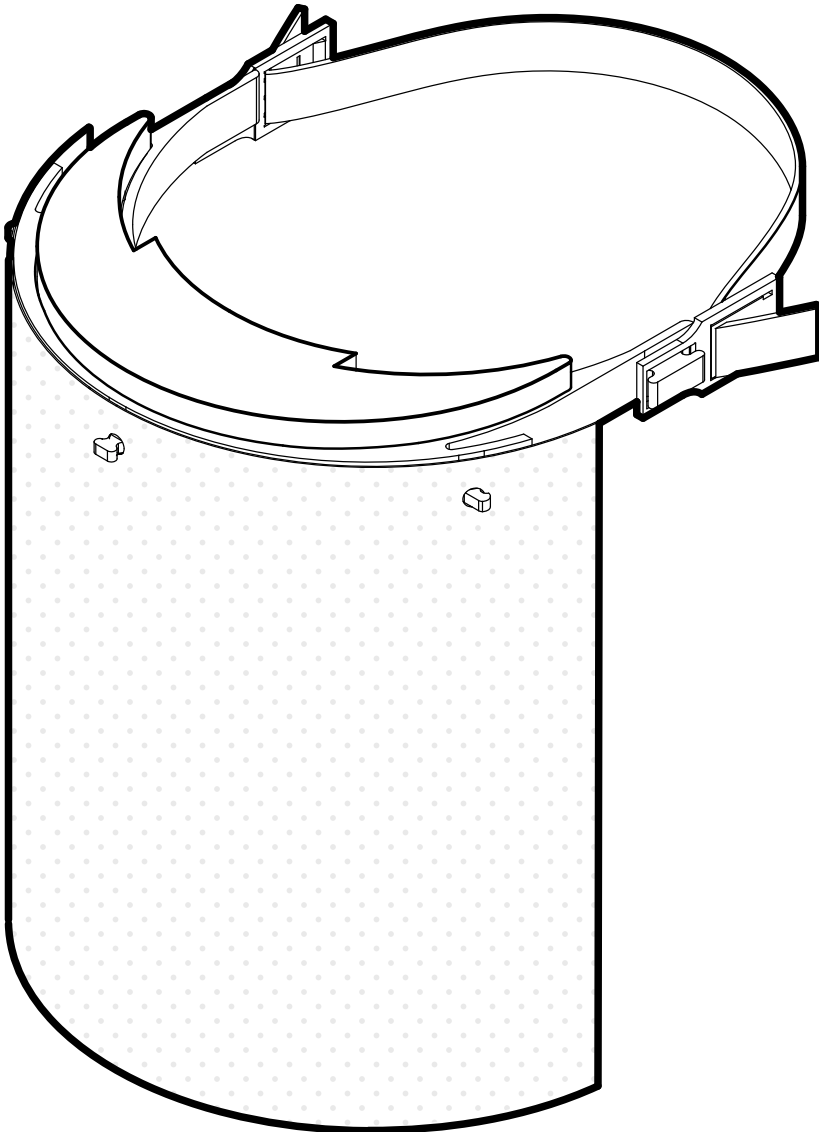




SHIELD PROCESS & USER MANUAL

INSTRUCTIONS:

RESIN CAST FACE SHIELD



NOTES:

The following document describes the tools, materials, and processes required for the mass production of the resin cast face shield developed by a transdisciplinary team at Temple University in Philadelphia. The face shield consists of 5 elements:

1. Shield Frame (cast resin).
2. Three Hole Punched Clear Plastic Shield.
3. Top Foam Protective Insert (optional).
4. 3D Printed Elastic Adjustment Clip (optional).
5. Elastic Strap.

Unlike 3D printed face shield frame designs which are straight forward but slow in production, this process requires the creation of reusable positive & negative molds at the beginning which allow for the rapid production of large numbers of repetitive parts per hour. As the most complex aspect of the design is the casting process developed for the shield frame, most of this document will be dedicated to these processes. Shield frame production consists of the following steps:

1. Nesting (number of parts per mold).
2. Creation of positive rigid mold (CNC milled or 3D printed).
3. Casting several negative molds from the positive mold.
4. Casting resin shield frames in rubber mold.
5. Post-processing & assembly.

REQUIRED TOOLS:

1. CNC Mill
2. Wall Powered Drill
3. Turbine Mixer
4. Rubber Squeegees
5. Mixing cups (1.5Qt)
6. Mixing Sticks
7. Sand Paper
8. 3 - Hole Punch
9. Paper Cutter
10. Scissors
11. 3D Printer

REQUIRED MATERIALS:

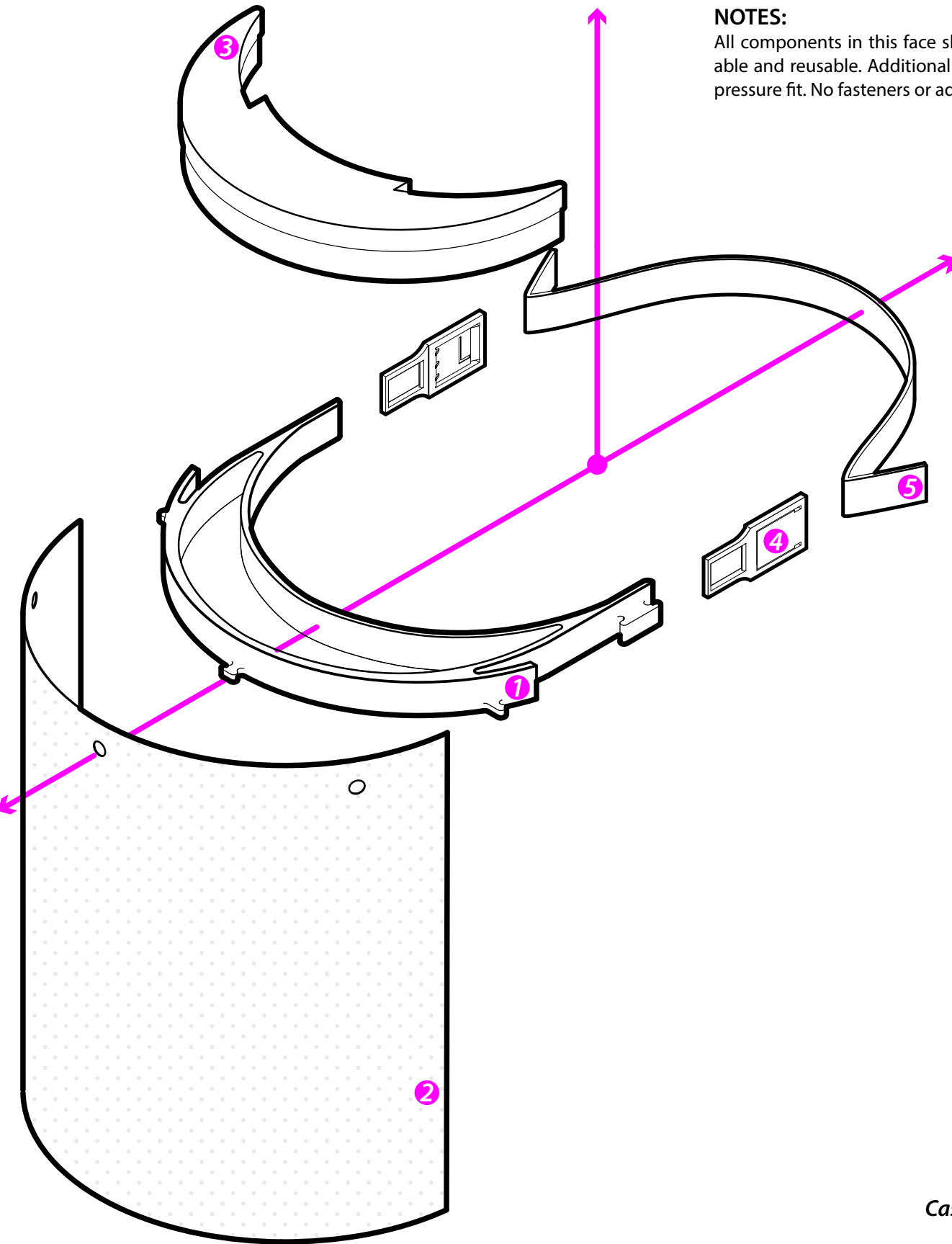
1. High Density Foam or comparable material (i.e. Renshape 5025).
2. Mold Casting Material (i.e. Moldmax 40).
3. Quick Curing Resin (i.e. SmoothCast 65D; Task 8).
4. Mold Release (i.e. Mann's Ease Release 200).

