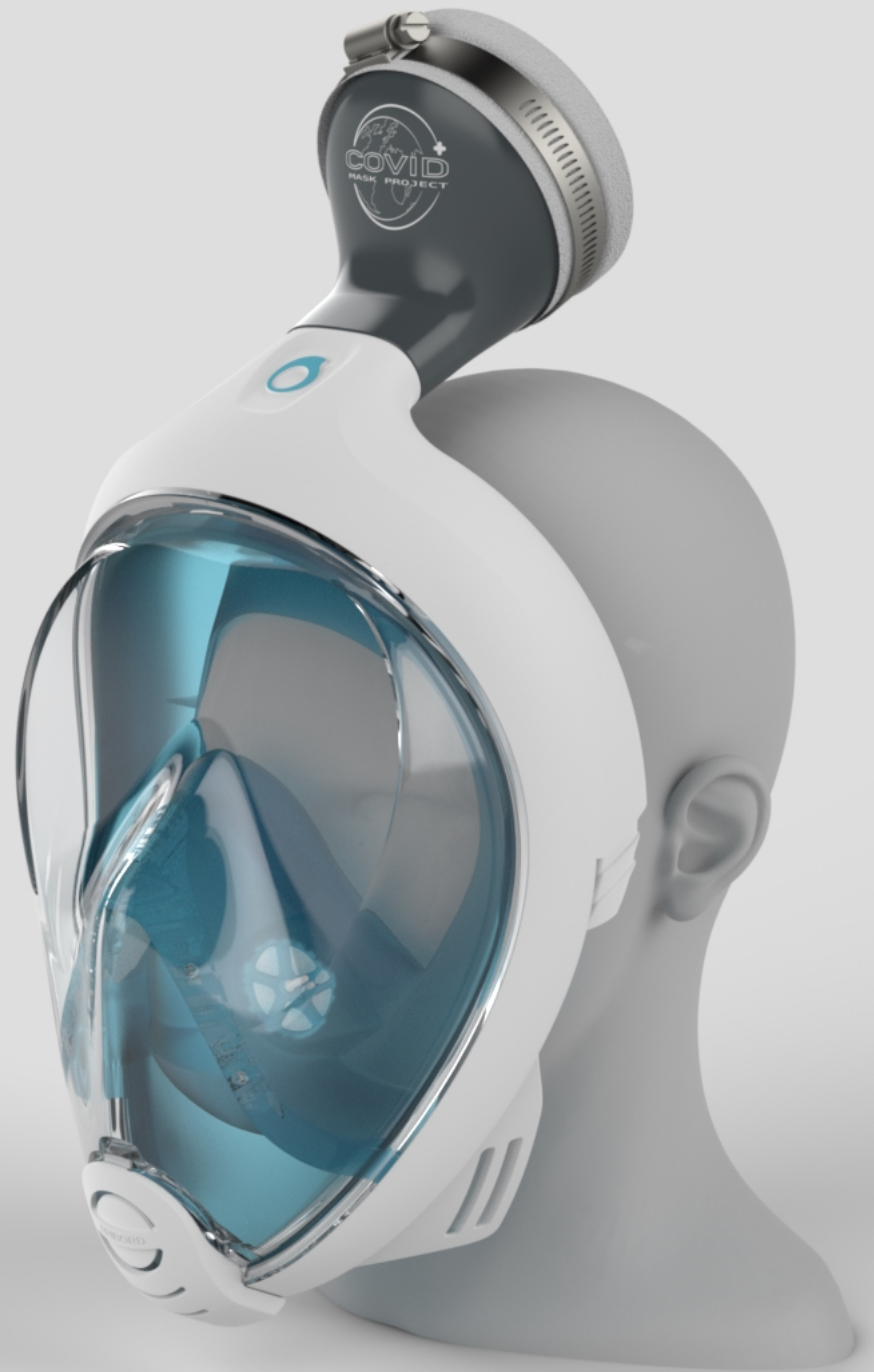




# COVID Mask Project Mask Testing



April 20, 2020  
RD.007 REV IR

# Objective



Qualitatively evaluate various commercial and DIY respirators to understand likelihood of implementation as emergency PPE and degree of protection offered by that solution.

## Likelihood of Implementation

- Is it **Comfortable** enough to be used for hours at a time? Is it easy to breathe through this size filter?
- Is there sufficiently **high visibility** while wearing the mask?
- Can we **communicate easily** while wearing the mask?
- Is it **simple** enough to actually get implemented?
- Is manufacturing and distributing it **cost effective**?

## Effectiveness of User Protection

- Does the mask pass the **vapor test**?
- Does the mask pass the **sage test**?
- What **features** does the mask include? Splash protection? Filtration? Face shielding?

