

Experiment Name: 3d printed rapier tips

Original Submission Date:

Returned by SRM Date:

Posted to the KRMs list Date:

Revision Submission Date:

Final Decision Date:

Decision:

Submitting Kingdom(s): Aethelmearc

Submitting KRM(s): Diego Miguel Munoz de Castilla

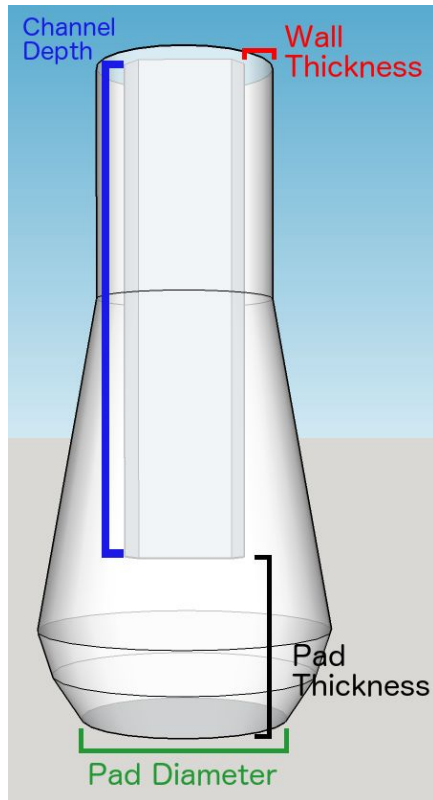
What & Why

Particularly with the advent of C&T, many new types of blades are entering use. Many of these are difficult to tip with standard, pre-approved archery blunts and the home-made tips must (in Aethelmearc) be individually examined by the KRM to be approved.

At the same time, home 3d printers are becoming less expensive and more common. These seem ideal for creating custom tips for strange blades. If standards are developed for doing so, a tip which is printed to the standard could be inspected by any marshal instead of needing high-level inspection.

Early test prints have produced tips which seem to have similar characteristics to commercially-produced blunts.

How



Phase 1:

A small collection tips will be produced. All will be based on the sizes and thicknesses of standard, commercial bird blunts. The measurements of most interest are Pad Thickness, Pad Diameter, Wall Thickness, and Channel Depth. They will be distributed to a handful of nearby marshals who possess blades of the categories desired.

4 types of tips will be made and tested (see designs at the end of this document):

1. Standard-sized tip for use with a nail-head blade to be tested without a metal washer/nut
2. Standard-sized tip with a pocket for a metal insert, to be used both on a straight blade with a standard tip and on a curved, saber-type blade.
3. Wide tip with a pocket for a metal insert, to be used with a 2-handed blade which is too wide for a standard archery blunt.
4. Wide tip with a metal insert pocket, for use with a wide, curved C&T blade

Two of each type will be printed (Except #2, which will be used on 2 different types of blades) one printed in thermoplastic polyurethane (commercially known as NinjaFlex) and one in ABS

plastic. *Edit: Due to printing and time difficulties, we are following the original plan with only Ninjaflex filament. If the ABS part of the experiment is conducted, then its phase 1 will be while the ninjaflex is in phase 2.*

These will be tested over a period of 6 months. At regular intervals (no less than once per month) (**Edit: time period extended due to travel issues. Probably once every 2 months**) their outsides will be photographed to show any exterior wear. The tips will be removed and the inside inspected for wear, visually if possible, and by measurement otherwise. If significant degradation has occurred, that tip will be considered a failure. At that point, either a redesign will take place or that use case will be given up as not viable. The experimenter, experiment director, or KRM may declare any tip a failure at any point when significant damage takes place. These reports will be compiled and submitted to SRM quarterly

If a significant number of the tips made with a particular material fail, that material will be considered a failure. Depending on circumstance, a redesign may be appropriate (thicker walls, wider pad, etc)

Phase 2:

Once Phase 1 is complete, Specs will be written for production and sent to a wider collection of marshals to be designed and printed individually on their equipment, with monthly reports being sent back to the experiment director and compiled quarterly and sent to the SRM. The length of this phase will be determined after seeing the results of phase 1 to determine likely failure points.

If the original tips created using standard measurements are passed without redesign to increase a measurement, then during this phase the phase 1 experimenters may test versions with thinner measurements to refine the standards proposed to society.

Risks

The greatest risk in this experiment is that of a catastrophic failure of a tip in the course of a hard shot. However, since our armor standard is designed to protect against untipped or broken blades, this risk should be minimal. This experiment should therefore not be combined with any reduced armor experiment, and all participants should be armored at or above society/kingdom standard.

Where and When

Phase 1 will be conducted over the course of 6 months in the northern area (regions 4 and 5) of the Kingdom of Aethelmearc (in this phase, all experimenters must be in reasonable proximity to the experiment director so that measurements can be taken) This time period should include some hot-weather months, as degradation due to being left in a hot car is one point of concern. **Edit: Further research shows that hot cars top out at about 80°C (175°F) which is well short of the melting points of either of the materials involved in this experiment. (200°C/390°F for ABS, 210°C/410°F for Ninjaflex)**

Who

Experiment Director:

Lord Simon Caminante
MKA James Fitch

Backup:

Master Raev Halle
MKA Benjamin Cooper

Submitting reports:

Master Diego Miguel Munoz de Castilla
MKA Robert Peterson

Phase 1 Experimenters:

- Tip 1 and 2: Lord Simon Caminante (Tip designs 1 and 2 with straight blades)
- Tip 3: Master Benedict Fergus atte Mede (Tip Design 3)
- Tip 4: Pan Henryk Bogusz (Tip design 2 with curved blades)
- Tip 5: Master Eric Grenier de Labarre (Tip Design 4)
- **Added: Tip 6: Master Diego Miguel Munoz de Castilla (Tip Design 5)**
- **Added: Tip 7: Master Thomas de Castelon (Tip Design 2)**

Communication

We are conducting an experiment to determine standards for custom rapier tips which can be produced on the widely-available 3d printers with materials they are capable of printing. The goal of this is to produce a standard which a custom-designed tip must meet in order to be considered safe for SCA rapier without individual approval at a high level.