ADDITIONAL RESOURCES:

Throughout these instructions please find links to video tutorials for tooling, material preparation and processes as well as assembly.

NOTES:

All components in this face shield are interchangeable and reusable. Additionally, all components are pressure fit. No fasteners or adhesives are necessary.



Cast Shield Frame_ 1

CNC Milled Positive_ 1A-

3D Printed Positive_ 1B-

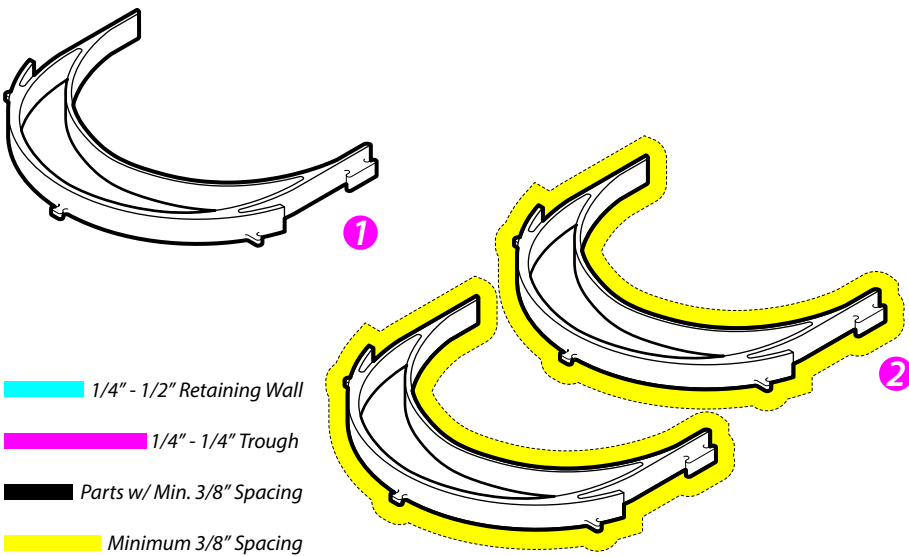
Clear Plastic Shield w/ 3-hole punch_ 2

Foam Insert_ 3

3D Printed Elastic Adjustment Clip_ 4

Hand Cut Elastic Strap_ 5

OVERVIEW: CAST FACE SHIELD COMPONENTS **B**



NOTES:

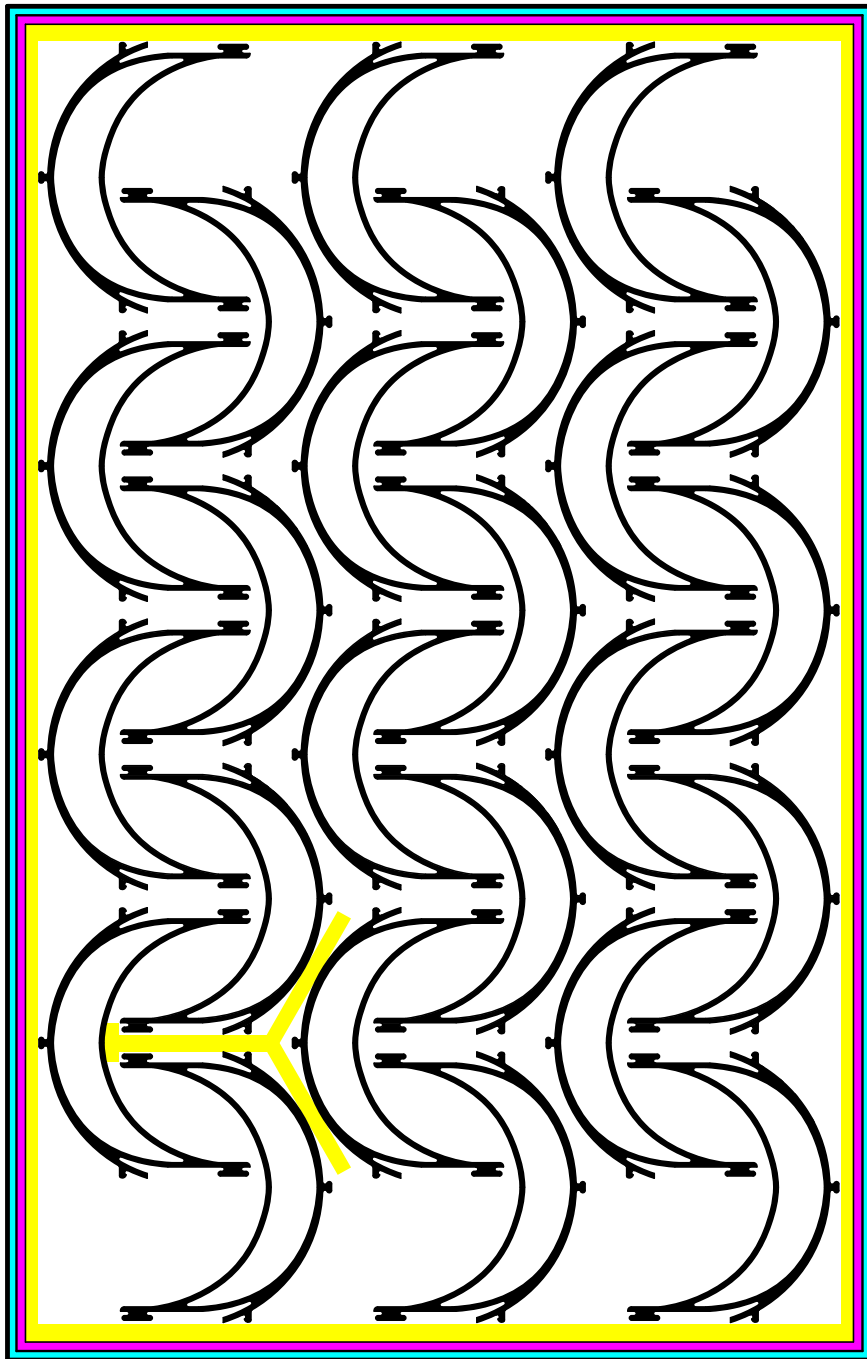
Nesting can be completed either manually by measuring the relationship of one part to the next or computationally. During the nesting process it is important to consider the following:

1. In addition to frame parts, each positive rigid mold must also accommodate a retaining wall for the rubber casting and a trough for the resin casting). Each of these can be seen in this plan, as well as in the milling diagrams.

2. Listed minimums were only tested with specific materials. Material tolerances will vary based on the individual material properties of the high density rigid foam positive, the cast rubber negative as well as for the cast resin frames.

3. All tolerances should also allow for the clearing of material during the CNC milling process.

Please ensure that 3D parts are oriented correctly. Connection tabs for the plastic shield and elastic should be oriented down towards the bottom of the stock. Please reference the CNC MILLED POSITIVE RIGID MOLD "Components" Diagram.