# Test Results ([Video](#))



Mask	Comfort	Visibility	Communi- cation	Simplicity	Cost	Likelihood	Vapor Test	Sage Test	Features	Protection
Bandana	3	3	3	3	3	15/15	1	1	1	3/9
Surgical	3	3	3	3	3	15/15	1	1	1	3/9
KN95	3	3	3	3	3	15/15	1	1	2	4/9
Honeywell	2	2	3	2	1	10/15	3	1	2	6/9
AMBU	1	1	1	1	2	6/15	1	1	1	3/9
DIVELUX	2	2	2	1	2	9/15	1	1	3	5/9
Knit Bonbons	2	2	2	1	2	9/15	2	1	3	6/9
SeeReef	2	2	2	1	2	9/15	2	1	3	6/9
Dolfino	2	2	2	1	2	9/15	3	1	3	7/9

## Vapor Leak Test

Used to visualize aerosol leak paths through respirators.

Procedure:

1. Using an electronic cigarette and non-nicotine, vegetable glycerin based e-liquid, user inhales vapor and holds breath.
2. User dons respirator and quickly fit checks to make sure mask is properly sealed to face.
3. User exhales vapor inside mask.
4. If no vapor is seen leaking from mask, and air exhausting from filter shows no signs of vapor, respirator passes test.

## Smoke Detection Test

Based off Honeywell [Irritant Smoke Test](#) used to fit check air purifying respirators.

Procedure:

1. User dons respirator in a well ventilated environment.
2. Stream of smoke from smoldering sage bundle is directed around the perimeter of the mask.
3. Perimeter is traced several times, and user turns head to stress mask,
4. If user does not smell sage smoke, check sensitivity by gently releasing face seal. If user can only then smell smoke, respirator passes test.

# Surgical Mask

Mask does not conform to face sufficiently to force air through material. Material does not filter vapor, even with four stacked layers.



Ultraguard APP0340-W

Comfort	3
Visibility	3
Communication	3
Simplicity	3
Cost	3
Likelihood	15/15
Vapor Test	1
Sage Test	1
Features	1
Protection	3/9

# KN95

Material filters out vapor well, but despite best efforts face seal was insufficient to pass qualitative OSHA fit testing and all visible vapor flowed around rather than through mask.



MASKin KN95(N95) #6115

Comfort	3
Visibility	3
Communication	3
Simplicity	3
Cost	3
Likelihood	15/15
Vapor Test	1
Sage Test	1
Features	2
Protection	4/9

# Honeywell with P100 Filters

Respirator successfully filtered vapor and sealed well to face. However, filters are expensive and mask cannot be used with a face shield (compatible with goggles only).



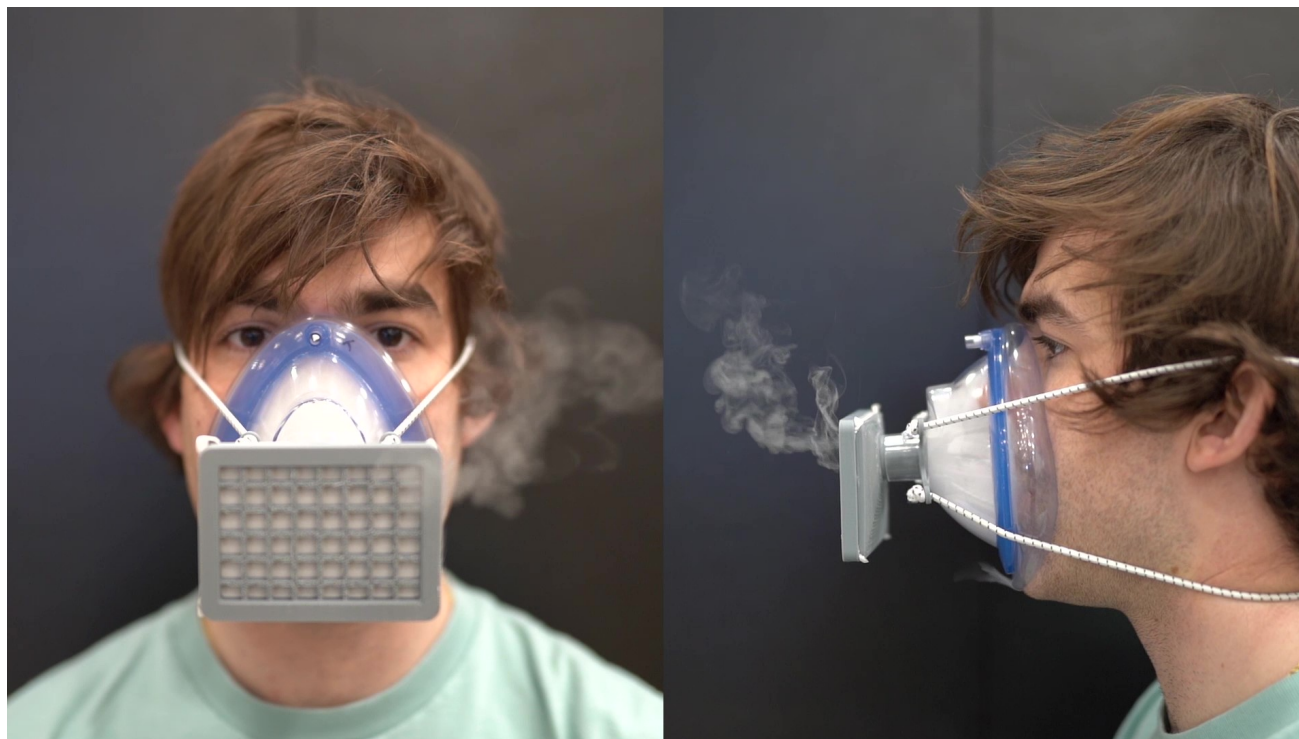
Honeywell RU8500 Mask and P100 Filter #7583P100L

