Heat-set inserts and Rivet Nuts

Heat-set inserts and Rivet nuts are both metallic and internally threaded fasteners which use installation equipment to embed themselves into a part. They are prevented from rotating with a press-fit — using ridges that embed into the material in which they are inserted. They are used when it's not feasible to thread into the material directly — either the material is too weak (e.g. with heat-set inserts and 3d-printed plastic) — or too thin (e.g. with rivet nuts and sheet metal).

Heat-set Inserts

Overview

Material: Brass, Aluminum, Stainless Steel
To be used with: Plastic parts, especially 3d-printed parts
Installation equipment: Soldering Iron, preferably with installation tips
Thread sizes: 6-32, 8-32, 10-32, ¼-20

Applications

Low load — e.g. electrical/sensor mounting

Be mindful of the material being used — and make sure that if the material being used emits hazardous fumes, to take all necessary precautions to prevent harm. Follow all safety precautions you would follow when using a soldering iron for another application. Do not touch the heat set insert or the area immediately surrounding it until the part has cooled.

Note that there are variations from distributor to distributor in the exact composition of filaments.

Material	Temperature	Safety Precautions
PLA	225 °C	Fumes — Lactide. 2nd Safest option on this list, but still emits fine particles that aren't good for you. Use a KN95 mask or a respiratory mask. See Machine Safety Data Sheet.
ABS	235 °C	Fumes — Styrene (small doses.) Wear a respiratory mask and use in a well-ventilated area. See MSDS.
PETG	245 °C	Fumes — Widely regarded to be safe. Use a KN95 mask or a respiratory mask. See MSDS.
CF-Nylon	265 °C	Fumes — Irritating, but not widely harmful. Avoid Thermal Decomposition (i.e. do not use a temperature higher than 265 °C.) MSDS.

Do not use heat-set inserts with PVC, Polycarbonate, or unknown plastics. **These fumes are extremely toxic and can be lethal**.

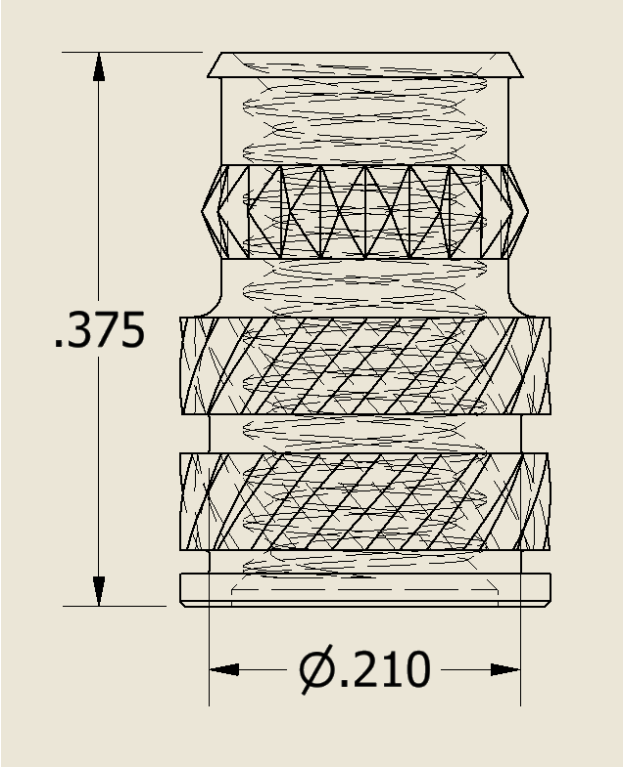
Design Process

1. Find the insert dimensions

The part details (shown on the supplier's websiteMcmaster) should specify a "Maximum Hole Diameter" — this is usually slightly smaller than the diameter of the non-knurled section.

This is the diameter at the top of the taper, (the taper angle is also specified) and then the diameter tapers down to its minimum value over the length of the insert. You can find the through hole size for the screw you are using as the minimum value (see Gearboxes p.4).

When making the hole in the part file, add 0.01" to the maximum hole diameter for the 3d-printer. This is for easy installation. Do not add 0.01" to the minimum hole diameter — what it actually tapers down to.



