MEMO

Dominion Engineering, Inc.

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Subject: CV-19 Guardian Respirator Adaptor – Filter Insert Testing

1 Background

In response to the shortage of approved PPE such as N95 respirators and faceshields during the COVID-19 crisis, DEI developed the CV-19 Guardian Respirator Adaptor that, along with commonly available materials, can be used to convert a standard snorkel mask into a reusable, full face respirator that effectively protects the eyes, nose and mouth from airborne particles. In an emergency, commonly available materials such as HVAC filters and fabrics/netting for blown insulation can be cut into consumable filter inserts for use with the CV-19 Guardian Respirator Adaptor and a compatible mask as shown in Figure 1 and Figure 2.

DEI conducted testing to evaluate the efficacy of various materials that are readily available and can be used to make these filter inserts. This testing is summarized below.

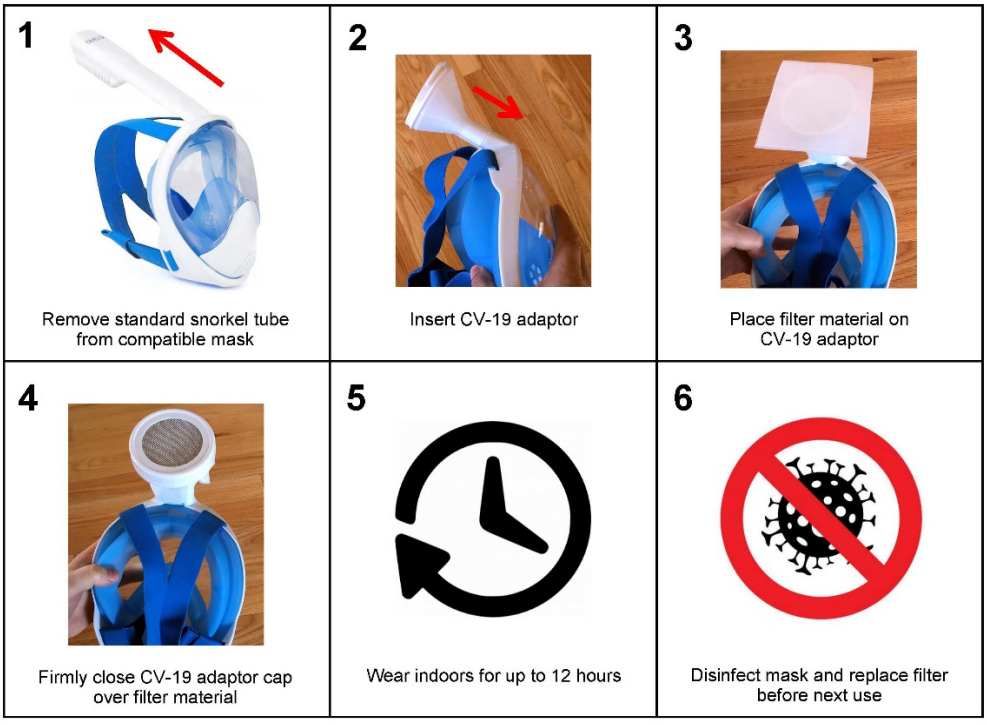

Figure 1 Use of Flexible Filter Insert in CV-19 Guardian Respirator Adaptor
(ex., 2 layers of ADO Pro Pac insulation fabric)

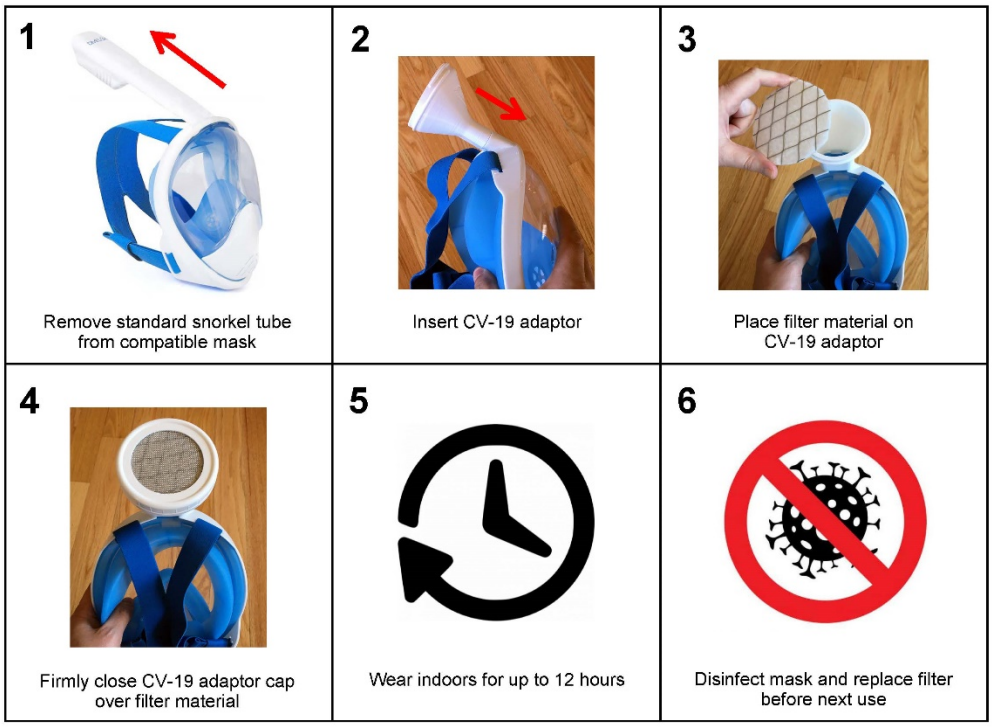

Figure 2 Use of Rigid Filter Insert in CV-19 Guardian Respirator Adaptor
(ex., Aprilaire 213 furnace filter with rigid metal backing)

