

Cloth Mask – Filter Tests

4/3/2020 & 4/4/2020

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Overview:

This study was undertaken to attempt to qualitatively assess the airflow characteristics of a sewn cloth mask both with and without a filter. The goal was to show that airflow would effectively pass through the filter even though it presents an increase in air flow resistance. The filter material is a flat pad inserted into a pocket in the mask.

4 configurations were tested:

- Cloth mask only
- Cloth mask with 4x6 inch filter
- Cloth mask with 5.25x6 inch filter
- Cloth mask with 5.25x6 inch filter and side edges taped

There is also some additional data showing two nose piece options.

Nose piece refers to the formable insert used to shape and hold the mask against the nose – this can be wire, flat metal strip, etc.

There is more that could be done with this data, but the goal is to move this forward and make actionable recommendations that will improve the performance of sewn cloth masks.

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Cloth mask with extended filter installed



Filter Media:

- 100% non woven polypropylene media
- 95% efficient, MERV 15 - protects from sneeze and cough spray, as well as some virus, bacteria, and allergens.
- Electrostatically Enhanced



4/3/20 tests done with twist tie nose piece.

4/4/20 tests done with Laser North metal strip. (shown taped to top of filter)



Filter extension added with Gorilla tape (described in following slides).

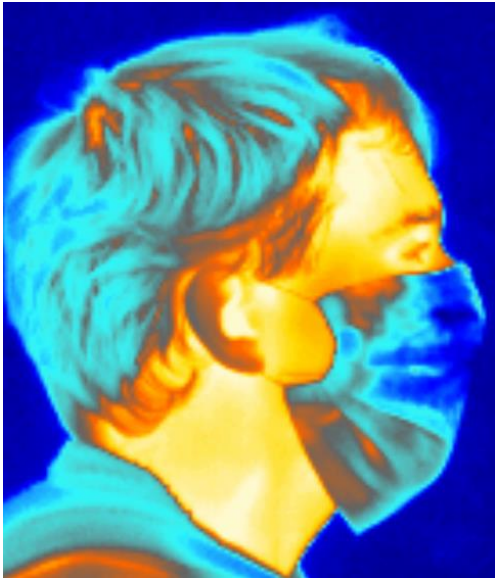
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Observations & Conclusions:

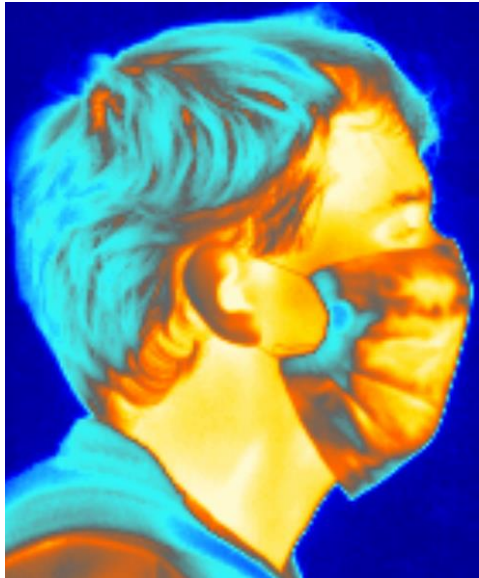
- The images are useful for seeing where the air flows through the mask. The mask has very little thermal mass, so its temperature changes quickly with each breath.
- Skin temperatures at the edge of the mask were helpful in determining if air was leaking past the edges.
- Some additional experimentation with the metal nose piece is recommended to improve the ease of fitment and assure a good seal. The addition of some sort of sealing material could help. The existing metal piece did work ok with the filter installed, but required a fair bit of adjusting.
- Cloth mask only: Edge seals ok. Appears to only utilize about ½ the available surface area for air flow due to low resistance.
- Cloth mask with filter: Filter needs to be sized to cover as much of the mask area as possible in order to seal well around the face. This likely means trimming to fit different size people. The increased flow resistance of the filter makes the nose bridge seal even more critical. Using the metal nose piece to press down on the filter is necessary for good seal. Taping the sides (where elastic passes through) does appear to provide some sealing benefit.
- Nose piece: The optimum nose piece may vary depending on if the mask is being used with/without a filter.
- One tester had trouble with the elastic ear loops on the cloth mask not staying on. She does have small ears. Did not attempt to adjust the length of the elastic. Different elastic configurations are likely better for different people.
- The “Duck Bill” design has some significant advantages in sealing to the face and easy of fitment. If a washable/reusable material can be found that will work with this style mask, it could be an excellent solution.
- Proper fitment of any mask is essential to good performance.
- Overall, it appears the addition of a filtration material to the mask pocket is worthwhile, and did not result in excessive air flow bypassing the mask.