Comfort	2
Visibility	2
Communication	3
Simplicity	2
Cost	1
Likelihood	10/15
Vapor Test	3
Sage Test	1
Features	2
Protection	6/9



# AMBU Mask Prototype

Sealed well to nose bridge, but poorly to cheeks and chin. Uncomfortable and blocked downward visibility. Required significant assembly and adjustment.



Legend Anesthesia Mask + 3D Printed Filter Cartridge

Comfort	1
Visibility	1
Communication	1
Simplicity	1
Cost	2
Likelihood	6/15
Vapor Test	1
Sage Test	1
Features	1
Protection	3/9

# DIVELUX Prototype

Major leak path due to split visor design, but mask performed well after sealing with epoxy. Curved visor led to minor view distortion, not compatible with glasses. Combined respirator and facemask improves protection.



[DIVELUX Mask](#) + 3D Printed Filter Cartridge

Comfort	2
Visibility	2
Communication	2
Simplicity	1
Cost	2
Likelihood	9/15
Vapor Test	1
Sage Test	1
Features	3
Protection	5/9

# Knit Bonbons Prototype

Minor leaks from frame after taping over chin valve from inside (taping from outside failed). Sealing mask with epoxy yielded marginal improvements. Poor separation of visor and mouth chambers. Not compatible with glasses. Combined respirator and facemask improves protection.



[Knit Bonbons Mask](#) + 3D Printed Filter Cartridge

Comfort	2
Visibility	2
Communication	2
Simplicity	1
Cost	2
Likelihood	9/15
Vapor Test	2
Sage Test	1
Features	3
Protection	6/9

# SeeReef Prototype

Minor leaks from frame after taping over chin valve from inside (taping from outside failed). Seems to be near-copy of Knit Bonbons mask. Poor separation of visor and mouth chambers. Not compatible with glasses. Combined respirator and facemask improves protection.



[SeeReef Mask](#) + 3D Printed Filter Cartridges

Comfort	2
Visibility	2
Communication	2
Simplicity	1
Cost	2
Likelihood	9/15
Vapor Test	2
Sage Test	1
Features	3
Protection	6/9

# Dolphino Prototype

No visible leaking after taping over chin valve from inside; single piece visor minimizes leak paths. Good separation of eye and mouth chambers. Not compatible with glasses. Combined respirator and facemask improves protection.



[Dolphino Frontier](#) + 3D Printed Filter Cartridges

Comfort	2
Visibility	2
Communication	2
Simplicity	1
Cost	2
Likelihood	9/15
Vapor Test	3
Sage Test	1
Features	3
Protection	7/9

# Appendix

# Vapor Test Details

Used to visualize aerosol leak paths through respirators.

## Procedure:

1. Using an electronic cigarette and non-nicotine, vegetable glycerin based e-liquid, user inhales vapor and holds breath.
2. User dons respirator and quickly fit checks to make sure mask is properly sealed to face.
3. User exhales vapor inside mask.
4. If no vapor is seen leaking from mask, and air exhausting from filter shows no signs of vapor, respirator passes test.

