Minimum Efficiency Reporting Value (MERV) 13 Filters are not sufficient to remove SARS-CoV-2 from the air.

A follow-up study to:

Genesis Air Purification Technology is Effective at Inactivating SARS-CoV-2

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Minimum Efficiency Reporting Value (MERV) is an American Society of Heating, Refrigeration and Air-Conditioning Engineers (ASHRAE) designation for filters capable of capturing particles sized 0.3 to 10 microns (μm) (1). MERV ratings range from 1 to 16, with a rating of 1 indicating the filter is 20% effective at removing 0.3 to 10 μm size particles. A rating of MERV 16 indicates the filter is 75% effective at removing particles within this size range. ASHRAE currently recommends the use of MERV 13 or higher filters in commercial settings to help reduce the cross contamination between people shedding SARS-CoV-2 (2). MERV 13 filters are 50% efficient for particles ranging from 0.3 to 1.0 μm, 85% for 1.0 to 3.0 μm, and 90% for 3.0 to 10.0 μm (1).

SARS-CoV-2 (the virus that causes COVID-19), is an enveloped RNA virus, 100 nanometers (nm) or 0.1 μm in diameter, that has the potential to spread through the air contained in both droplets and in aerosols. In general, droplets are larger in diameter whereas aerosols are smaller, with a general size distinction of 10 μm and larger for droplets, and smaller than 10 μm for aerosols (3). Furthermore, aerosols dry quickly becoming aerosol nuclei that are affected by buoyancy and remain suspended in the air especially when the air is still or lacking ventilation (4, 5), and SARS 2 has been shown to remain infective in these aerosol nuclei (6). As mentioned above, the smaller these aerosols become, the less efficient the MERV 13 filter is at capturing them. Furthermore, filters, in general, are known to release particles back into the environment when air is not actively passing though, thus a filter without active, unidirectional air flow is not effective (7).

In response to ongoing concern for the spread of SARS-CoV-2 and the search for safe and effective mitigation and remediation strategies, Genesis Air subjected their patented air purification technology to challenge testing with active SARS 2 virus at the biosafety level four lab (BSL-4) at the University of Texas Medical Branch (UTMB) in Galveston, TX and the results of this testing were presented in a position paper in June 2021 (8). In this study, the Genesis Air technology alone reduced the detection of active virus by 95% and the Genesis Air technology in combination with a MERV 13 pe-filter (the intended use of the purification technique) reduced detection of active SARS-CoV-2 by greater than 99.99% (8). These results raised the question: In this same viral challenge setting, how effective is the MERV 13 filter alone at removing SARS-CoV-2 from the air?

The SARS-CoV-2 challenge testing experimental design included culturing of virus, aerosolization of challenge virus using a nebulizer, and detection of viable virus pre-MERV 13 filter aerosol during challenge, and post-MERV 13 filter aerosol during challenge, and after challenge at 0-30 and 30-60 minutes. Although the MERV 13 filter was housed in the Genesis Air unit, the unit was off for the duration of the experiment rendering the viral inactivation capabilities ineffective, allowing the experiment to test only the MERV 13 pre-filter associated with the unit. Each experiment was conducted in triplicate and nebulization of the challenge SARS-CoV-2

virus was conducted at a flow rate of 14 liters per minute (LPM) and combined with additional airflow downstream of the nebulizer to achieve a final flowrate of 30 LPM. Each nebulization delivered a challenge of 1-9x10^6 TCID50* per milliliter (ml) for 15 minutes. During each 15 minutes nebulization, aerosol samples were collected pre-filter and post-filter. After each 15 min nebulization, the unit housing the filter was purged for 5 minutes using clean air and set to a flow rate of 30 LPM to remove any residual aerosol that was not captured by the filter. After purging, two post-filter samples were collected, one at 0-30 minutes and a second at 30-60 minutes. Each post-filter sample was collected for 30 minutes at 12.5 LPM.