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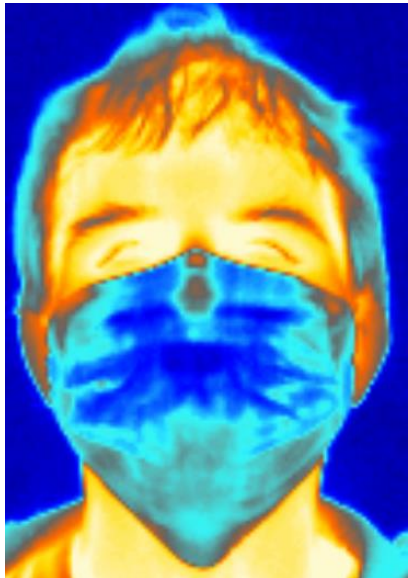
Cloth Mask – NO FILTER



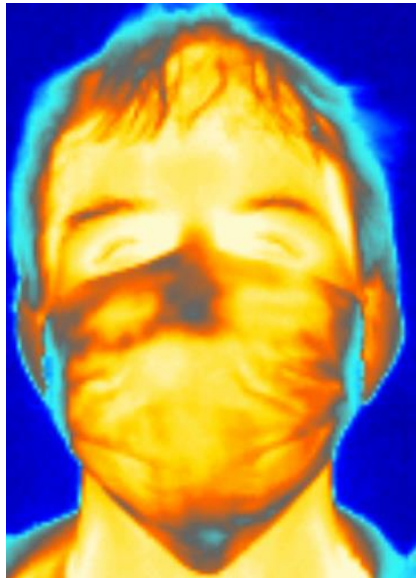
4700 – Y_NO-FILT_52/90
Inhale



4702 – Y_NO-FILT_52/90
Exhale



4696 – Y_NO-FILT_52/90



4698 – Y_NO-FILT_52/90

Hot

90.0°F



Increasing Temperature

52.0°F

Cold

Inhale: A full, strong breath was taken in and held. Image immediately taken.

Exhale: A full, strong breath was blow out and held. Image immediately taken.

There is likely some test to test variation in the breathing, through it was attempted to be consistent. My right nostril is also larger and likely flows about 70% of the air volume (this can be seen in the later filter tests).

52/90 signifies the scaling range used. The scale is included on the right and displays deep blue for the coldest regions and bright yellow for the hottest.

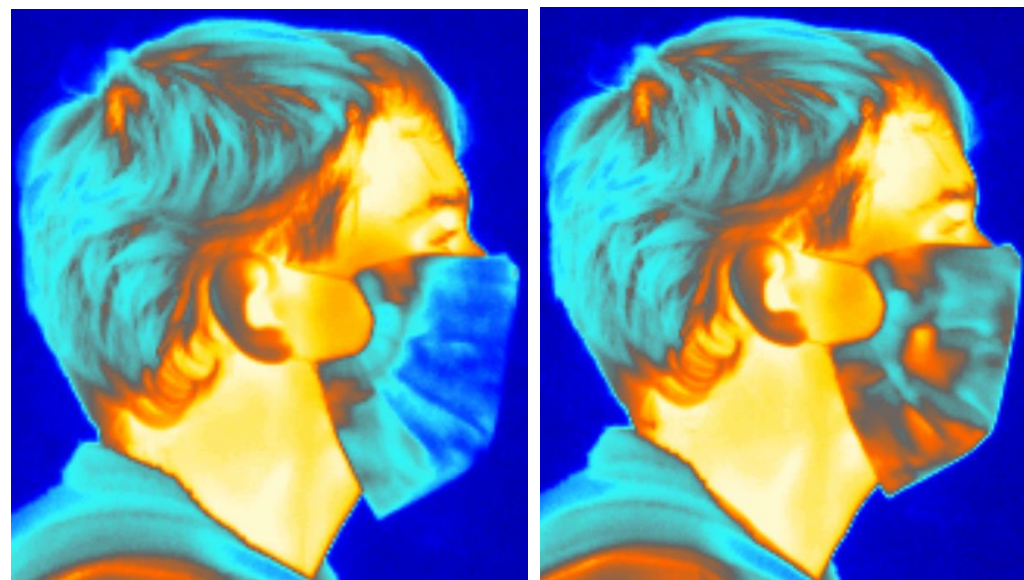
The temperatures shown are surface temperatures only (not air temperatures).