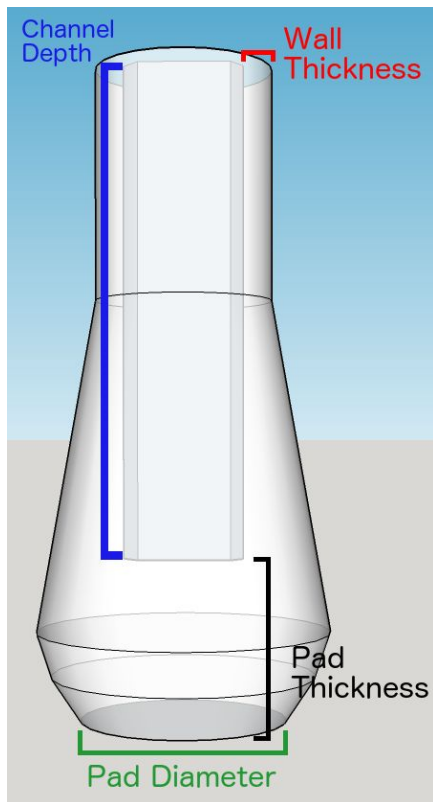
The first phase of this experiment will be conducted with a handful of marshals in the Kingdom of Aethelmearc in order to produce a standard. After we have a standard that we believe to be safe, a call will be sent out for other marshals to design and print their own tips and report on their effectiveness, design, and safety.

In the event of a successful outcome to the experiment, the following change to the Society fencing rules is proposed:

If the result is a change to society rules:

The specs on rapier tips in section 2.B.viii are fairly minimal, and all of the proposed printed tips fit this standard. Instead of a modification of the standard, the best way to include these tips is as an appendix similar to the instructions for creating a drop tester. This appendix will include whatever standard is determined to be safe at the end of the experimental period. The following is an example of what such an appendix might look like, using the measurements and materials used at the beginning of the experiment. It will likely require some modification as the standard is refined.

Accepted standards for 3D printed blade tips



Custom tips printed on commercially-available home 3d printers have been determined to be acceptable so long as they meet the following standards:

Material	Dimension	Minimum Measurement
TPU (NinjaFlex™)	Channel Depth	33mm
	Wall Thickness	1mm
	Pad Thickness	11mm
	Pad Diameter	14mm
ABS	Channel Depth	33mm
	Wall Thickness	1mm
	Pad Thickness	11mm
	Pad Diameter	14mm

Note: Kingdom-specific requirements for metal washers or other inserts are not included in this standard.

Definitions:

- Channel depth: the length of the blade which is inside the tip.

- Wall Thickness: minimum distance between any part the blade and any side-wall of the tip. (Walls may taper at the top, so long as the minimum thickness is maintained for at least the minimum channel depth.)
- Pad Thickness: Minimum distance between any part of the blade and the striking surface of the tip.
- Pad diameter: Minimum width of the striking surface of the tip.

If the result is a change to Aethelmearc Kingdom rules:

Section 3.A.i should be rewritten as:

3.A. The tip of a Heavy Rapier blade shall be covered as follows:

a.i. Blades must either have a manufactured with a permanent perpendicular safety tip (i.e. a “nail head” or “anvil head”) created as the tip of the blade at time of initial forging or be covered with a metal casing, washer, or nut.

a.ii. blades must then covered with a rubber archery bird blunt or equivalent. Padding may be used to hold the tip in place. Standard foil and epee tips are not to be used as Heavy Rapier tips.

Equivalent tips include:

a.ii.1. Darkwood Armory tips (these may be used without a washer or metal casing over the tip of the sword provided that the sword tip meets the requirements in (3.h) above. They are an exception to 3.A.i)

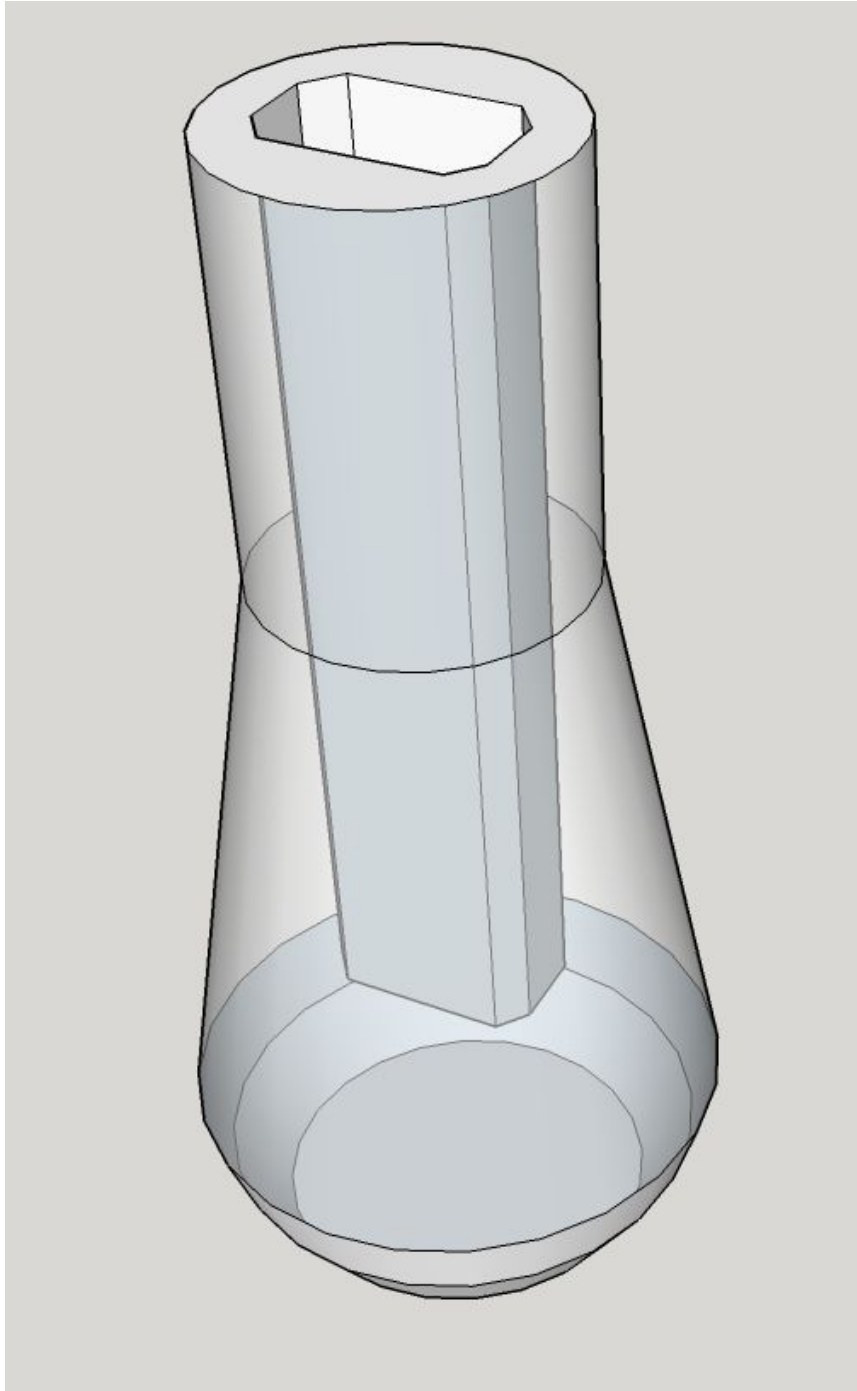
a.ii.2. 3D-printed tips which meet the specifications given in (insert appendix # here. The Appendix being similar to the one given above as a recommendation for society policy)