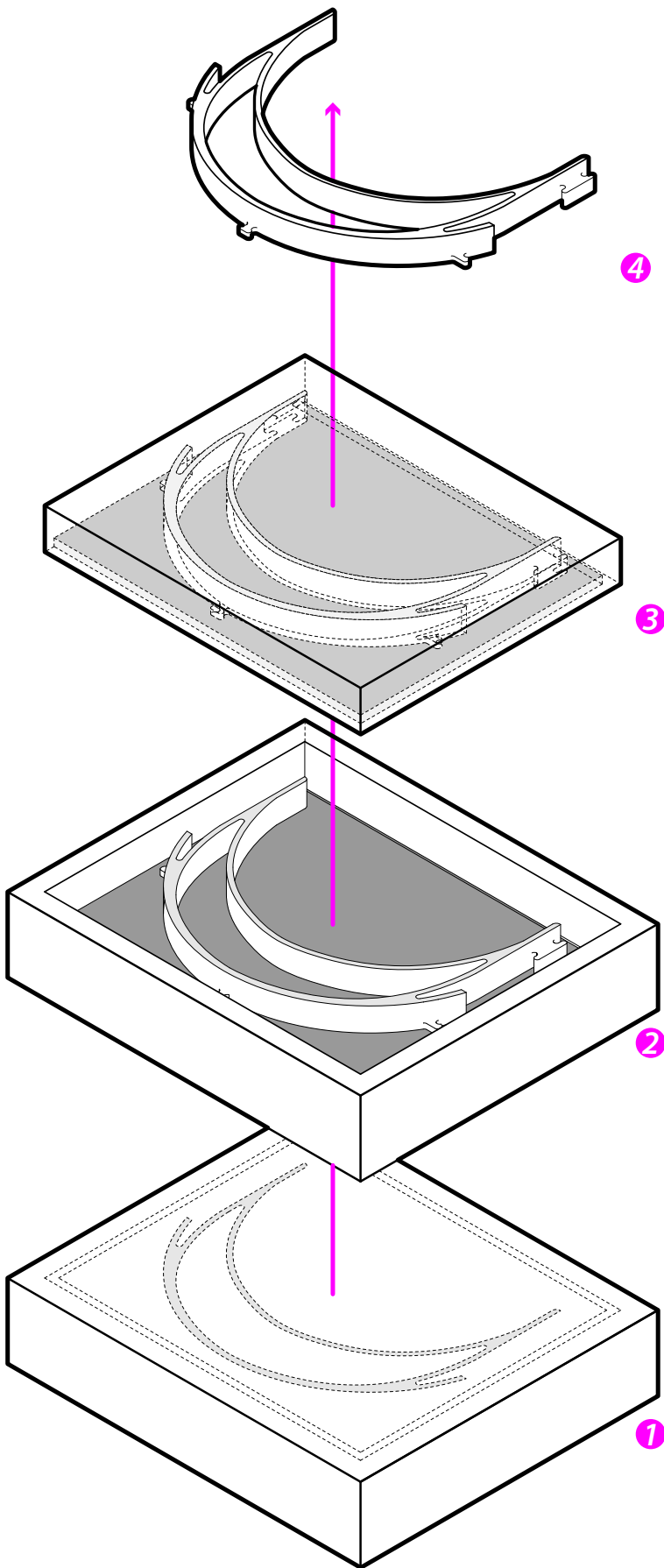


3D Digital or Physical Model _ 1
(For Part Layout & Material Optimization) -

Min. 3/8" Between Parts _ 2
(Larger Spacing May Increase Mold Life) -

Optimized 24 - Part Layout _ 3
(3/8" Between All Parts, Walls & Troughs) -





NOTES:

All components in these instructions have been tested as is. Processes and materials can be modified based on necessity or availability of materials. Outcomes can be highly dependent on the following of manufacturer specifications and instructions for each individual material throughout the process.

Nesting:

Nesting is the organizing of parts within the stock material. When nesting parts, several points should be kept in mind:

1. Size of Stock & desired number of parts.
2. The number of molds a single person can work simultaneously (i.e. as resin cures another batch or two can be poured).
3. Pot life of the given resin (do not make more parts than you can cast in a materials pot life).
4. Size workable by a single person (i.e. the 24-part mold seems to be a good compromise between material pot life and workability).
5. Tolerances between parts and walls.

Positive Foam Rigid Mold:

The positive rigid mold can be made by either CNC milling or through the creation of a sacrificial box with 3D printed shield frames nested and glued to the box bottom. Whereas the CNC mold and 3D printed frames are reusable, the 3D printed mold "box" has a shorter lifespan. These will only be used at the beginning of the process.

Cast Rubber Negative:

The rubber negatives will be the work horse of the project. Once the rubber negatives are cast, they will be reused over and over until failure to produce the final cast resin frames. It is of utmost importance during this process to ensure that the manufacturer instructions for the rubber casting are followed correctly to ensure the highest quality cast.

Additionally, it is important to use a mold release agent between casts (i.e. Mann's Ease Release 200) to ensure that the resin doesn't adhere to the mold, increasing the molds lifespan.

CAD Nested Frames w/ Boundaries _ 1

(For Part Layout & Material Optimization) -

CNC Milled Positive in Rigid Foam _ 2

(For Rubber Mold Casting) -

Cast Rubber Negative _ 3

(For Frame Casting) -

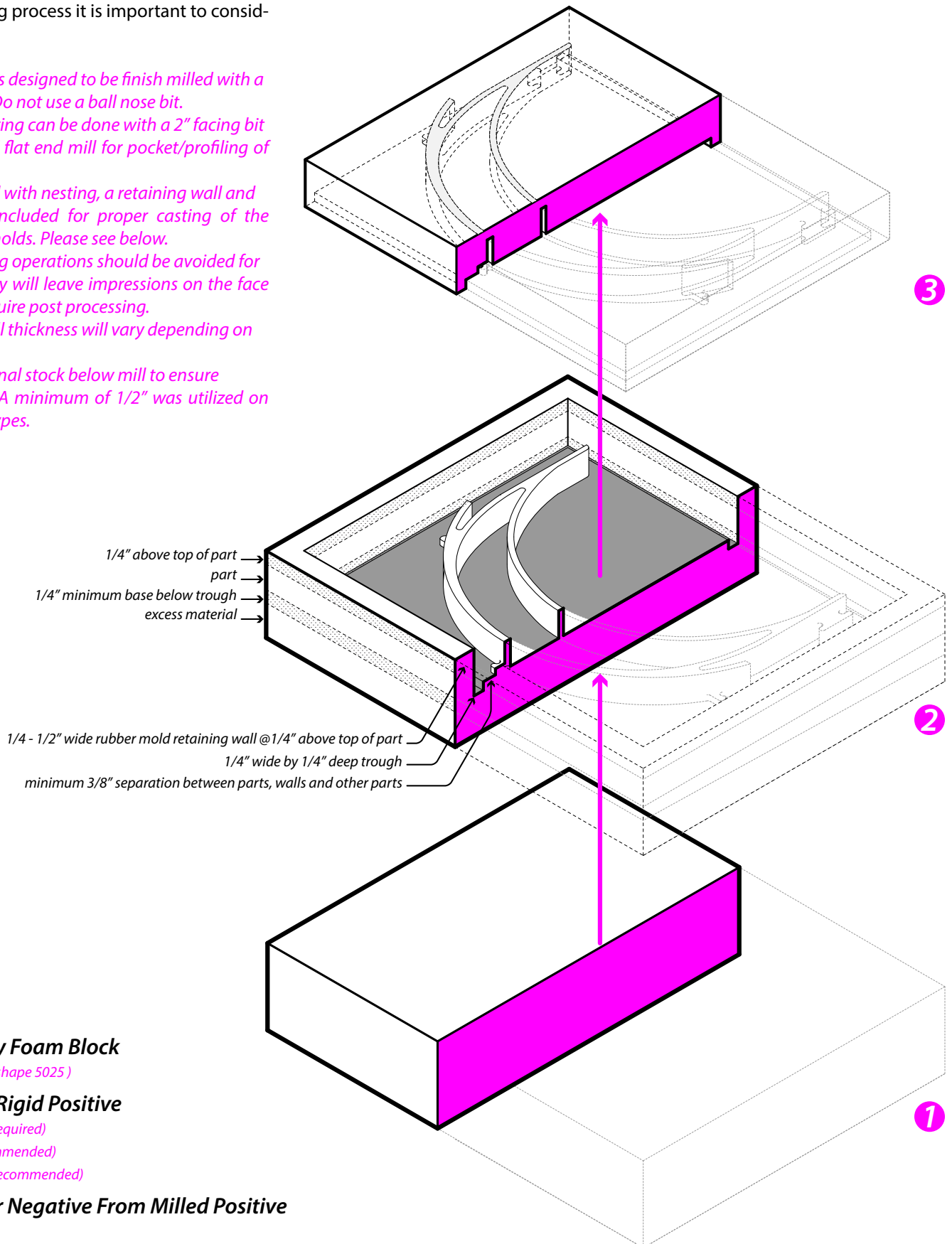
Cast Resin Frame _ 4

(Final Product) -

NOTES:

The CNC milled positive rigid mold consists of a one or more molds that can be reused to make numerous rubber molds for resin casting. The positive rigid mold should be CNC milled out of a durable high density rigid foam with high milling resolution. During the nesting process it is important to consider the following:

1. The shield was designed to be finish milled with a 1/8" flat end mill. Do not use a ball nose bit.
2. Material clearing can be done with a 2" facing bit followed by a 1/4" flat end mill for pocket/profiling of the final depths.
3. As mentioned with nesting, a retaining wall and trough must be included for proper casting of the rubber and resin molds. Please see below.
4. Parallel milling operations should be avoided for final passes as they will leave impressions on the face shield that will require post processing.
5. Retaining wall thickness will vary depending on foam rigidity.
6. Leave additional stock below mill to ensure strength of mold. A minimum of 1/2" was utilized on the Temple Prototypes.