Air appears to preferentially try to travel in along the sides of the nose and short-circuit the mask. Careful attention was paid to getting a good pinch on the metal nose piece on the sides of the nose. Based on the image, about ½ the mask handles the majority of the airflow.

On exhale, the skin temps at the edge of the mask to the sides of the nose appear higher, indicating air leakage in this region.

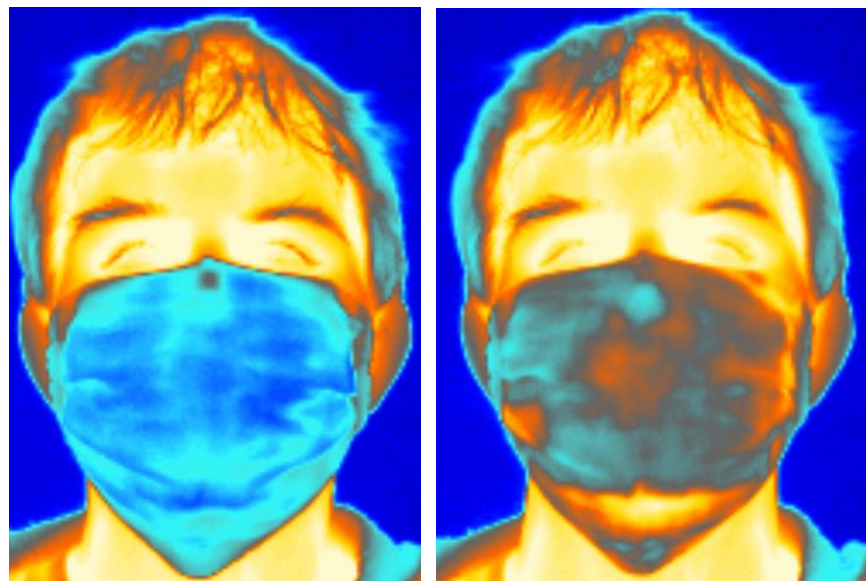
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Cloth Mask – 4x6 FILTER: MERV 15 (clipped under nose piece)



4710 – Y_FILT_52/90
Inhale

4712 – Y_FILT_52/90
Exhale



4706 – Y_FILT_52/90

4708 – Y_FILT_52/90

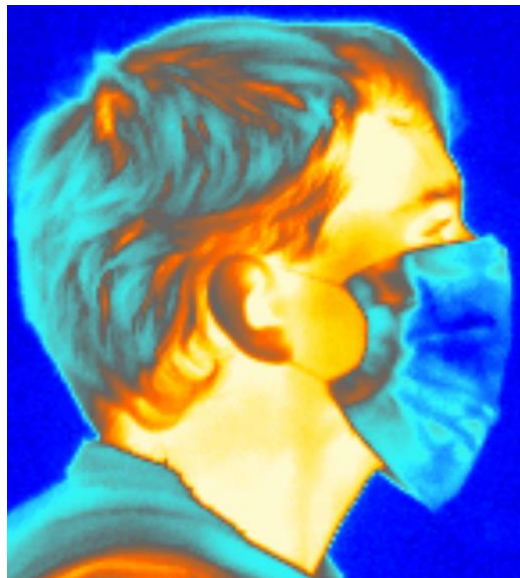


For this test, the filter element was positioned such that the metal nose piece would press it against the face. The metal strip was taped in place at the top edge of the filter. The goal was to improve the seal along the top edge. Compared to a previous test where the filter was not positioned this way, it did improve the seal (image GR_4594).

Airflow appears to be distributed across more of the mask surface during inhale. A significant jet travels down and out the bottom on exhale and the bottom edge of the filter is clearly defined. There is evidence of increased skin temperature in the profile view at the bottom edge. This raises concern about if the filter is being short circuited during inhale. The area of maximum cooling, however, does appear in the filter media area, so any leakage is likely minimal.

