FAKULTA ELEKTROTECHNIKY A KOMUNIKAČNÍCH TECHNOLOGIÍ
ústav automatizace a měřicí techniky

BUTMask H2

User and Assembly Manual

2nd ed.

BUTMask-H2

The original protection halfmask for non-professional use is mainly intended to replace regular surgical masks and respirators when these are unavailable or do not fit on tightly due to improper design or heavy everyday duty. The halfmask can be assembled from common, commercially distributed materials, and its basic parts are 3D-printable (via FDM and other standard technologies). A tight touch on the face and full sealing of the walls are ensured by a sleeve that, for practical and easy usage, is made of a disposable glove.

Main Benefits

Compared to a simple 3D-printed product, the VUTMask H1/H2 brings the following advantages:

- Full sealing thanks to a convenient sleeve
- Good face shape adaptability
- Face skin contact only with the actual material of the disposable glove (Nitril or Latex)
- Sleeve-protected structure eliminating external contamination completely
- A material quick and cheap to change and disinfect.

Innovations

- Markedly improved user characteristics: The original version H1 proved to be very uncomfortable if the size had not matched perfectly; thus, we modified the shape of the product to better distribute the pressure on the face and to reduce the discomfort in, above all, the nasal area.
- More sizes available: As custom-made hard plastic parts will never deliver the relaxed feeling and face adaptability of commercial soft plastic components, the utility of our half mask closely relates to finding the right size. To satisfy the widest set of users, we designed more size variants than offered in commercially marketed products.
- Children's options: For children and adults alike, the conveniently trimmed XS and XXS sizes are at hand. **The half mask is not to be provided to minors who, if unassisted, cannot put it freely on or off the face in problematic situations. A child wearing the mask must not be left unattended, requiring continuous communication with an adult.**
- A larger XL size.
- Less air leaks when on the face: Importantly, the efforts to optimize the product's shape not only increased the user comfort but also reduced the air leakage, such that where already the H1 version yielded very good measurement results, the improved model exhibits superior tightness.
- Modified filter housing: The preliminary tests showed that an original, good quality vacuum cleaner bag can be employed as a suitable improvised filtering medium. To facilitate smooth functioning of the filter, we adjusted its housing room and locking elements, thus decreasing spurious pressure on the bag's active surface.

- An innovated set of headstraps: A close fit on the face is ensured only when the straps have been attached to the head reliably. For this purpose, cross-tied fastening is recommended (the upper straps run above the ears while the bottom ones intersect them at the temples and run on to the crown of the head).
- Indirect venting via lamellae: The filter is partly protected by lamellae preventing diverse particles and droplets from impinging directly on the filter's surface; moreover, the lamellae direct the exhaled air downwards to eliminate its straight impact on another person's body.

Caution:

The protection provided by a half mask, surgical mask, or respirator depends mainly on a tight face fit; the filtering capability of the applied medium is a secondary parameter. Even improvised filtering instruments substantially reduce the virus contraction risk, although their protective performance cannot match that of a classic tool.

The half mask does not comprise an expiratory valve, and the humidity aggregates in the filtering medium; similarly to surgical masks, there then forms a potentially bacterial environment, meaning that the filter must be dried and disinfected or replaced.

The half mask is not to be provided to minors who, if unassisted, cannot put it freely on or off the face in problematic situations. A child wearing the mask must not be left unattended, requiring continuous communication with an adult.

Using the Product

When or before using the halfmask, proceed as follows:

- **If allergic to latex, always put on a nitril glove!**
- Check the integrity of the product and/or its components, the sleeve in particular. **Never use a damaged halfmask.**

- When handling the product, do not touch the inner parts and components that directly fit on the face.
- Ensure tight skin touch.
- Adjust the wearing time to the applied filtering material.
- Disinfect after use.

Tightness Testing

After putting the half mask on, cover the filter with your palm and breathe in slightly to create a vacuum. In an optimal case, there should be no air sucked in over the edge. If you feel air leaking inside, reposition the mask on the face to find a better fit. The actual shape of the PLA-based product can be altered mildly in hot water (60 °C) and then adjusted when put on. At customer's request, the product can also be equipped with a sealing band (such as D-profile rubber seals for windows), the scale of applicable materials being very wide.

A D-profile sealing element is one of the many options available.

Size

In most adults (about 70%), the distance between the bottom of the chin and the nasal bridge equals approximately 12 cm, where the **M or L** sizes are sufficient. Your personal measure is easy to determine: just use a caliper.

Table of sizes

Size	Distance between the bottom of the chin and the nasal bridge
XXS	Children's size, 5-6 yrs (must try on)
XS	Children's size, 7-8 yrs (must try on)
S	Less than 10 cm
M	11 to 12 cm
L	13 cm
XL	More than 14 cm

Disinfecting the Surfaces

The product must be disinfected before further use; the individual steps and alternatives are described below.

Filter

Ideally, the filter should be heat-treated (by using tools such as a flatiron) or replaced with a new one; the procedure has to be chosen according to the printing material used.

