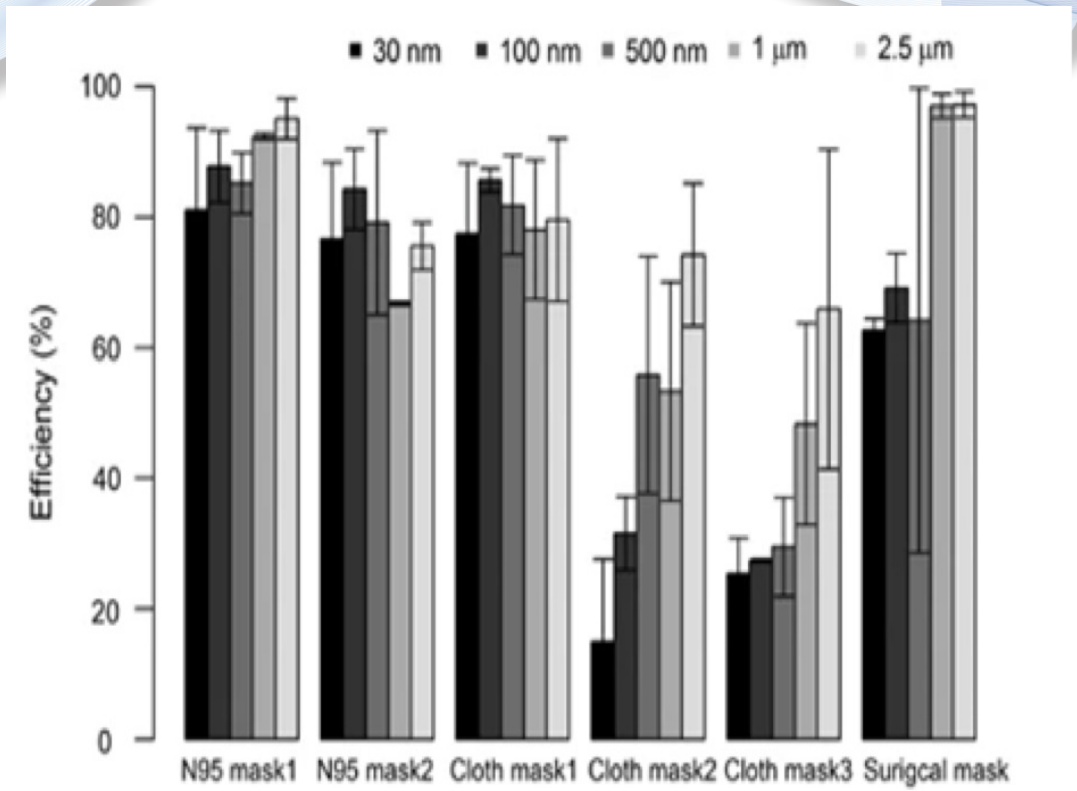

Figure 2 (shakya et al.,2016)

3.2 N100 /P100 and FFP3 Masks

The N100 and P100 rated masks are rated by NIOSH with a 99.7% efficiency of 0.3-micron particles. FFP3 are the European counterpart which have an efficiency of 99% up to 0.3 microns.

4.Coronavirus

Using an electron micrograph Covid-19 particle were seen to be generally spherical with diameters varying from 60-140 nm

5.Hepa Filter

The chosen Hepa filter in Purex unit are of H14 standard.
“A HEPA filter's 99.97% efficiency is ascribed to the most penetrating particle size normally taken to be 0.3 µm” (Collum, 2017)
H14 filters have an efficiency of 99.995% (EN 1822)