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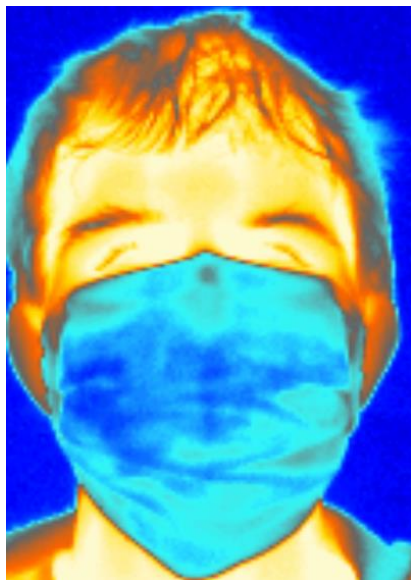
Cloth Mask – EXTENDED FILTER (approximately 5 x 6)



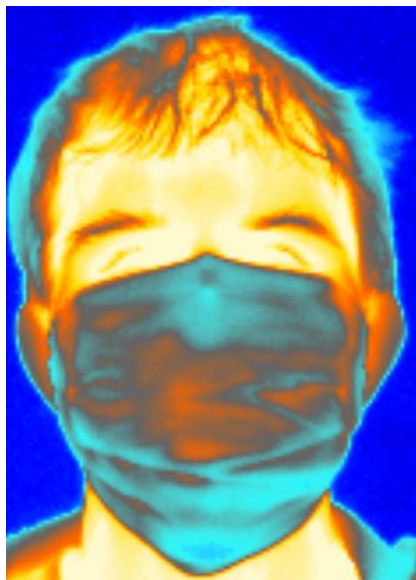
4722 – Y_EX-FILT_52/90
Inhale



4724 – Y_EX-FILT_52/90
Exhale



4718 – Y_EX-FILT_52/90



4720 – Y_EX-FILT_52/90



Based on observations from the 4 x 6 filter test, the filter media was extended in length to reach the bottom of the mask (5-1/4 x 6). This was accomplished by cutting an additional strip and taping it with a narrow piece of gorilla tape on both sides.

At inhale, there is less definition on the bottom edge of the filter and the right/left bias in airflow is starting to appear. I believe this is attributed to better sealing forcing more airflow through the filter.

It appears more air is now forced out the sides of the mask on exhale vs down through the bottom and past the filter. This is the easiest area for the pressure to overcome the inward force of the mask against the face.

Sealing in the nose bridge region looks good for both inhale and exhale.

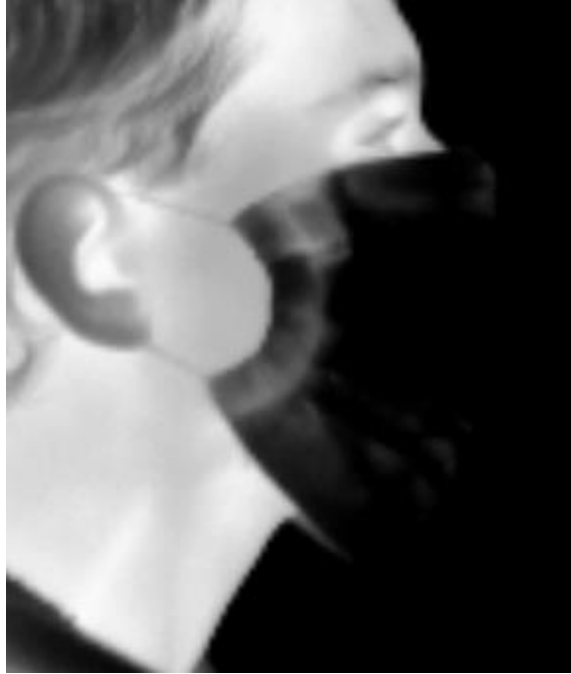
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Cloth Mask – STANDARD VS EXTENDED FILTER: additional images



4710 – Y_FILT_60/95

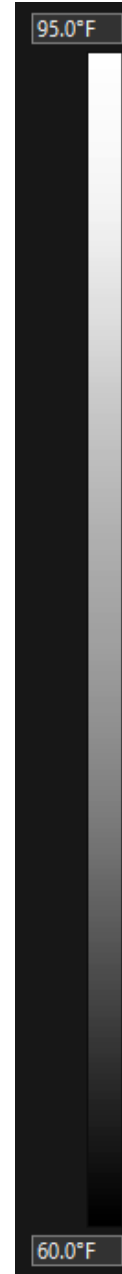
4" x 6"



4722 – Y_EX-FILT_60/95

5.25" x 6"