a.ii.3. Other equivalent tips may be approved by the KMoF on a case-by-case basis.

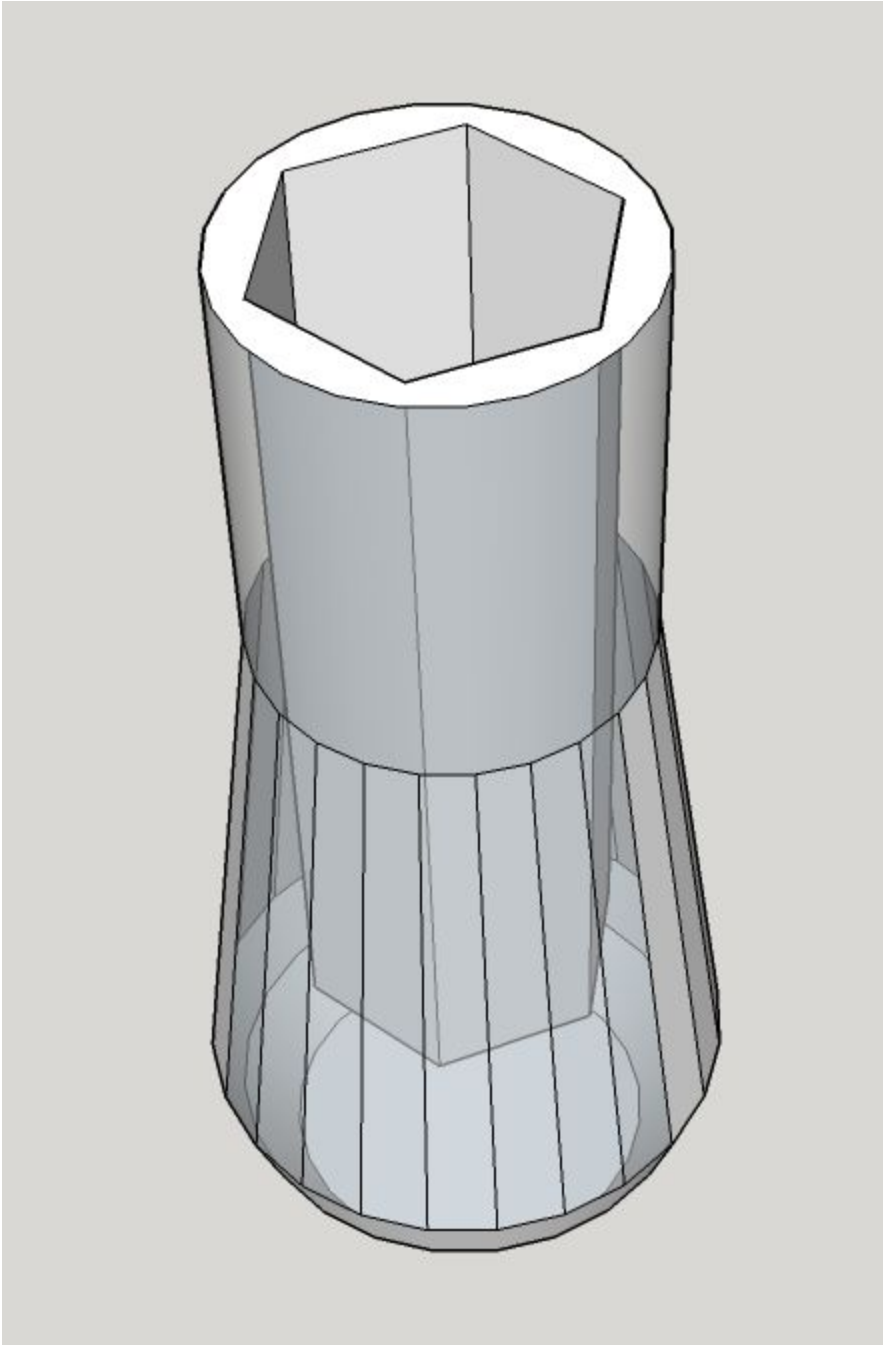
Phase 1 tip designs:

Stereolithography (.stl) files are available upon request to provide full details to anyone with a 3d modeling program. Trimble Sketchup Make is available for free at <https://www.sketchup.com/download>