1 _ High Density Foam Block

- (Recommended. Reshape 5025)

2 _ CNC Milled Rigid Positive

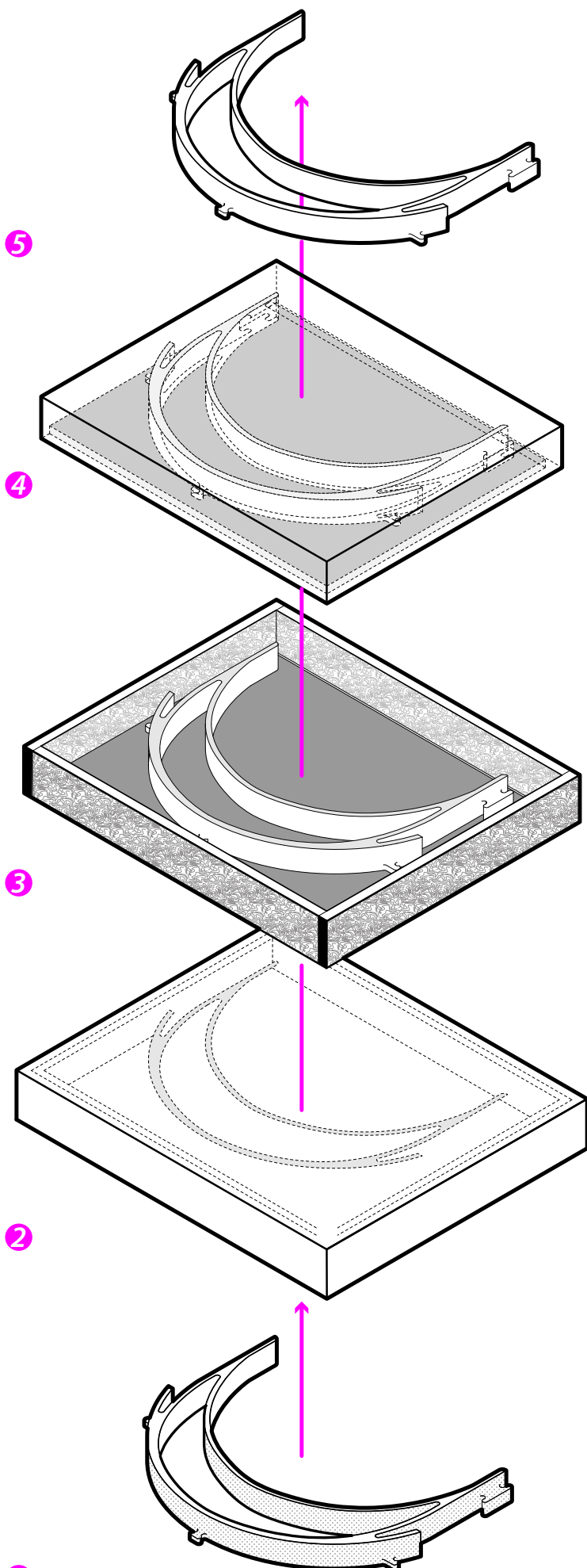
- (1/8" Flat End Mill Required)

- (2" Facing Bit Recommended)

- (1/4" Flat End Mill Recommended)

3 _ Cast Rubber Negative From Milled Positive

- (For Frame Casting)



NOTES:

Overall, the CNC milled positive and the 3D printed sacrificial positive are basically the same process with the exception of the positive material and how it is fabricated. Although the CNC milled rigid foam mold will be reusable, everyone will not have access to the required tools. For that reason a manual setup was also developed.

Rather than milling the positive forms of the shield frames for the mold as seen in the 24-piece mold previously, this process requires that the desired number of positives first be 3D printed in a durable material. Please remember that the mold will only be as good as the print. It is recommended that the highest resolution setting be utilized for each of the sacrificial 3D prints.

Following the printing of the desired number of shield frame positives, individual parts will then need to be nested in a similar way to the CNC milled version. This can be done computationally, or simply by laying the parts in the sacrificial formwork with material tolerances between all parts.

Prior to nesting, a mold containment box will need to be constructed. This can be made out of nearly any rigid material with enough strength and water resistance to withstand the pressure from the poured rubber. This mold can be as simple as engineered wood or acrylic and held together with hot glue or fasteners depending on the mold size. Please keep in mind that all boxes need to be leak resistant.

Once built, the nested 3D printed parts will be glued to the bottom of the box and cast over in the chosen rubber mold material. Following the curing of the rubber (see manufacturer specifications), the sacrificial box will be dissembled and the 3D printed parts removed to be fixed to the next box.

The remaining rubber negative will be utilized for the casting of the final shield frames.