Inhale

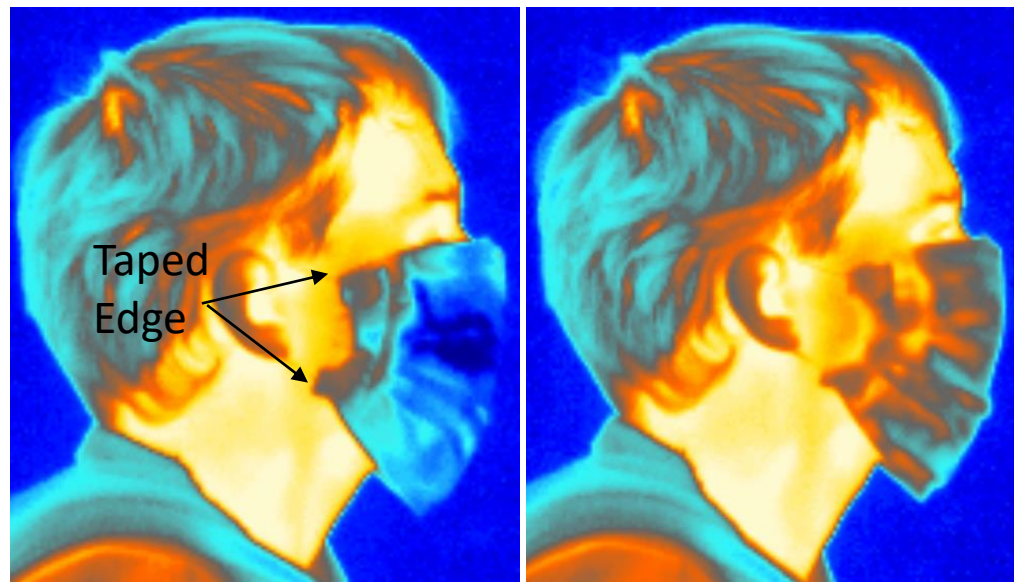


This set of images illustrates the difference between the standard and extended filter. The image on the left is the 4 x 6 filter. The bottom edge of which is clearly defined. The image on the right uses the extended filter, which extends below the bottom of the jaw.

The longer, full coverage filter is the better option.

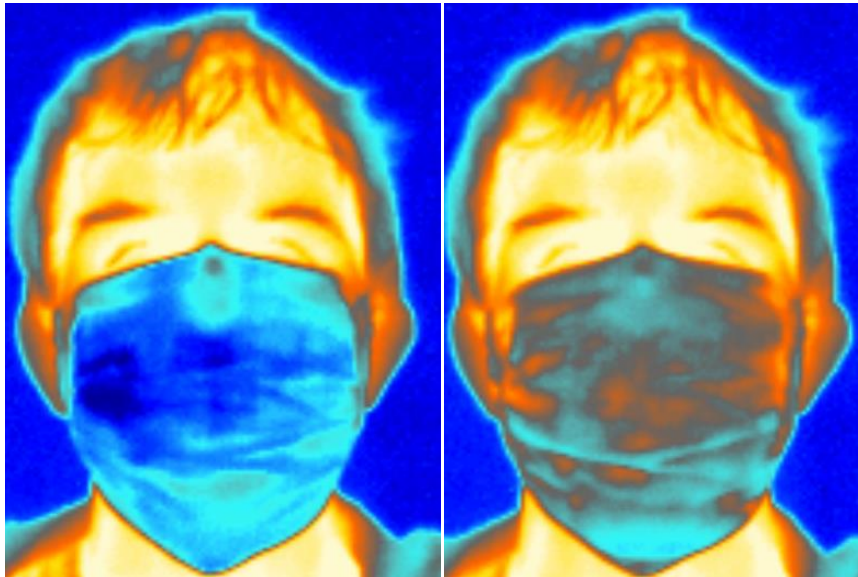
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Cloth Mask – EXTENDED FILTER: ELASTIC EDGE TAPED



4731 – Y_EX-FILT_T_52/90
Inhale

4733 – Y_EX-FILT_T_52/90
Exhale



4727 – Y_EX-FILT_T_52/90

4729 – Y_EX-FILT_T_52/90



For the final test, medical tape was used to hold the sides of the mask (where the elastic passes through) against the face.

At inhale, there appears to be more pronounced cooling in the filter region, which would indicate stronger airflow (could also be variation in the breath size). It also appears there may again be some leakage around the nose bridge on the right side. This could be caused by removing and re-fitting the mask slightly differently, or an improved side seal now forcing the flow elsewhere.

For the exhale, the side edges of the mask now look hotter, which is likely due to increase flow through the mask/filter instead of out the bottom edge of the filter.