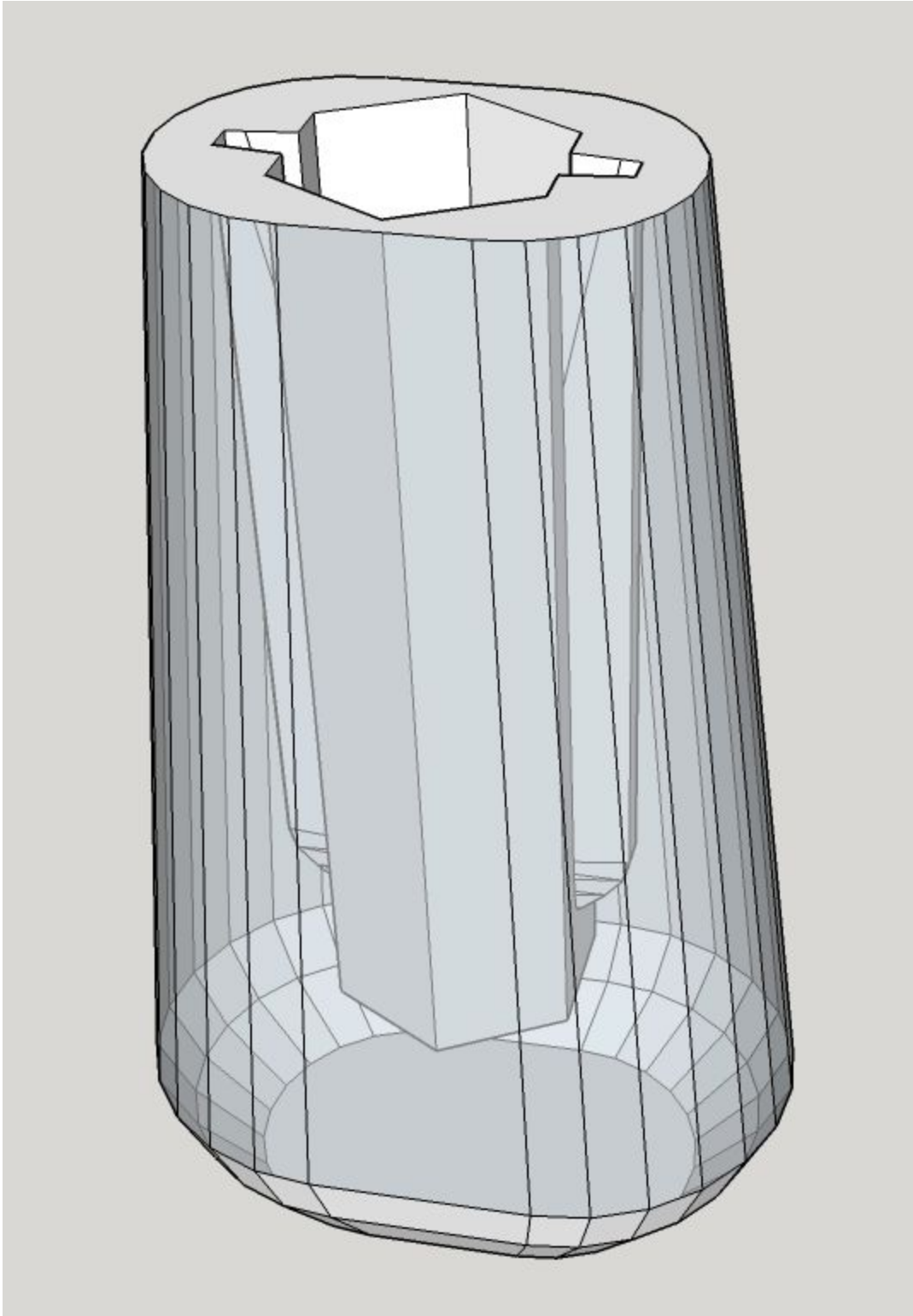
1: Standard-sized tip for use with a nail-head blade to be tested without a metal washer/nut:



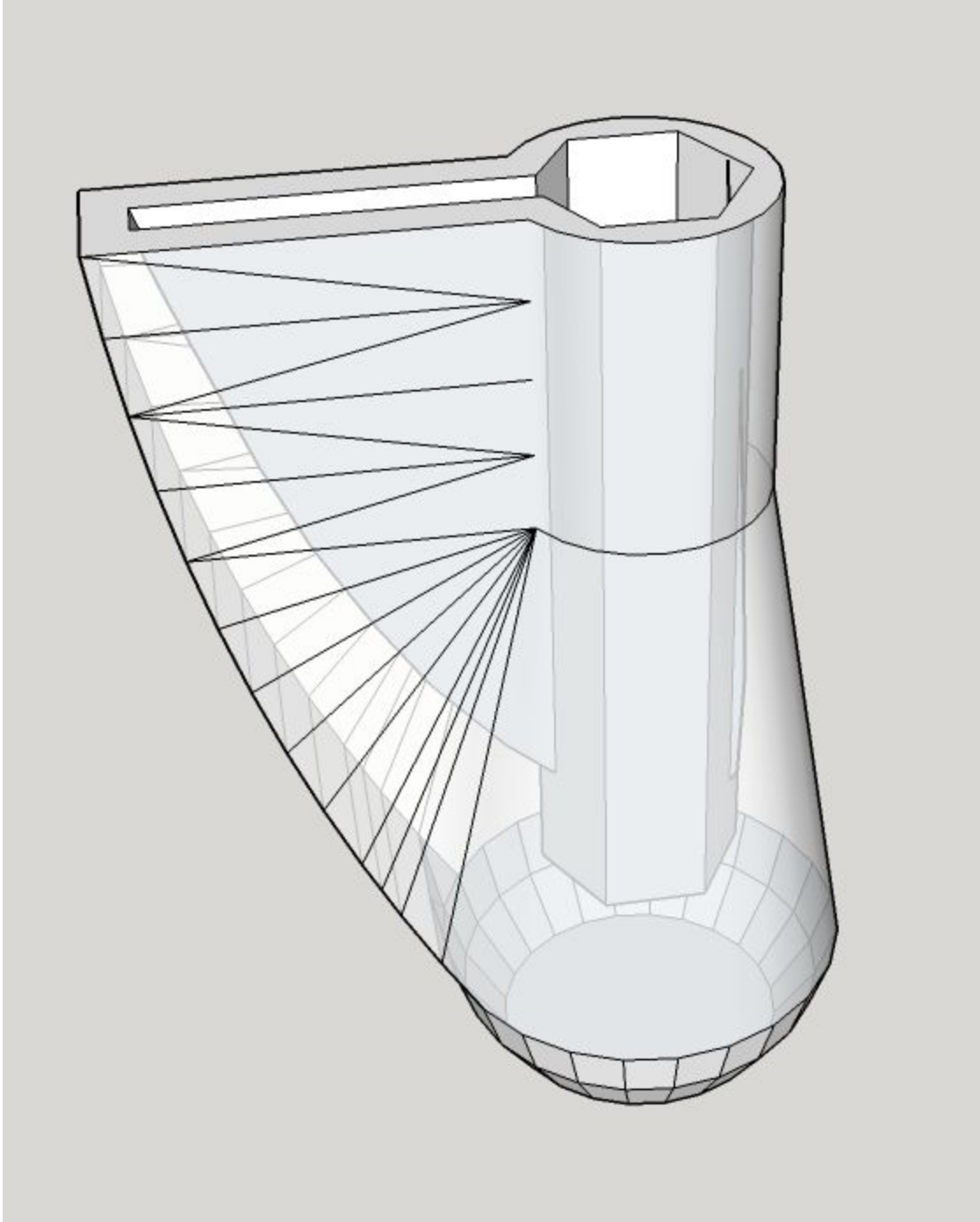
2: Standard-sized tip with a pocket for a metal insert, to be used on a straight blade with a standard tip