3D Printed Frame _ 1

(Sacrificial Frame) -

Nested Frames w/ Boundaries _ 2

(For Part Layout & Material Optimization) -

Hand Built Positive in Rigid Material _ 3

(For Rubber Mold Casting) -

Cast Rubber Negative _ 4

(For Frame Casting) -

Cast Resin Frame _ 5

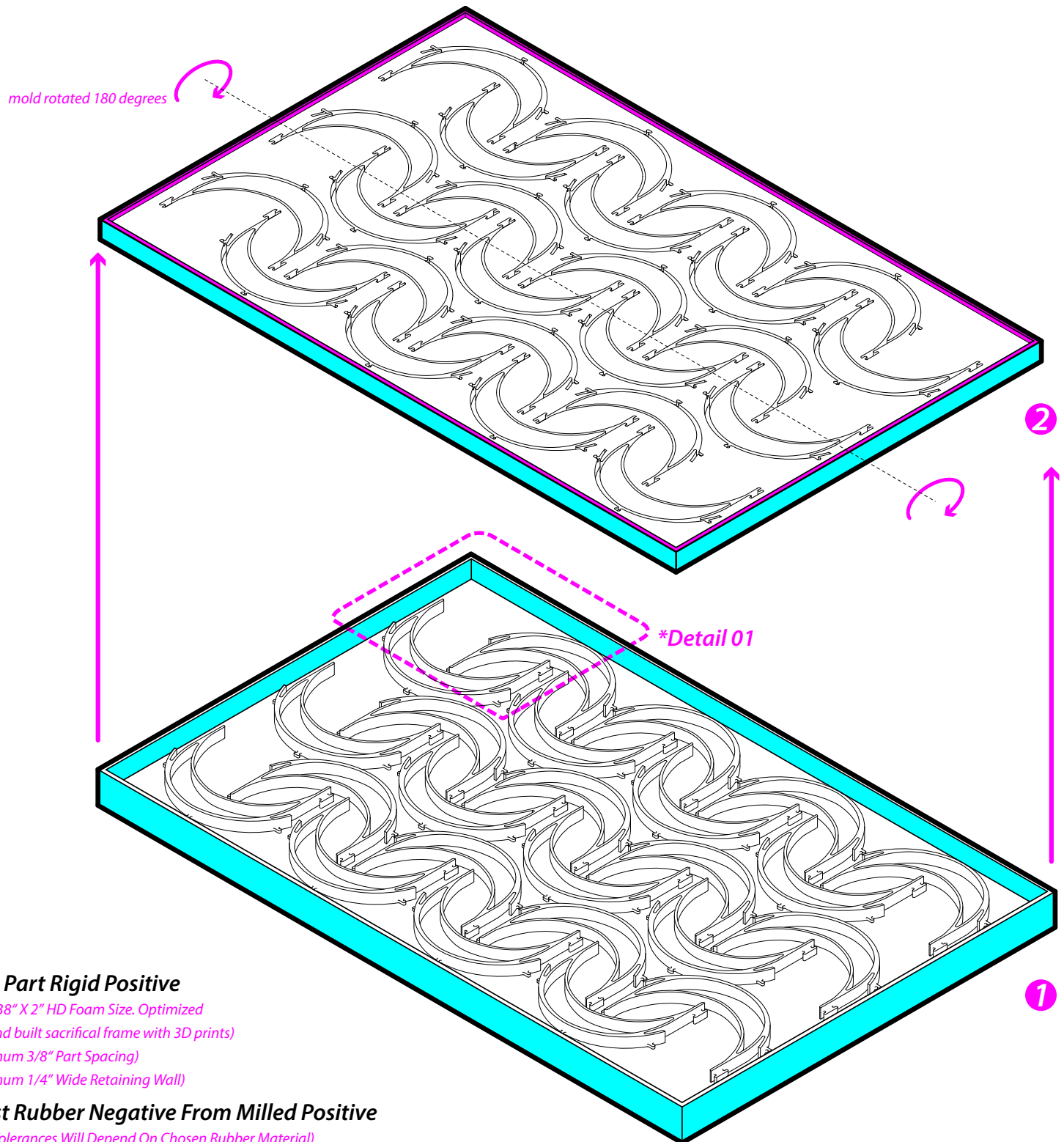
(Final Product) -

SECTION 02B: 3D PRINTED POSITIVE RIGID MOLD "Process"

NOTES:

Please note the relationship of all elements on the positive rigid foam mold with the cast rubber mold. The rubber mold has been lifted and rotated 180 degrees in the diagram below for ease of viewing. Additionally, see *Detail 01* for additional coordination.

Additionally, all mold details and tolerances should be the same on both the rigid foam CNC milled mold as well as 3D printed sacrificial positive.

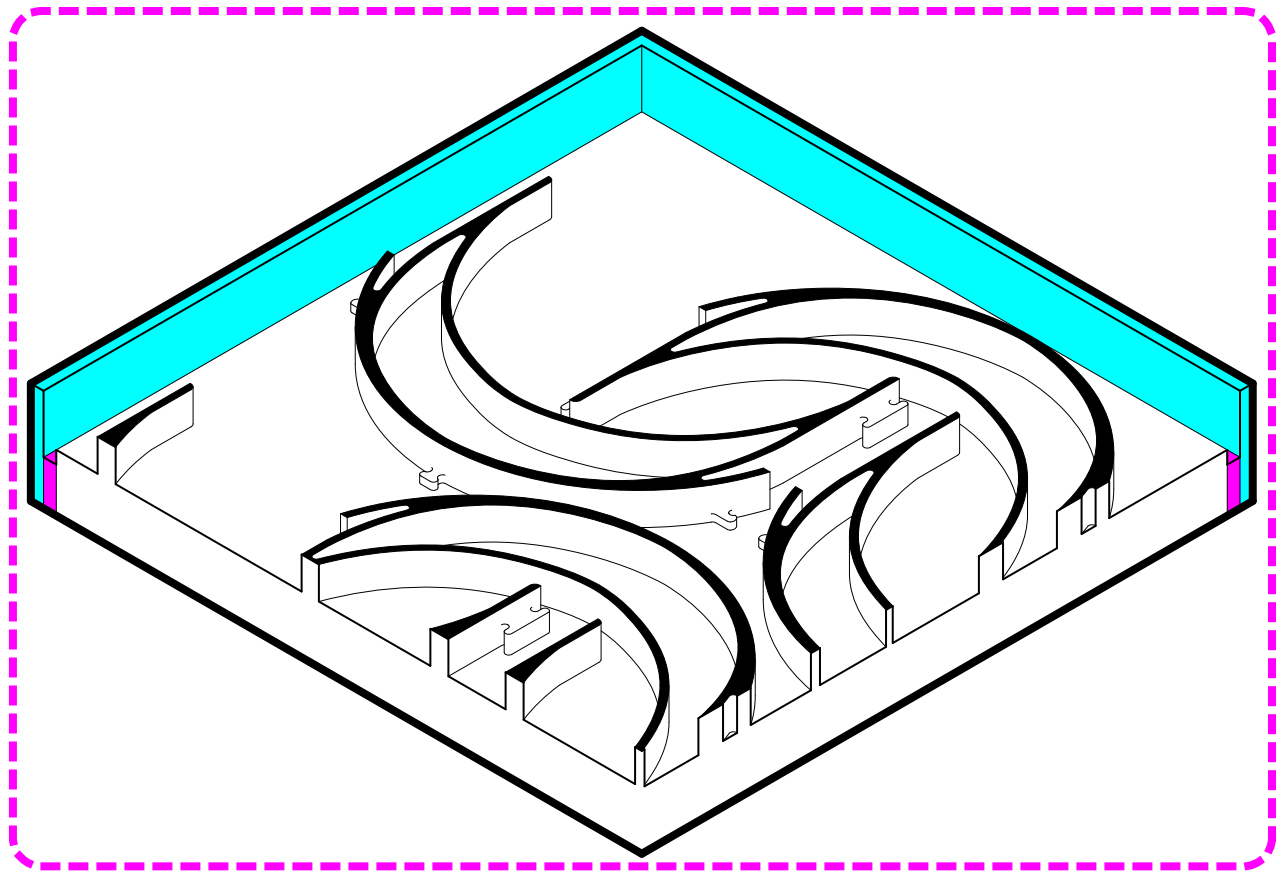


1_ 24 - Part Rigid Positive

- (24" x 38" X 2" HD Foam Size. Optimized or hand built sacrificial frame with 3D prints)
- (Minimum 3/8" Part Spacing)
- (Minimum 1/4" Wide Retaining Wall)

2_ Cast Rubber Negative From Milled Positive

- (Part Tolerances Will Depend On Chosen Rubber Material)



- 1/4" - 1/2" Retaining Wall
- 1/4" - 1/4" Trough
- Parts w/ Min. 3/8" Spacing
- Minimum 3/8" Spacing

1_24 - Part CNC Milled Positive Rigid Mold

- (24" x 38" X 2" HD Foam Size. Optimized)
- (Minimum 3/8" Part Spacing)
- (Minimum 1/4" Wide Retaining Wall)
- (Roughing Passes Can Utilize 2" Facing Bit & 1/4" Flat End Mill For Pocketing/Profiling)
- (Finishing Passes Must Be Made w/ 1/8" Flat End Mill)
- (Contour Cutting Should Be Avoided in Final Pass)

2_ Cast Rubber Negative From Milled Positive

- (Part Tolerances Will Depend On Chosen Rubber Material)

NOTES:

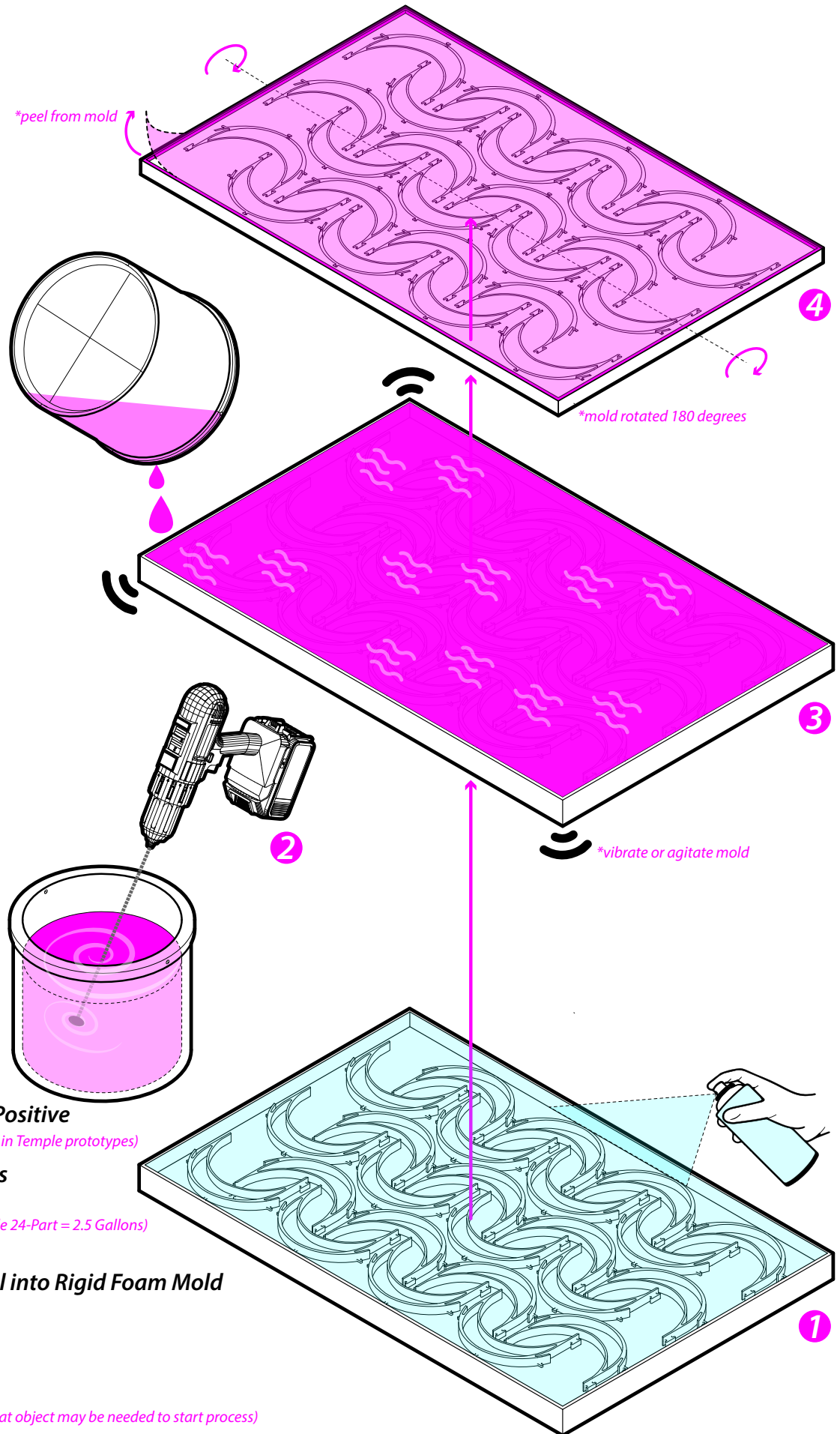
During the mold making process, it is essential to closely follow the manufacturer instructions for the chosen rubber casting material. These rubber molds used **Mold-Max 40** cast rubber. Any imperfections in the mold will affect the overall quality of the cast resin shield frame.

When beginning the process, always remember to clean (i.e. remove any dust or particulate, do not clean with soap and water) and lubricate the mold to minimize bonding between the rubber and foam. **Mann's Ease Release 200** and petroleum jelly were used here.

When mixing and pouring, follow all manufacturer recommendations for proper ventilation, mixtures and cure times. Always completely fill the mold to the top and agitate rigid mold to minimize air pockets. Allow for manufacturer recommended curing time prior to demolding.

When demolding, take care to not damage the foam or rubber molds. Gently pry one edge of the mold up first by hand or with a flat object. Once rubber begins releasing continue pulling until demolded.

Clean and repeat as needed.



1_ Apply Mold Release to Rigid Positive

- (Petroleum jelly/Mann's Ease Release 200 used in Temple prototypes)

2_ Mix Rubber Casting Materials

- (Follow manufacturer instructions)

- (Calculate mold volume prior to mixing. Temple 24-Part = 2.5 Gallons)

- (Mix using electric drill & turbine mixer)

3_ Pour Rubber Casting Material into Rigid Foam Mold

- (Completely fill mold to top in single pour)

- (Vibrate or agitate mold to eliminate bubbles)

- (Follow manufacturer instructions for curing)

4_ Demold

- (Carefully peel mold from rigid foam mold. A flat object may be needed to start process)

5_ Repeat

NOTES:

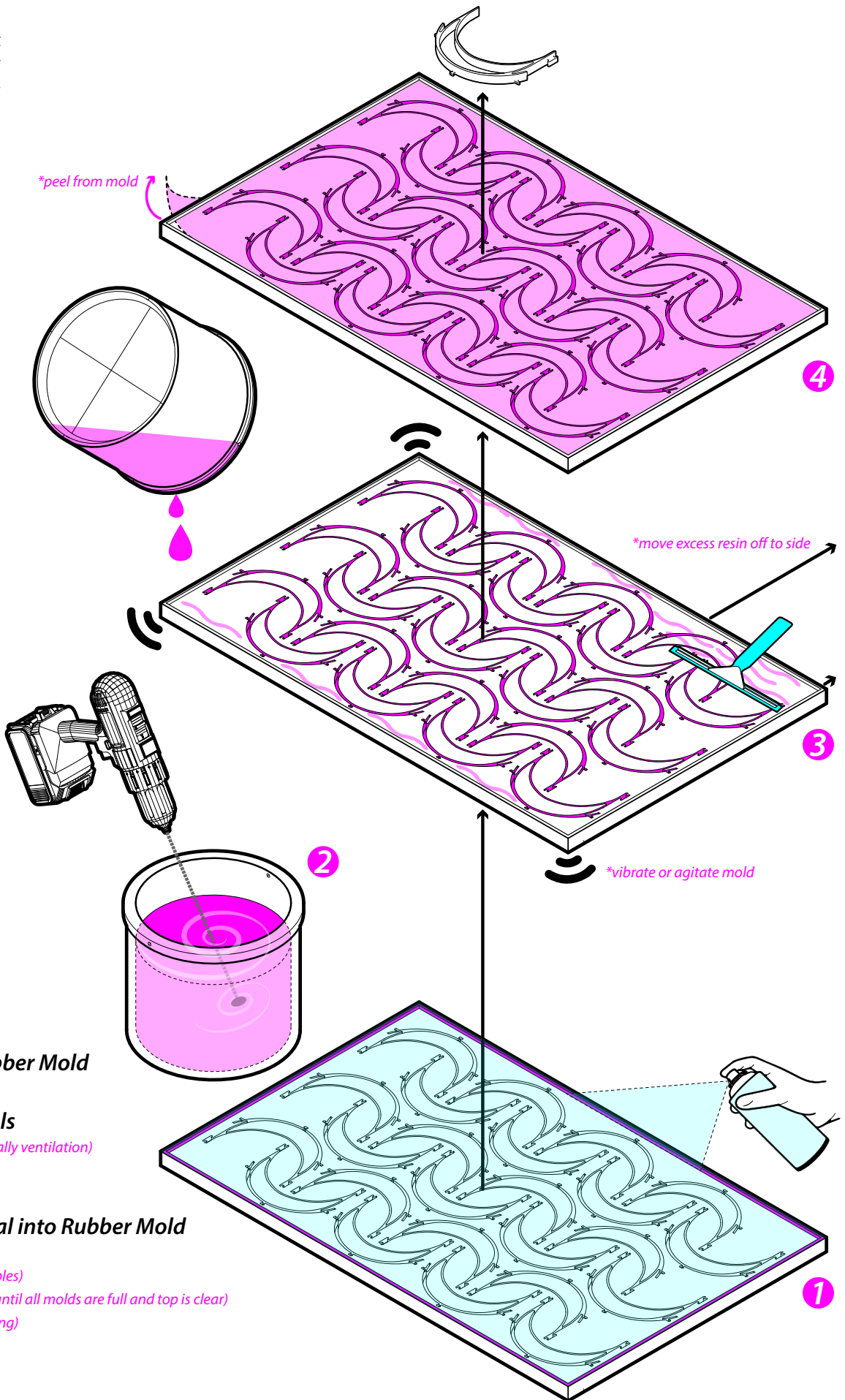
During the resin casting process, it is extremely essential to closely follow the manufacturer instructions for the chosen face shield frame making material. These frames used **SmoothCast 65D** cast resin. Any imperfections in the mixing of materials will affect the overall quality of the cast resin shield frame.