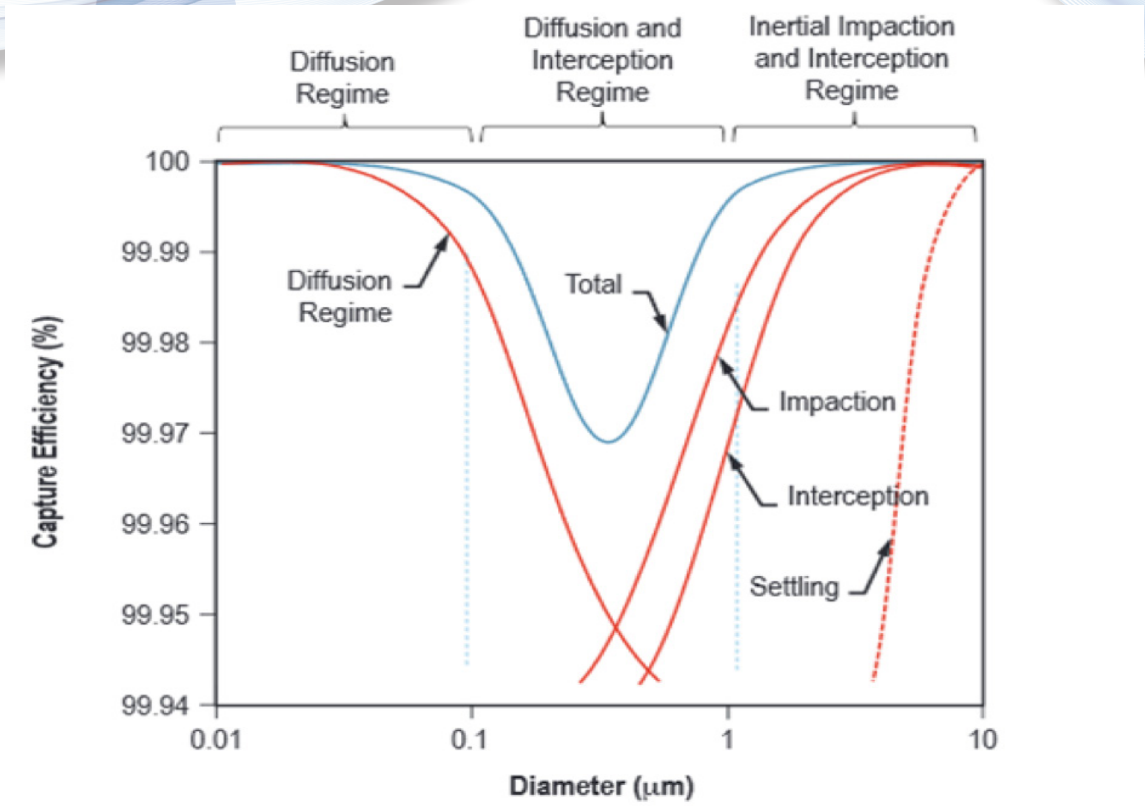

Figure 3 (Agui, Perry &vijayakimar, 2016)

Both HEPA media filters and packed beds of granular material, such as activated carbon, which are both commonly employed for cabin atmosphere purification purposes, are found to have efficacy for removing nanoparticulate contaminants from the cabin atmosphere. When used alone, HEPA-rated media provides superior performance for removing virtually 100% of particulates (Agui, Perry & Vijayakimar, 2016)

6.Conclusion

The N95, FFP2 and FFP3 masks are rated down to 0.3 microns with 95%, 95% and 99% efficiency respectively, however according to Zhu et al., 2020 the diameter of coronavirus varies from 0.06-0.14 microns. Shakya et al., 2016 produced a graph shown in figure 2 that shows these N95 masks are only around 87% efficient at 0.1 microns but this still shows that even the lowest rated N95 masks can still capture coronavirus particles.

Particles as small as coronavirus are captured by brownian diffusion through the HEPA which makes them more efficient than their 'standard' rating of 0.3 microns. A NASA study performed by Agui, Perry & Vijayakimar, 2016 stated that when used alone HEPA rated media provides superior performance by removing virtually 100% of ultrafine particles (<0.01 microns) shown in figure 3. HEPA filters are used on aircrafts and have already been proven to effectively trap viruses (Brossman, 2016).

Van Doremalen et al., 2020 conducted a recent study that showed coronavirus particles present in the air up to 3 hours post aerosolization. This can be from breathing, sneezing, or coughing. An extraction system would remove the covid-19 at the source and not allow for the further dispersion of the virus hence protecting patients that may enter the room afterwards.

7.References

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