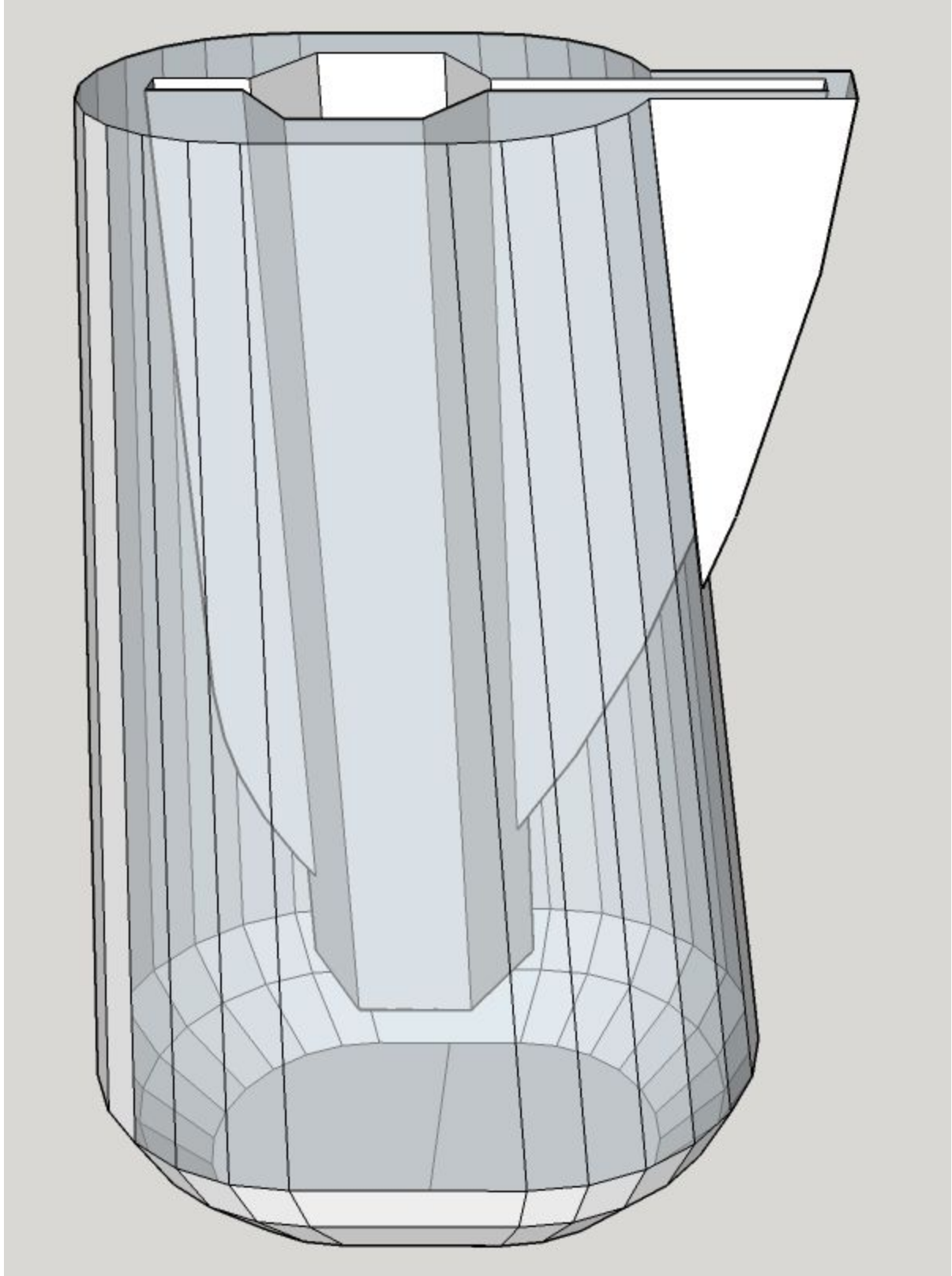
3: Wide tip with a pocket for a metal insert, to be used with a 2-handed blade which is too wide for a standard archery blunt.



4: Wide tip with a metal insert pocket, for use with a wide, curved C&T blade



5: Wide tip with a metal insert pocket, for use with a wide, curved C&T blade



Reports

Report definitions:

- Usage will be categorized as:
 - None: not used during this period at all
 - Light: anything less than Moderate
 - Moderate: at least once per week on average, but less than Heavy.
 - Heavy: at least 3 different practices or events per week on average
- Shed:
 - Any material which falls out of the tip when it is removed.
- Measured flexibility of the material
 - It is difficult to measure the depth of a material which flexes. It is easy to flex the material and get a depth reading which appears to indicate compression or degradation of the material. In order to account for this, we also measure the flexibility of the material by measuring the “Depth” of the flat striking surface of the blunt using the same means we use to measure the depth inside the tip. This can be subtracted from the measured depth inside in order to better estimate what the depth would be if the tip were rendered incapable of flexing.