When beginning the process, always remember to clean (i.e. remove any dust or particulate, do not clean with soap and water) and lubricate the mold to minimize bonding between the resin and rubber. **Mann's Ease Release 200** was used here.

When mixing and pouring, follow all manufacturer recommendations for proper ventilation, mixtures and cure times. Always completely fill each individual frame mold to the top, agitate rubber mold to minimize air pockets and squeegee the top of the mold following the completion of the pour. Always allow for manufacturer recommended curing time prior to demolding.

When demolding, take care to not damage the rubber mold or resin shield frame. Gently bend one edge of the rubber mold down by hand popping each cast resin frame out of the mold until complete.

Clean and repeat as needed.



1_ Apply Mold Release to Rubber Mold

- (Mann's Ease Release 200)

2_ Mix Resin Casting Materials

- (Follow manufacturer instructions. Especially ventilation)

- (Calculate mold volume prior to mixing)

- (Hand or machine mix)

3_ Pour Resin Casting Material into Rubber Mold

- (Completely fill mold to top in single pour)

- (Vibrate or agitate mold to eliminate bubbles)

- (Wipe mold with rubber edged squeegee until all molds are full and top is clear)

- (Follow manufacturer instructions for curing)

4_ Demold

- (Carefully peel frames from rubber mold)

5_ Repeat

NOTES:

During the shield cutting process, it is important to ensure that the plastic is not scratched. Additionally, it is important to work in a clean environment as during unrolling, the plastic may become electrostatically charged, thereby picking up local debris.

For final assembly, the elastic can be attached either by means of a slit cut on the strap or by means of an optional 3D printed adjustment clip. Although the 3D printed clip allows for variable pressure in the shield, the simple elastic cut works equally well.

The foam insert is meant to accomplish two goals: 1. Protect the face from contamination from above and 2. Create a soft surface between the shield frame and increase comfort to the face. When laser cutting the foam, it is important to follow machine and material guidelines for cutting and ventilation.

1_ Plastic Shield Production Line

- (12" clear PET plastic spool, 7 mil minimum)
- (Large paper cutter)
- (Ruler)
- (3-hole punch)

2_ Elastic Cutting

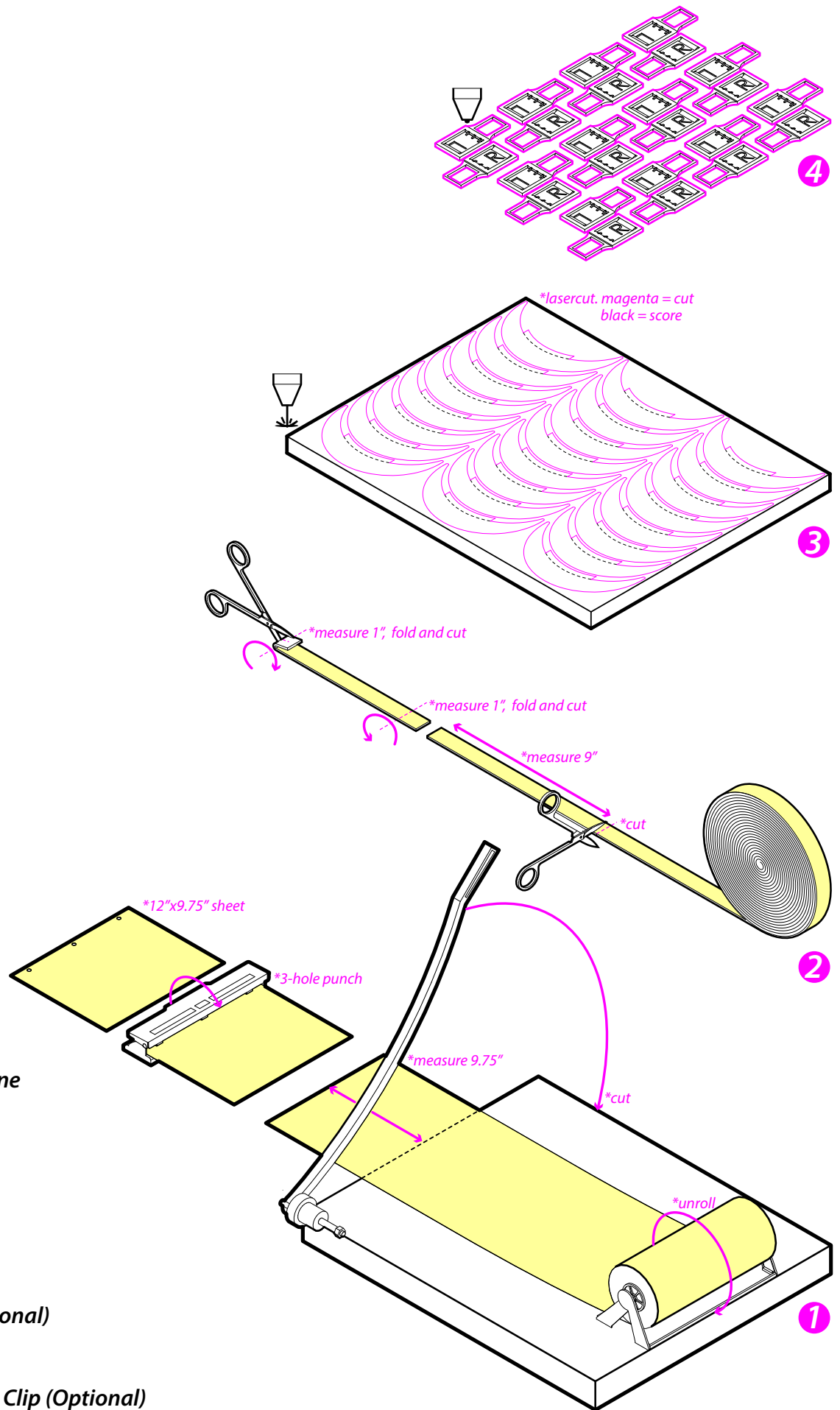
- (Elastic spool)
- (Scissors)
- (Ruler)