2 Filter Efficacy Testing

A converted respirator mask assembled using a DIVELUX mask, a CV-19 Guardian Respirator Adaptor and filter insert were subjected to and successfully passed a standard mask fit test using a PortaCount 8038 testing system as shown in Figure 3.

Figure 3 Respirator Fit Testing Using PortaCount 8038

This testing system was also used to test the filtration efficiency of a number of readily available materials that could be used to make consumable filter inserts for the CV-19 Guardian Respirator Adaptor. In these tests, airborne particles were passed through candidate filter inserts and the particle concentration was measured before and after passing through the filter insert. Test results are summarized in Table 1.

As summarized in this table, a number of commonly available materials were found to capture >99% of airborne particles of interest* with good breathability. When paired with a suitably tight fitting mask, filter inserts made from these materials provide a level of protection equivalent to or exceeding that of an N95 respirator (>95% capture, including leakage). In testing presented herein, a DIVELUX snorkel mask fitted with a CV-19 Guardian Respirator Adaptor and such filter inserts met the filtration performance requirements for an N95 respirator under typical fit testing activities (talking, moving head, bending over, etc.).

When making and installing filter inserts from flexible material such as the ADO Pro Pac insulation fabric, it is recommended that the chosen material be cut into squares at least 4.5 x 4.5 inches in size (see Figure 1). This ensures that the filter insert completely covers the sealing face of the adaptor and is held in place between the threads of the adaptor and lid. The four corners of the square should stick out past the lid after assembly in equal amounts, indicating that the full sealing face of the adapter is covered with material. Use of flexible sheet material as described above is the recommended approach in most cases, as it requires the least precision and is easily done without special tools.

When making and installing filter inserts from rigid material such as the Aprilair 213 furnace filter which has a robust metal backing, the filter insert must be cut into a circle with a diameter of 3.40 inches and pressed into the lid with the metal grid oriented away from the adaptor (see Figure 2). This ensures that the filter media seals properly against the adaptor, and that the filter insert is reliably positioned.

* The test equipment used counts particles that are in the 0.02 to 1.0 micron size range.

Table 1 Filtration Efficiency of Commonly Available Materials

Description	Ambient Particulate	Filtered Particulate	Filter Efficiency (% Capture)	Recommended as Filter Insert?	Comments & Product URL
ADO Pro Pac Insulation Fabric (2 layers)	801	5	99.4%	Yes	Excellent filtration, good breathability, readily available in large quantities, easy to work with https://www.homedepot.com/p/ADO-Products-10-2-ft-x-375-ft-Pro-Pac-Insulation-Fabric-ICPP122/302709283
ADO Pro Pac Insulation Fabric (1 layer)	807	39	95.2%	Yes (2 layers)	Acceptable, but recommend using 2 layers for improved filtration https://www.homedepot.com/p/ADO-Products-10-2-ft-x-375-ft-Pro-Pac-Insulation-Fabric-ICPP122/302709283
Aprilaire 213 Furnace Filter	102	0.01	100.0%	Yes	Excellent filtration, good breathability, includes helpful metal reinforcement https://www.amazon.com/dp/B00R3G53NI/ref=cm_sw_em_r_mt_dp_U_NwcGEb2XZH3ZD
Filtrete 1000 Alergen Defense AC Filter	100	0.1	99.9%	Yes	Excellent filtration, good breathability, but small pleats and metal grids are hard to work with https://www.amazon.com/dp/B004Q69HIU/ref=cm_sw_em_r_mt_dp_U_8S-GEb6YMVXM5
Vigoro Landscape Fabric Weed Barrier	809	39	95.2%	No	May work acceptably with 2 layers (similar to ADO Pro Pac insulation fabric); not yet tested https://www.homedepot.com/p/Vigoro-4-ft-x-200-ft-Polypropylene-Landscape-Fabric-Weed-Barrier-2232RV/311040972
Swiffer Dry Sweeping Cloth (4 layers)	129	0.2	99.8%	No	Useful for sewn DIY masks in low quantities
Swiffer Dry Sweeping Cloth (1 layer)	72	6	91.7%	No	
Vigoro Matrix Grid Landscape Fabric	807	210	74.0%	No	https://www.homedepot.com/p/Vigoro-4-ft-x-100-ft-Matrix-Grid-Landscape-Fabric-VPNM410085/302802172
Brown Cone Coffee Filter	113	20	82.3%	No	
Cotton Round Pads (for Makeup Removal)	112	12	89.3%	No	
Hanes Cotton T-Shirt (2 layers)	110	22	80.0%	No	Included for reference, poor overall performance