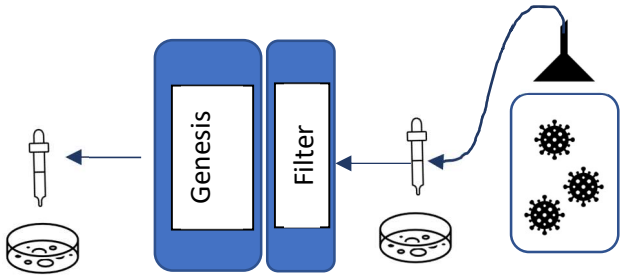

Figure 1A (Left). Laboratory hood set up with aerosolization and detection equipment and the Genesis Air unit housing the MERV 13 filter. From right to left: nebulizer, an upstream Biosampler, MERV 13 filter, Genesis Air unit housing filter, and a downstream Biosampler. Figure 1B (Right) A schematic diagram of the experimental set up showing the pathway of the aerosolized virus from right to left as traveling out of the nebulizer, through upstream Biosampler, though the filter housed in the inactive Genesis Air unit, and finally back through a downstream Biosampler.

Viable virus was collected using Biosamplers and viability was quantified with plaque assays, TCID50 assay. The four experimental configurations were tested as follows:

1) Pre-MERV 13 filter during SARS-CoV-2 virus challenge (baseline viral quantification)
2) Post-MERV 13 filter during SARS-CoV-2 virus challenge
3) Post-MERV 13 filter 0-30 min after challenge nebulization was stopped
4) Post-MERV 13 filter 30-60 min after challenge nebulization was stopped

Each experimental configuration was tested in triplicate on each of three different days.

Aerosolized concentrations during challenge nebulization averaged 1.02x10^5 TCID50 per ml when testing pre-filter (#1 above) and 3.12x10^4 TCID50 per ml when testing post-filter (#2). Post-filter testing averaged 6.65x102 TCID50 for 0-30 minutes (#3) and less than the lower limit of detection (LLOD) for the 30-60 minute samples (#4). Table 1

Table 1. Experimental configurations, replicate results and average result, and percent reduction from pre-filter nebulized aerosol sample.

	Test	Replicate 1	Replicate 2	Replicate 3	Average TCID50/ml (log reduction)	% Reduction from pre-filter aerosol sample
1	Pre-MERV 13 filter during challenge (baseline)	$8.41x10^4$	$2.84x10^4$	$1.92x10^5$	$1.02x10^5$	NA
2	Post-MERV 13 filter during challenge	$2.82x10^4$	$1.54x10^4$	$4.99x10^4$	$3.12x10^4$	69.4%
3	Post-MERV 13 filter 0-30 min after	$8.41x10^2$	$3.14x10^2$	$8.41x10^2$	$6.65x10^2$	99.3%
4	Post-MERV 13 filter 30-60 min after	None detected	None detected	None detected	None detected	>99.999%

None detected = no viable virus was detected based on the lower limit of detection for the TCID50 assay.

The MERV 13 filter removed 69.4 percent of the viable virus during active challenge nebulization, reducing detectable virus from an average of 102,000 TCID50/ml to an average of 31,200 TCID50/ml. After the nebulization was stopped and the unit housing the filter was purged, the sample collected within the first 0-30 minutes showed the removal of 99.3 percent of detectable virus, reducing virus to 665 TCID50/ml. After 30 minutes, no viable SARS 2 was detected.

Although the MERV 13 filter did remove approximately 70% of the virus during active challenge, viable virus was still detected after the nebulization was stopped and the unit housing the filter was purged with clean air (TCID50 $6.65x10^2$). This indicates that not only will viable virus remain in the air even with a MERV 13 filter present, but it may also escape from the filter after the source of the virus has been removed.

“This finding underscores the need for additional safeguards, in addition to filtration, that would assure stoppage of viral aerosol dispersion. One such measure would be to inactivate all aerosolized viral particles during and after capture so that no live virus penetrates the filter.” (UTMB) As presented in the previous paper and stated above, the combination of the MERV 13 filter and the activated Genesis Air technology removes and inactivates greater than 99.99 percent of SARS-CoV-2 during active nebulization challenge. Extrapolation of these data from laboratory challenge testing to live inhabited indoor spaces would suggest that a MERV 13 filter in combination with an inactivating technology will effectively eliminate SARS-CoV-2 from the air.

*TCID50/ml of Tissue Culture Infectious Dose per ml is the viral titer that kills 50% of the tissue culture. It is estimated that infected patients expel viable SARS-CoV-2 in concentrations ranging from 6,000 to 74,000 TCID50/ml (14).

**Due to biohazardous nature of the experiments, the airflow speed and amount of air that passed through the test stand were limited by the laboratory set up and capability. Due the extremely fast nature of the

photocatalytic reaction there is no reduction in the effectiveness of the Genesis Air technology at typical operating airflow speeds.

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