Disinfecting the Printed-Out Parts

During our testing cycle, PLA plastics were immersed in undiluted SAVO Originál (a 4.7% sodium chlorite-based disinfectant) for more than 48 hrs, with no structural or aesthetic changes revealed at the end. Thus, the printed PLA components can be readily sunk in diluted solutions of SAVO Originál or other similarly composed disinfectants. In SAVO Originál, we recommend the sodium chlorite concentrations of between 0.5% to 0.1%, meaning that the dilution rates range between 1:6 and 1:40.

Ethanol or isopropyl alcohol are also applicable, at concentrations from 70% to 90%; above the latter value, alcohol might have negative impact on the surfaces and overall integrity of the parts.

The disinfection of half masks has been systematically discussed on the PrusaPrinters company's website, https://help.prusa3d.com/cs/article/dezinfekce-prusa-oblicejovy-stit_125458.

Due to the porosity of a 3D-printed component, the real disinfection time should be longer than that recommended in the literature for nonporous materials.

When handling the disinfectant, always follow the manufacturer's instructions. If you immerse the half mask components, leave them in the (lukewarm) solution for at least 5 minutes, though the ideal process takes 15 mins. To ensure reliable disinfection, clean any dirt from the mask before using the agent.

The filter holder is to be disinfected by being immersed in a convenient solution (Savo Originál diluted at 1:6; ethanol; or isopropyl alcohol); the suitability of a disinfectant depends on the concrete printing material.

Sleeve

The glove has to be either treated with a disinfecting solution or replaced with a new one.

Manufacturing Components

To fabricate the halfmask, the following items are necessary:

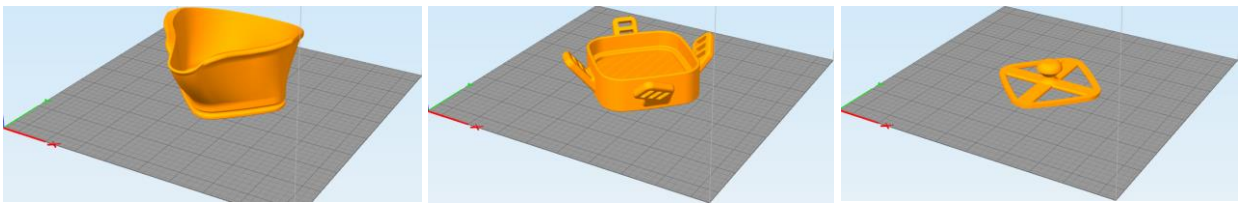
- A 3D printer having an area of at least 130 x 130 x 70 mm
- Printing material (filament); generally, the requirements are very minimal, and the user can employ PLA, ABS, PET, PETG, ASA, CPE, or any alternative item (however, PLA is recommended, as after the printing and possible re-heating in hot water (60 °C) the product's shape can be finalized and adjusted to better fit the face)
- An elastic, disposable, L- or M-sized glove. Nitril gloves are recommended thanks to their durability and overall strength; a latex sleeve is also convenient but offers less reliability and must not be used by persons allergic to latex
- Improvised filtering inserts having a minimal size of 70 x 70 mm.
- Strings, wider elastic rubber bands, or other material applicable for the head straps
- Thin kitchen rubber bands (40 mm in circumference)
- Optional: a self-adhesive rubber sealing band (such as D-profile elements).
- A pair of scissors.

3D printing settings

The main 3D printing parameters are as follows:

Nozzle	Layer height	Top solid layers	Bottom solid layers	Outline shells	Infill	Support	Raft
0.4 mm	0.2 mm	3	3	2	40 %	no	no

The positions of the parts in printing are shown in the following images:



Manufacturing Procedures

The individual assembly steps are indicated below.

1. On a 3D printer, print out the
    a. half mask frame of the desired size (BUTMask_H2_Frame XXS, XS, S, M, L, XL);
    b. filter holder, after customizing the front cover (ButMask_H2_FilterCover);
    c. and template (guide) to shape the filter (FilterShaper). Alternatively, the PDF version of the guide can be printed out on paper.

2. The manufactured half mask can be adjusted to a certain extent to suit the face, depending on the actual material of the product. When customizing the shape, proceed as follows:
    a. Find the temperature at which the material becomes plastic (in PLA, for example, the threshold is 60 °C), and heat approximately 0.5 liter of water up to the appropriate value.
    b. Let the face-fitting portion of the half mask partially sink in the water, allowing the water level to reach only about 1/3 of the mask's height; now, heat the product for several seconds. **Caution**: Do not immerse completely, as the hot water may deform the front section that accommodates the filter.
    c. Remove the mask from the bath to gently reshape it.
    d. If necessary, put the product in the bath again, preventing overheating and major deformation of the material.
    e. In general terms, only the width of the half mask is adjustable to a better fit, meaning that the initial length must be selected properly and carefully before printing.

3. Lay the frame (BUTMask_H2_Frame.stl) on a desk, with the face-fitting side upwards.

4. Glue the sealing strip (15 cm long for the L-size but shorter in the lower sizes) on as illustrated. The actual length of the path depends on the person's requirements: Some users are comfortable with only the nasal area sealed, while others do not need the sealing at all. Try the product out and optimize it to suit.