## Equipment Used:

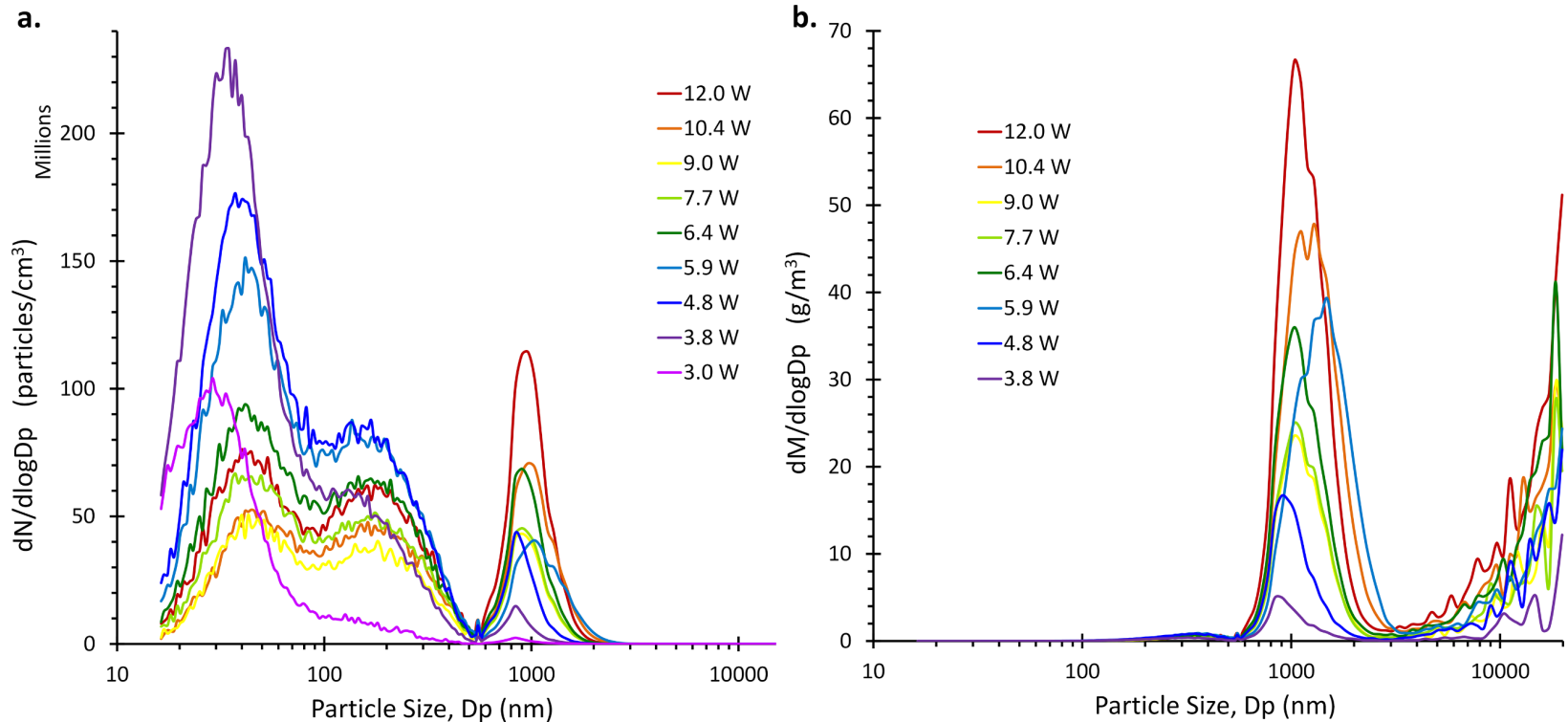
- Respirator/device under test
- SMOK "NORD" electronic cigarette
- Naked 100 "Lava Flow" e-liquid, 0mg, 70% vegetable glycerin, 30% propylene glycerin



# Vapor Test Details



The COVID-19 virus is approximately 60-140nm in diameter (1), and e-cigarette vapor is a tri-modal aerosol with peaks at 40nm, 200nm, and 1000nm (2). Fine e-cigarette vapors are representative of the size of airborne virus particles.



- (1) Cascella M, Rajnik M, Cuomo A, et al. Features, Evaluation and Treatment Coronavirus (COVID-19) [Updated 2020 Mar 20]. In: StatPearls. 2020 Jan-. Available from: <https://www.ncbi.nlm.nih.gov/books/NBK554776/>
- (2) Floyd EL, Queimado L, Wang J, et al. Electronic cigarette power affects count concentration and particle size distribution of vaping aerosol. In: Plos One. 2018 Dec-31. Available from: <https://doi.org/10.1371/journal.pone.0210147>



# Smoke Detection Test Details



Based off Honeywell [Irritant Smoke Test](#) used to fit check air purifying respirators.

## Procedure:

1. User dons respirator in a well ventilated environment.
2. Stream of smoke from smoldering sage bundle is directed around the perimeter of the mask.
3. Perimeter is traced several times, and user turns head to stress mask,
4. If user does not smell sage smoke, check sensitivity by gently releasing face seal. If user can only then smell smoke, respirator passes test.

## Equipment Used:

- Respirator/device under test
- Bundle of dried sage