Report 1 (December 5th, 2017)

Tip 1: (Design 1 in Ninjaflex: straight, normal blade with no metal insert)

- Examined 11/29/17 after 7 weeks of “moderate” use by Simon Caminante
- Exterior:
 - Shows some wear, mostly in the wearing off of print lines.
 - One noticeable nick.
 - No safety concerns.
- Removal:
 - Shed:
 - 2 small plastic particles on removal. I believe these are printing artifacts.
 - Depth:
 - Design: 33mm
 - Maximum measured: 33.3mm
 - Measured flexibility of the material: .29mm
 - No measurable compression or decay of the material.
 - No safety concerns











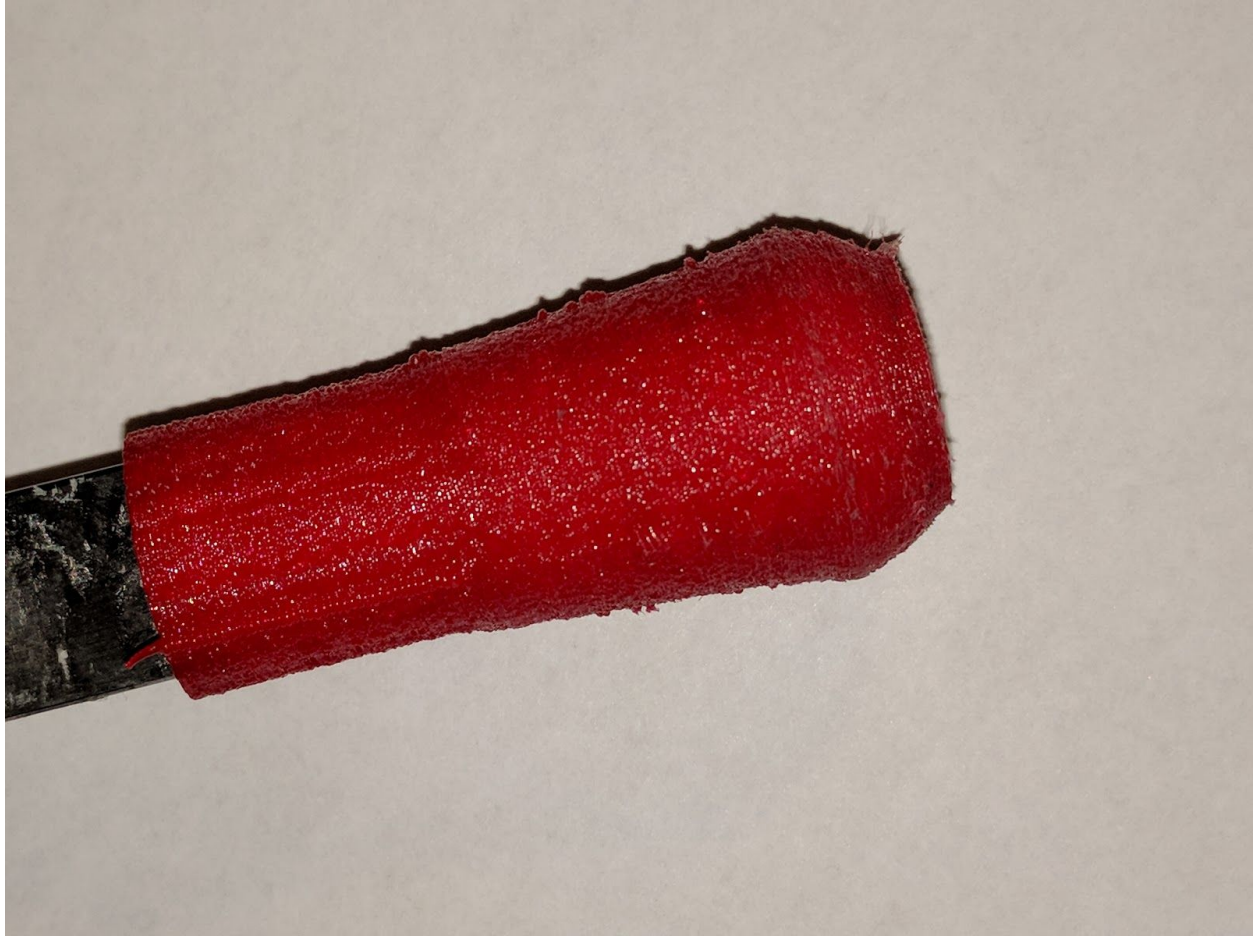


Tip 2: (Design 2 in Ninjaflex: straight, normal blade with metal insert)

- Examined 11/29/17 after 7 weeks of “moderate” use by Simon Caminante including C&T
- Exterior:
 - Shows some wear, mostly in the wearing of print lines
 - There is a ridge caused by adhesion to the print bed which is wearing off
 - There is also a mark which seems to be from a sword strike, crossing a spot where some burned filament adhered to the print
 - No safety concerns
- Removal
 - Shed:
 - No shed of plastic material.
 - Slight shed of the metal finish of the nut inside
 - Depth:
 - Design: 30ish mm to nut, 33.02mm total
 - Maximum measured to nut: 29.80mm
 - Maximum measured to center: 33.38mm
 - Measured flexibility of material: .43mm
 - No measurable compression or decay of material
 - No safety concerns











Tip 3: (Design 3 in Ninjaflex: straight, wide blade with metal insert)

- Examined 11/29/17 after 6 weeks of moderate use by Benedict Fergus atte Mede
- Exterior:
 - Shows very little wear
- Removal
 - Shed:
 - None
 - Depth:
 - Design: 36ish mm to nut, 39.18mm total
 - Maximum measured to nut: 36.79mm
 - Maximum measured to center: 39.48mm
 - Measured flexibility of material: .39mm
 - No measurable compression or decay of material
 - No safety concerns
- Notes:
 - Benedict Fergus atte Mede: *seems equal if not superior to commercial tips.*