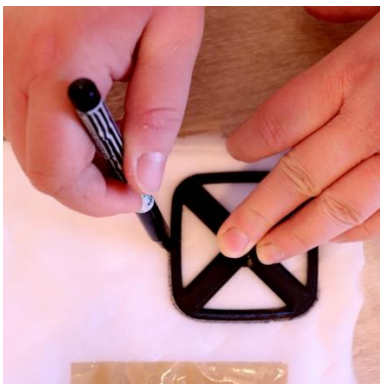
5. Lay the frame (BUTMask_H2_Frame.stl) on a desk, with the face-fitting side upwards. Take a glove, stretch its mouth with both hands, and put it over the frame of the halfmask.

6. Adjust the position of the glove, letting its hem to run (at least approximately) along the halfmask's edge, at a distance of about 2 cm.

7. Use the scissors to cut off the glove fingers in the area of the halfmask's vent, approximately 1 cm from the outer edge.

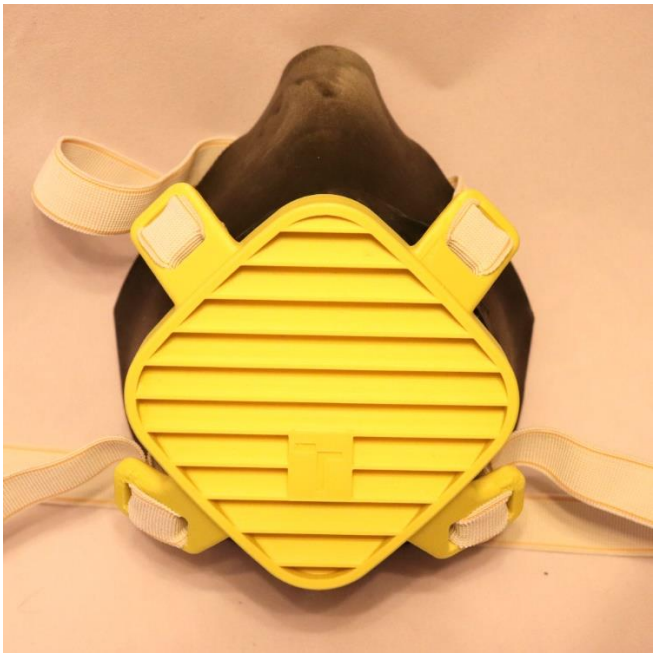
8. Fix the glove by inserting the kitchen rubber bands in the groove below the edge of the halfmask's vent. Adding some more rubber bands at a later time will improve the locking ability of the filter cover.

9. Use the printed filter guide to mark on the filtering material (cotton tissues, a car cabin filter, a vacuum cleaner HEPA filter or bag, or another convenient item) the shape of the halfmask filter, then cut the filter out. The filtering properties can be improved by combining several layers of different materials. Depending on the resulting filter thickness, select the correct filter cover size. Finally, insert the filter into the cover.

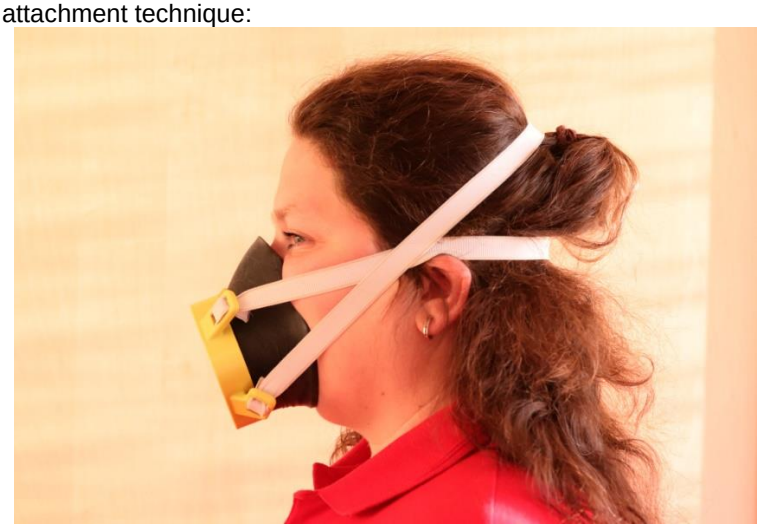


Make the headstraps by utilizing a string, wider elastic rubber bands, or another suitable type of material, and fasten them to the filter cover. The straps should be long enough to fit and hold.

10. Attach the filter cover to the headmask's frame. The product is now ready for use.



The recommended strap attachment technique:



Designed by:

Brno University of Technology
Faculty of Electrical Engineering and Communication
Department of Control and Measurement
Industrial Automation Group
– Michal Husák – Ondřej Baštán – Václav Kaczmarczyk – Lukáš Votava – Jan Zouhar –
– Petr Fiedler – Zdeněk Bradáč – Přemysl Dohnal –

Contact information:

vutmaska@gmail.com
http://www.vut.cz/mask

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