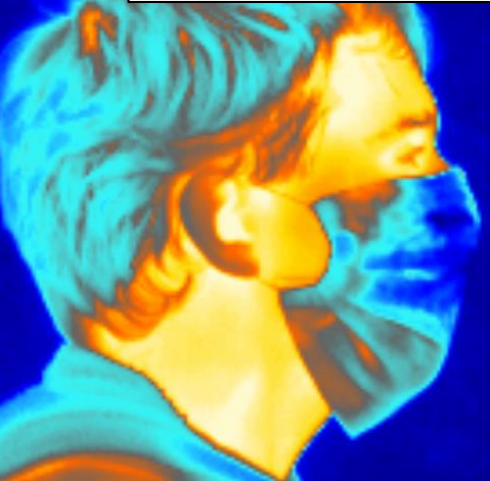
Taping the entire perimeter would likely be the best option, but is not very convenient.

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Cloth Mask – NO FILTER: Nose piece comparison

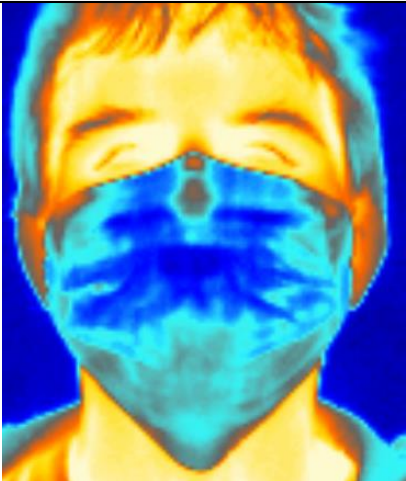
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METAL STRIP NOSEPIECE