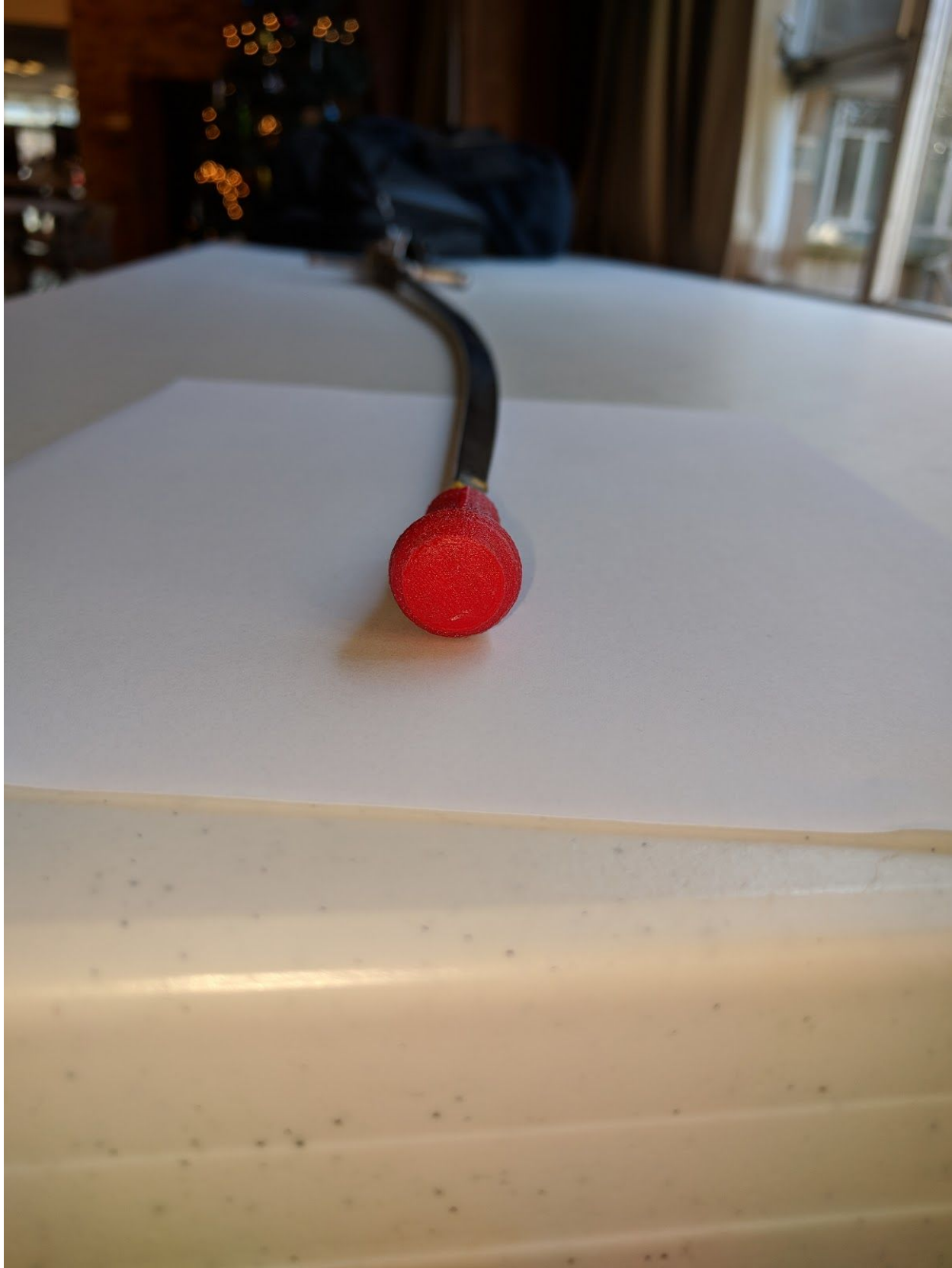


Tip 4: (Design 2 in Ninjaflex: curved, normal blade with metal insert)

- Examined 12/3/17 after 6 weeks of moderate use by Henryk Bogusz
- Exterior:
 - Shows very little wear
- Removal
 - Shed:
 - None
 - Depth:
 - Design: 30ish mm to nut, 33.02mm total
 - Maximum measured to nut: 30.13 mm
 - Maximum measured to center: 33.21mm
 - Measured flexibility of material: .61mm
 - No measurable compression or decay of material
 - No safety concerns















Tip 5: (Design 4 in Ninjaflex: curved, wide blade with metal insert)

- Examined 12/5/17 after one day of use by Eric Grenier de Labarre
- Exterior:
 - Shows very little wear
- Removal
 - Shed:
 - None
 - Depth:
 - Design: 33ish mm to nut, 36.34mm total
 - Maximum measured to nut: 33.34mm
 - Maximum measured to center: 37.04mm
 - Measured flexibility of material: .69mm
 - No measurable compression or decay of material
 - No safety concerns
- Notes:
 - Simon Caminante: I am not happy with this design. It moves much more than I would like because the edge of the blade falls inside the channel for a metal insert. Design 3 fits much more snugly because the blade extends to both sides of the channel. We are leaving this tip in play to determine if this movement creates a safety concern. It does not seem any different than the movement seen in commercial tips, which are nothing BUT channel. This may be a way that printed tips may actually be superior to commercial ones for any blade which is wider than its metal insert.









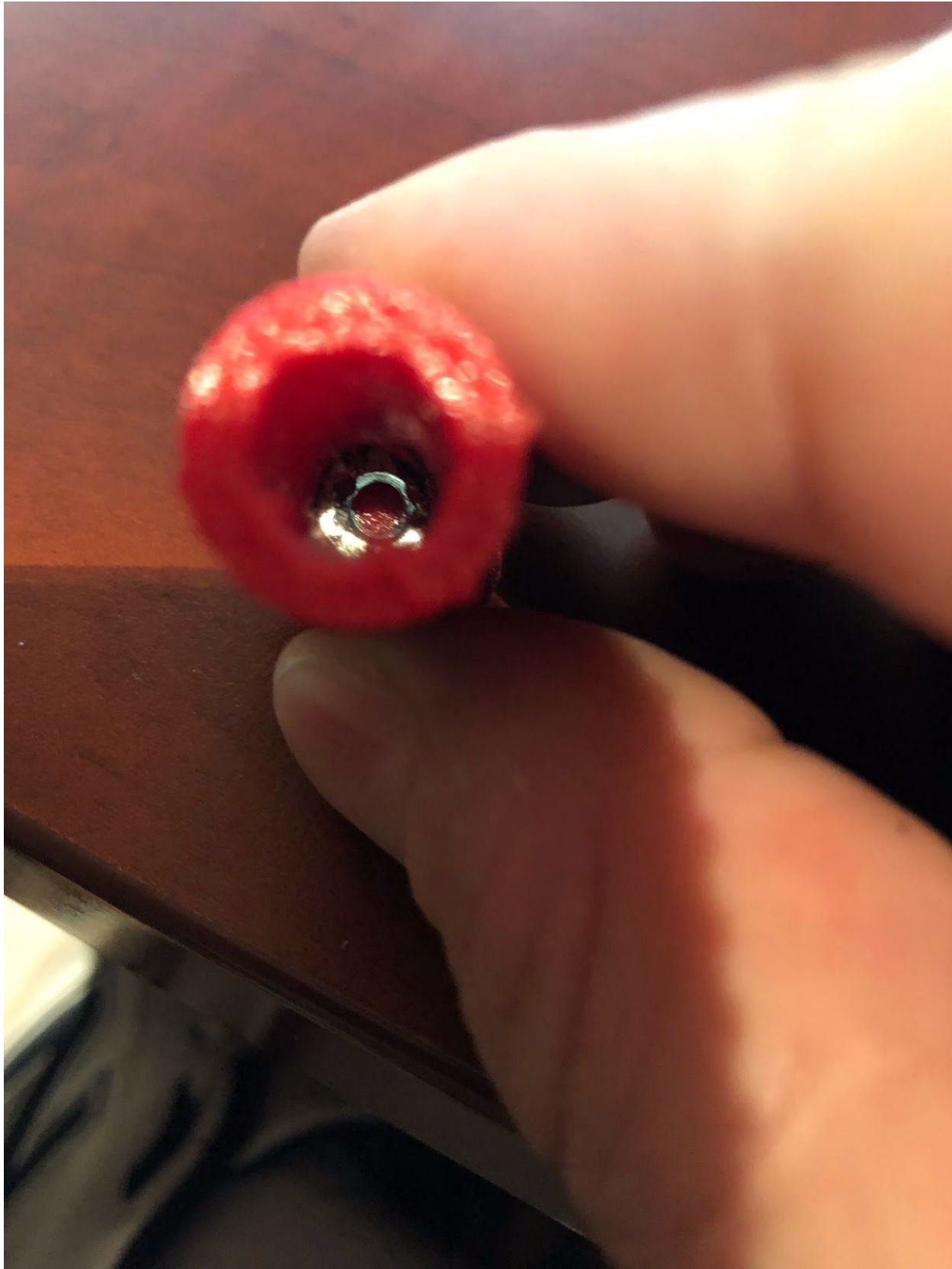
Tip 6: (Design 5 in Ninjaflex: curved, wide blade with metal insert)