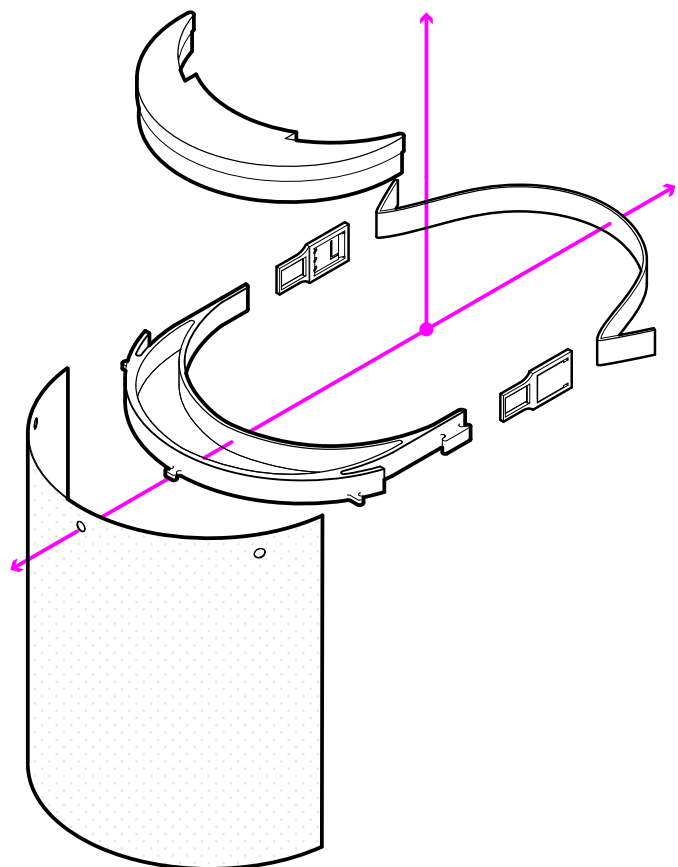
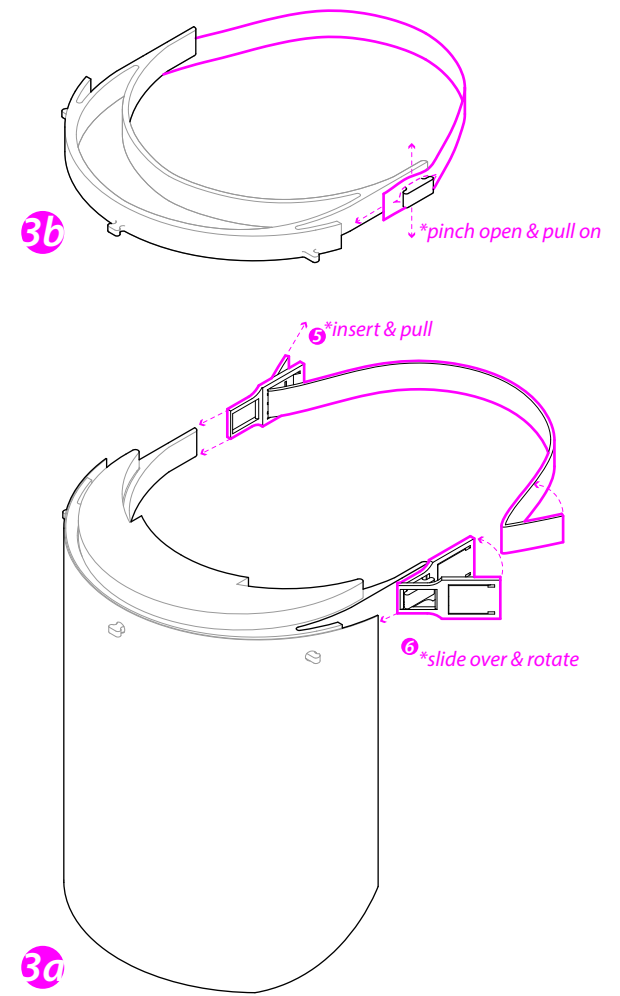
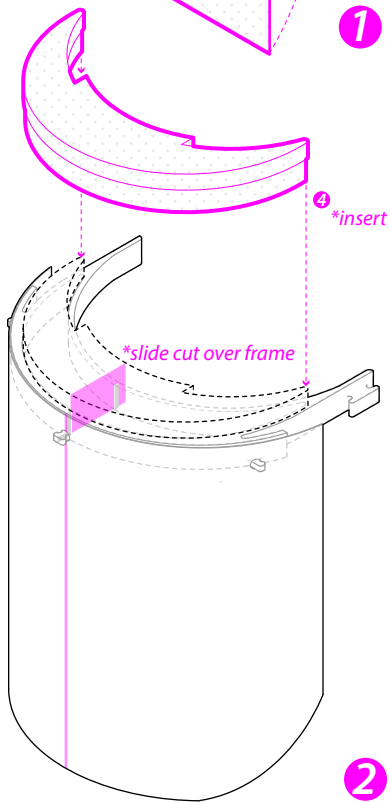
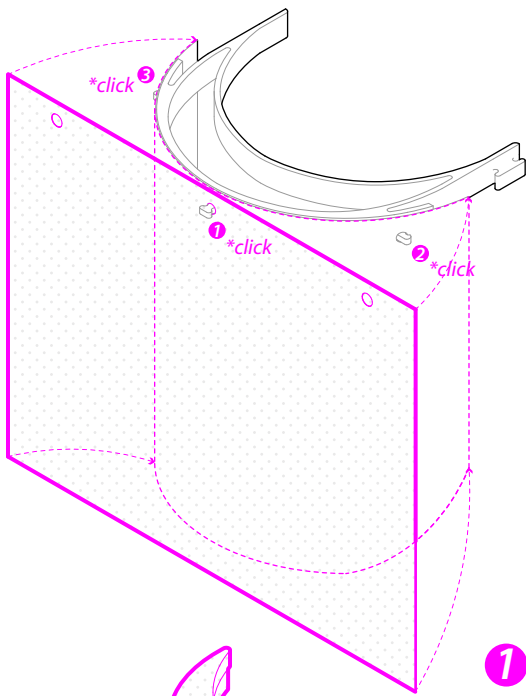
3_ Laser Cut Foam Insert (Optional)

- (Nest parts on desired foam size)
- (Closed cell PE foam)

4_ 3D Print Elastic Adjustment Clip (Optional)

- (Nest and Print)





1_ Attach Plastic Face Shield

- (Begin by inserting middle hole of plastic sheet into the middle face shield connector)
- (Bend one side connecting a second hole and repeat for the third)

2_ Inserting Foam Insert

- (Slide foam insert into hole in cast resin shield frame)
- (Laser cut trough should fit over inside resin frame creating a forehead cushion)

3a_ Attach Elastic Headband & Clip

- (Slide elastic band through headband clip opening)
- (Attach headband clip to both sides of face shield frame)

3b_ Attach Elastic Headband & Clip

- (Pinch & pull open cut on elastic band and slide over the frame mount)

DISCLAIMER & NOTICE:

This document is made available by Temple University for informational and educational purposes only and does not constitute legal or medical advice regarding the design, manufacture, or use of face shields.

Face shields may constitute a class I medical device when used in certain healthcare settings. This product has NOT been FDA cleared or approved. Manufacture of this product may be authorized by FDA under an Emergency Use Authorization (“EUA”) letter for use by healthcare providers as personal protective equipment, see <https://www.fda.gov/media/136842/download>. If produced in accordance with the EUA, this product is only authorized for the duration of the declaration that circumstances justifying the authorization of emergency use under Section 564(b)(1) of the Act, 21 USC 360bbb-3(b)(1) unless the authorization is terminated or revoked sooner.

This device should NOT be used as a replacement for conventional and approved Personal Protective Equipment (PPE) when available. Use of these face shields alone will NOT prevent infection from microbes or viruses, including COVID-19. This device has not been industry tested nor has it been NIOSH approved.

These face shields have been designed by Temple University for low impact use to protect the user's eyes and face from bodily fluids, liquid splashes, or potentially infectious materials. These face shields were designed for multi-use by a single provider, however, users should exercise caution and clean the face shields after each use. Manufacturers and users are solely responsible for any and all risks associated with production, use, and cleaning of face shields. THIS PRODUCT DESIGN AND RELATED INFORMATION IS MADE AVAILABLE AS-IS, AND TEMPLE UNIVERSITY EXPRESSLY DISCLAIMS, ANY WARRANTY, EXPRESS OR IMPLIED, INCLUDING WITHOUT LIMITATION THE WARRANTIES OF MERCHANTABILITY, FITNESS FOR A PARTICULAR PURPOSE, AND NON-INFRINGEMENT. Reference to any particular product brand name or materials does not constitute an endorsement, guarantee, or representation by Temple University.

RESOURCES:

Turbine mixer: <https://www.smooth-on.com/products/turbine-mixer/>

Mixing cups: <https://www.uline.com/Product/Detail/S-22983/Pails/Mixing-Containers-2-1-2-Quart> (note: this is the one we actually ordered, at the 2.5 qt size. We talk about 1.5 qt in the document, which they don't have. I worry that 1 qt is going to be too small.

Mixing sticks:

https://www.homedepot.com/p/5-gal-Paint-Stick-3-Pack-PS5G-3/206871624?MERCH=REC-_pipsem_-_206137830_-_206871624_-_N

Renshape 5025: <https://www.freemansupply.com/products/machinable-media/renshape-modeling-and-styling-boards/renshape-5025-polyurethane-foam-board>

Mold Max 40: <https://www.smooth-on.com/products/mold-max-40/>

Smooth-Cast 65D: <https://www.smooth-on.com/products/smooth-cast-65d/>

Task 8: <https://www.smooth-on.com/products/task-8/>

Mann's Ease Release 200: <https://www.smooth-on.com/products/ease-release-200/>

Accel-T: <https://www.smooth-on.com/products/accel-t/> (Note: We do not mention this in the document, but we are using Accel-T to drop the 24-hour cure time on the Mold Max 40 to 6-12 hours. If we add that into the details, we can list this as another material we're using.)

Note: All drawings & diagrams by Andrew John Wit unless otherwise noted. No use or modification without prior written consent.