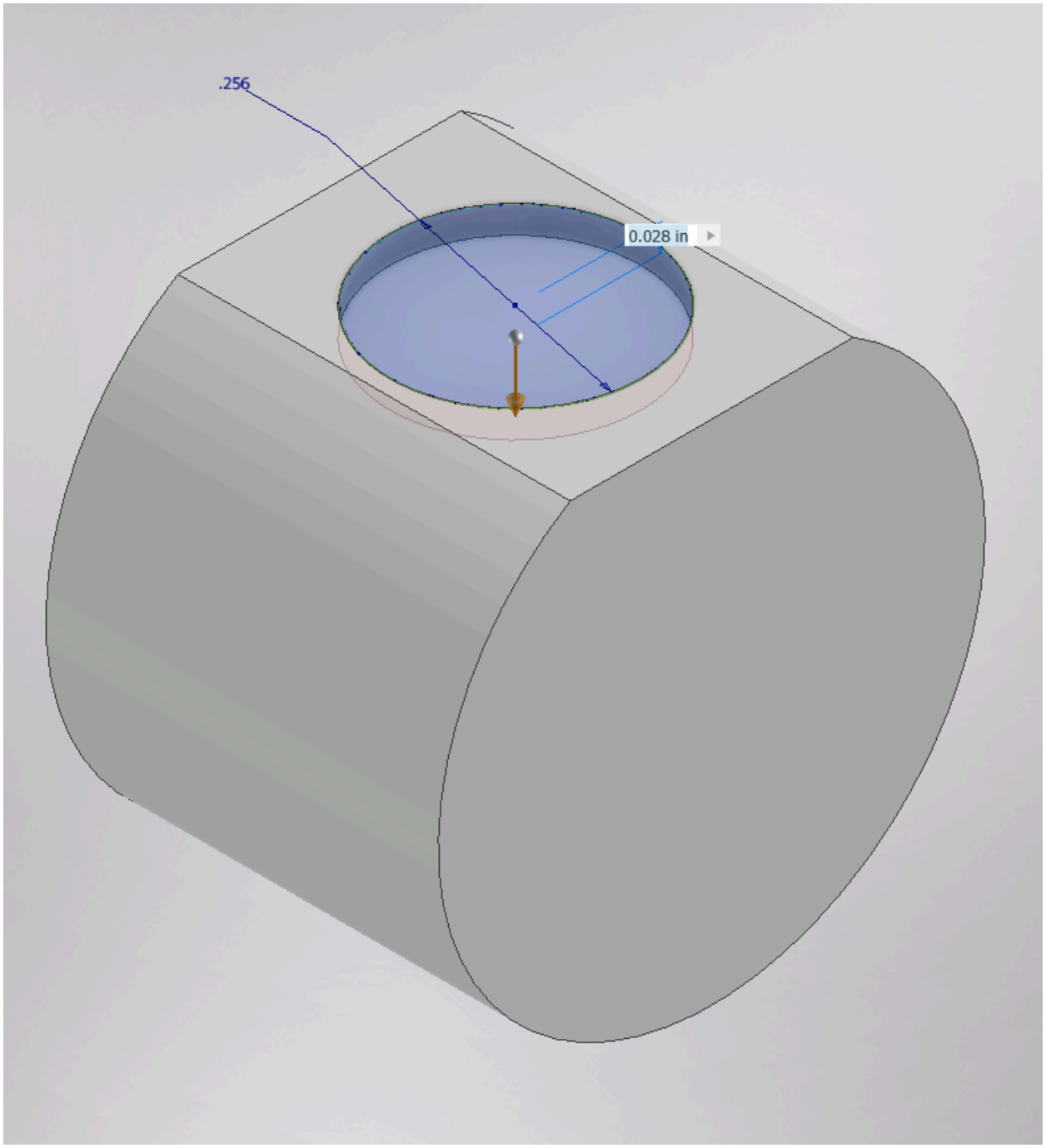
Installed Length	3/8"
For Min. Material Thickness	0.405"
Drill Bit Size	No. 5
For Maximum Hole Diameter	0.208"
For Hole Taper Angle	8°

Measurements required:

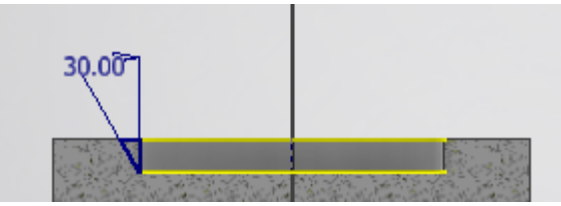
- Taper Angle (found in part specifications)
- Installed length (found in part specifications)
- Maximum hole diameter (found in part specifications)
- Chamfer angle — can be found in CAD file, usually 30 degrees from vertical.
- Depth of the chamfer — can be measured in CAD file
- Minimum value — the through hole size for the screw.

2. Add the hole for the insert

Begin by making the base of the hole for the chamfer. Extrude the maximum hole diameter + 0.01” to the depth of the chamfer in the heat-set insert. In the case below, the 10-32 heat set insert has a maximum hole diameter of 0.246” and its chamfer is 0.028” deep, and so the hole is being extruded is 0.256” wide and 0.028” deep.