- Not used in this period

Tip 7: (Design 2 in ninjaflex: straight normal blade with metal insert)

- Examined 11/29/17 after 5 weeks of light use by Thomas de Castelon
- Exterior:
 - flawless
- Removal
 - Shed:
 - None
 - Depth:
 - Note: because of distance, Thomas took his own measurements which were done in a different fashion from mine
 - *I'm getting 13.82mm as the thickness of the tip (i.e. blade contact to target contact). Overall length is 43.85mm, leaving 30.03mm of "shaft"*
 - Design: 30ish mm to nut, 44.02mm total length
 - 1mm discrepancy in measurement is probably not significant and is likely due to the unmeasured flexibility of the tip. This should be apparent in the next report, if it has changed again.

- No safety concerns
- Notes:
 - Thomas de Castelon: *So far it's just like any other tip.*



Report 2 (March 6, 2018)

Cold Testing:

Material Spec sheet:

Glass transition temperature of the material is listed as -31°F . This means that below that temperature, the tip will be brittle. However, this is 10° colder than the recommended temperature for throwing a cup of boiling water into the air and watching it turn to snow on the way down. If you are fencing outside below the glass-transition temperature of ninjaflex, you have bigger problems than shattering tips and should seek immediate psychiatric evaluation.

Experimental Confirmation:

- Tip left in deep-freeze freezer for 2 weeks, removed and allowed to warm up: Returned to flexibility very quickly.
- Tip left outside when not at practice for several months. Minimum recorded temperature: -6°F gave several hard shots against a garage frame at 4°F in the morning after a colder night: No noticeable damage. Tip returned to flexibility quickly (This tip is less flexible from the beginning than the one in the deep freeze.
- Tip left in deep-freeze for 1 week after previous test, placed on blade and immediately given several hard shots against the floor: No noticeable damage and tip returned to flexibility very quickly.
- Tip returned to deep freeze after previous test for 1 week, then hit with a hammer: No noticeable damage and tip returned to flexibility very quickly.

Tip 1: (Design 1 in Ninjaflex: straight, normal blade with no metal insert)

- Examined 11/29/17 after 7 weeks of “moderate” use by Simon Caminante
- Exterior:
 - Shows wear, mostly in the “buffing” off of print lines. There are some lines on the striking surface left by a mask at QRC.
 - No safety concerns.
- Removal:
 - Shed:
 - A few small plastic particles on removal. So small it is difficult to get a good picture of them.
 - Depth:
 - Design: 33mm
 - Maximum measured: 33.48mm
 - Measured flexibility of the material: .15mm
 - No measurable decay of the material, but it does seem to be compressing slightly.
 - No safety concerns
 - Notes:

- This is probably the single most used tip in the experiment, and it is showing some wear. Some compression seems to be happening, and the tip is more rigid than the others, but has not become brittle.











Tip 2: (Design 2 in Ninjaflex: straight, normal blade with metal insert)

- Examined 3/3/18 after 20 weeks of “light” use by Simon Caminante including C&T
- Exterior:
 - Virtually identical to last examination 13 weeks ago.
 - No safety concerns
- Removal
 - Shed:
 - No shed of plastic material.
 - Depth:
 - Design: 30ish mm to nut, 33.02mm total
 - Maximum measured to nut: 30.04mm
 - Maximum measured to center: 33.37mm
 - Measured flexibility of material: .17mm
 - No measurable compression or decay of material
 - Striking surface seems to have become less flexible (.17 compared to last measurement of .43), but is still not brittle and is more flexible than commercially available hard plastic tips.
 - No safety concerns









Tip 3: (Design 3 in Ninjaflex: straight, wide blade with metal insert)

- Examined 02/14/18 after 18 weeks of moderate use by Benedict Fergus atte Mede
- Exterior:
 - Virtually identical to last examination 11 weeks ago, if slightly dirtier.
- Removal
 - Shed:
 - None
 - Depth:
 - Design: 36ish mm to nut, 39.18mm total
 - Maximum measured to nut: 35.077mm
 - Maximum measured to center: 35.738mm (Measurement discrepancy probably due to difficulty getting measuring tool inside of the nut)
 - Measured flexibility of material: .28mm
 - No measurable compression or decay of material
 - No safety concerns









Tip 4: (Design 2 in Ninjaflex: curved, normal blade with metal insert)

- Not used in this period

Tip 5: (Design 4 in Ninjaflex: curved, wide blade with metal insert)

- Not used in this period

Tip 6: (Design 5 in Ninjaflex: curved, wide blade with metal insert)

- Not used in this period

Tip 7: (Design 2 in ninjaflex: straight normal blade with metal insert)

- Notes:
 - Thomas de Castelon: After light use, it's virtually unchanged from last time.