4700 – MET_STRIP_52/90

Inhale

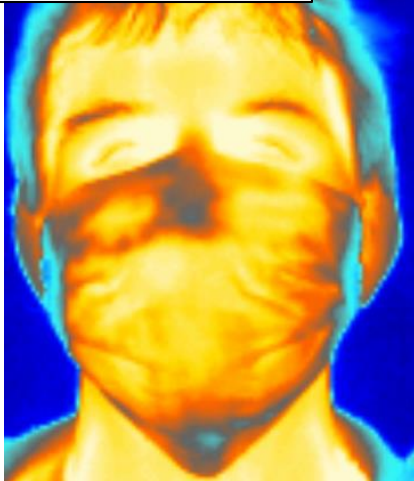


4696 – MET_STRIP_52/90



4702 – MET_STRIP_52/90

Exhale

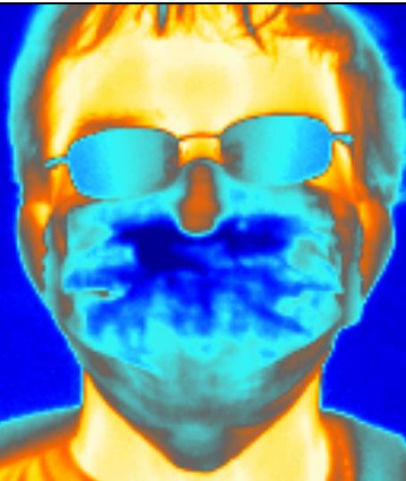


4698 – MET_STRIP_52/90

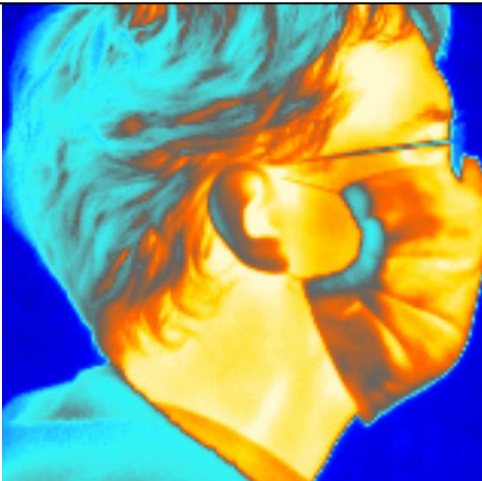
TWIST TIE NOSEPIECE



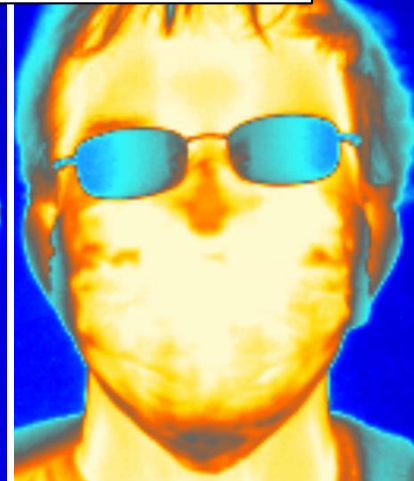
4588 – TWIST_TIE_52/90



4584 – TWIST_TIE_52/90



4590 – TWIST_TIE_52/90



4586 – TWIST_TIE_52/90

90.0°F

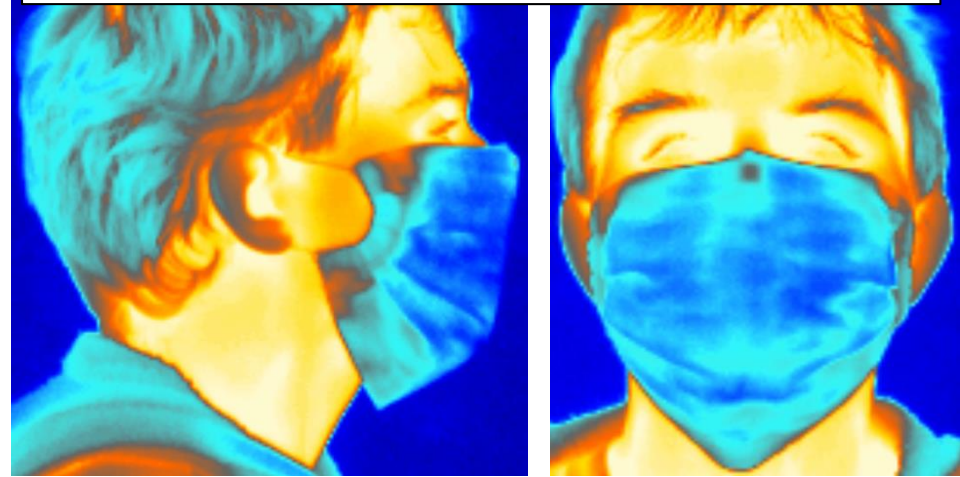
52.0°F

On the first day of testing, a triple twist tie was used for the nosepiece of the mask. On the second day, a flat metal strip manufactured specifically for these masks was used. It seemed like the twist tie was too soft for the application, and the expectation was the metal strip would perform better. It appears for the mask only configuration, the twist tie was actually better at sealing around the nose during inhale, but not exhale. It could be that the softer, more flexible twist tie allowed the mask to be sucked down to the face and form a better seal during inhale, but would then lift on exhale. The metal strip did the opposite – it would not allow the mask to deform and suction to the face on inhale, but did resist deformation and thus the exhaled air flow.

I don't believe the glasses are contacting the edge of the mask.

Cloth Mask – 4 x 6 FILTER: Nose piece and filter position comparison

METAL STRIP NOSEPIECE, OVER TOP OF FILTER

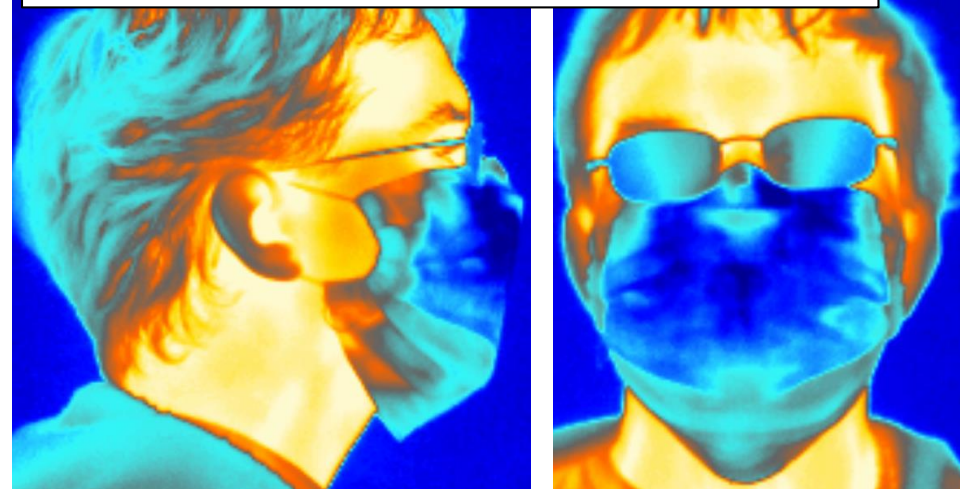


4710 – MET_STRIP_52/90

4706 – MET_STRIP_52/90

Inhale

TWIST TIE NOSEPIECE, FILTER NOT AT TOP



4599 – TWIST_TIE_52/90

4594 – TWIST_TIE_52/90

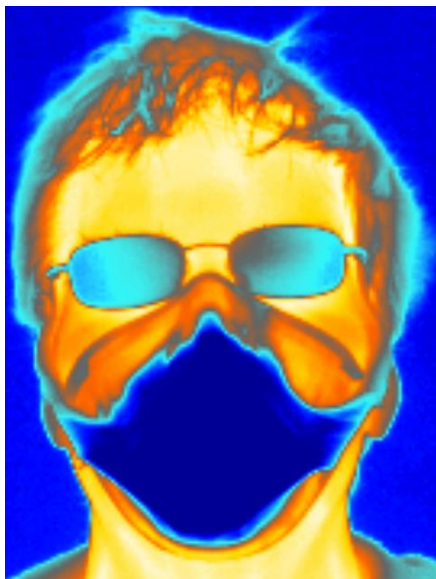
Unfortunately there are two variables here. The lower set of images used the twist tie nose piece and the filter media was positioned $\frac{1}{4}$ to $\frac{3}{8}$ " from the top of the mask. It was just above the tip of the nose. The upper set of images uses the metal strip which was taped to the top edge of the filter. This held the filter at the top of the mask and pressed it down against the face.

While the filter in the lower set of images likely sealed better at the bottom of the face, due to the lower position, it appeared to leak a lot of air at the top. The edge of the filter is visible in the image. In the upper images, there was likely more leakage at the bottom (which motivated the extended filter test), but far better seal at the top.

The recommendation is to have the nose piece positioned so that it will press the filter material down against the face.

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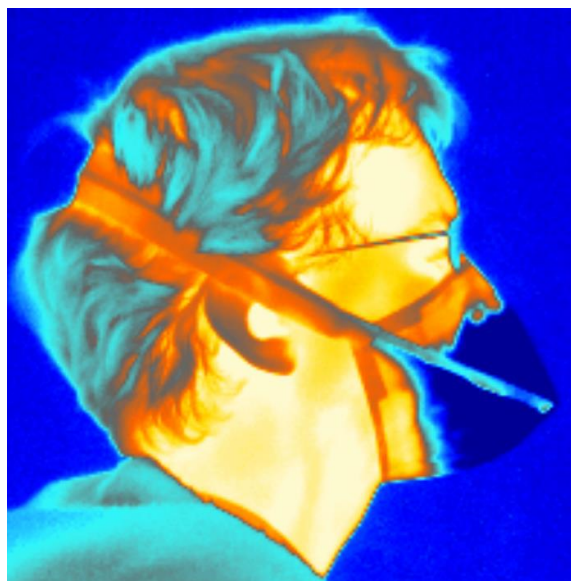
Alternate Mask Design – “DUCK BILL”



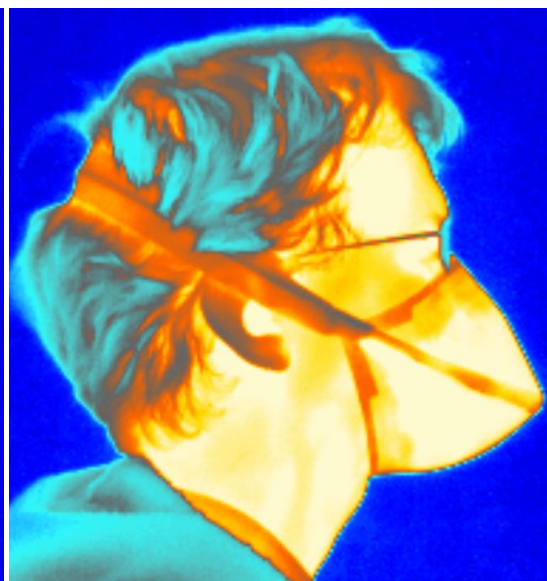
4616 – DUCK_52/90
Inhale



4618 – DUCK_52/90
Exhale



4621 – DUCK_52/90



4623 – DUCK_52/90



An additional mask was tested – the “Duck Bill”. This was provided by Bob Emmert, owner of Bissonette’s Sew & Vac. It is made with vacuum bag material and is constructed by gluing the seams. The single elastic band is a draw-string type waist band material.

The mask is very easy to fit to the face and provides an excellent seal around the full perimeter. This is probably the best design for allowing an easy, low leak fitment.

It is not a washable material.

Breathing was very easy due to the large surface area.



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