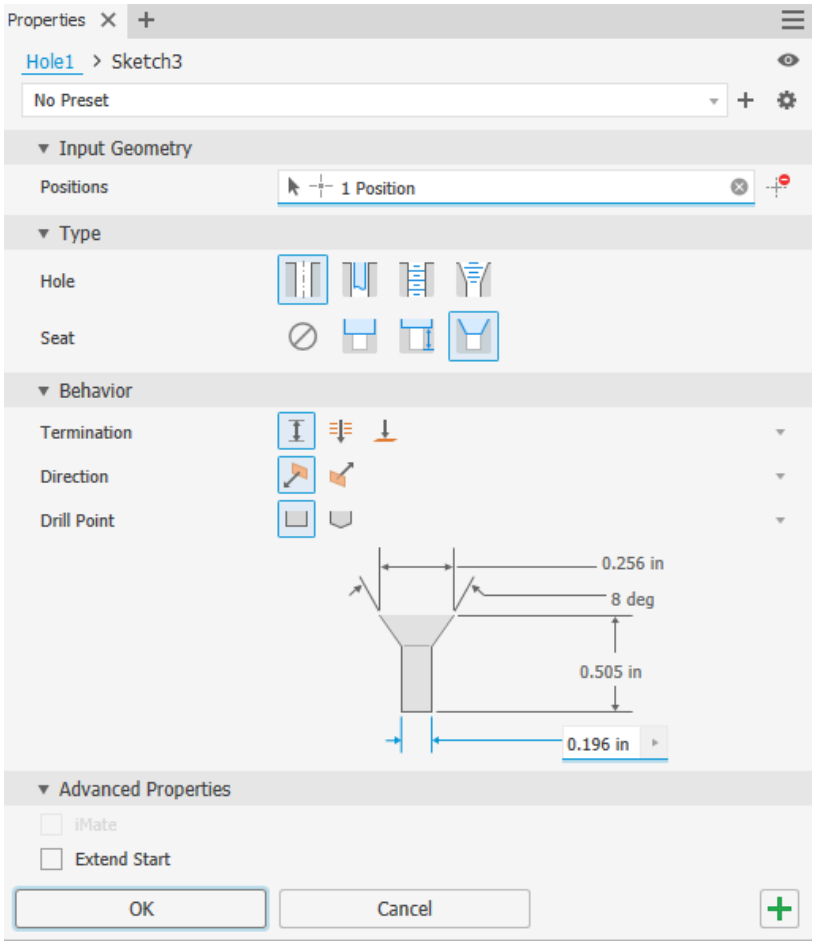
Then match the chamfer by making a revolution that will form a chamfer to guide the heat-set insert into its position, using the angle measured in CAD.



You can also use the “Draft” feature

The rest of the hole and the Relief

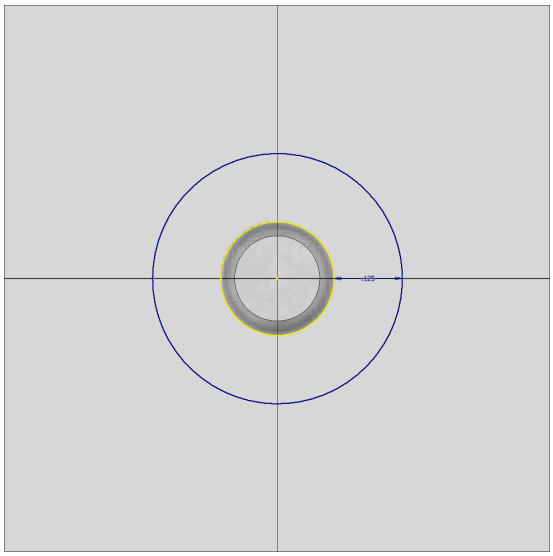
When designing for heat-set inserts, if the hole is not a through hole, you need to add relief — i.e., space for the plastic displaced by the heat set insert — to your holes. You do this by extending the minor diameter of the heat-set insert to half of the length of the heat-set insert

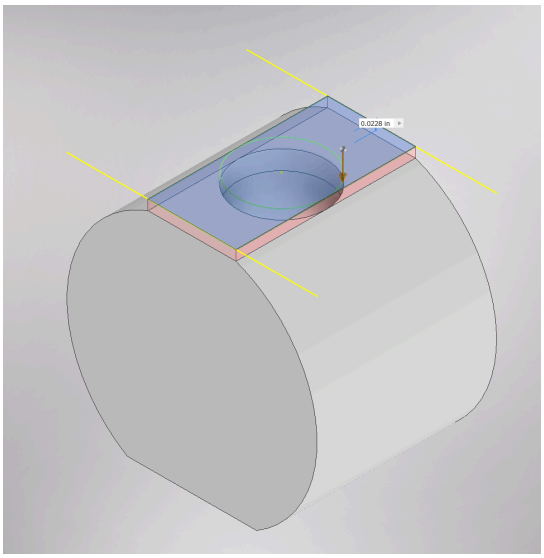


Major diameter (e.g. .256”) — the “For Max Hole Diameter” specification + 0.01”
Taper (e.g. 8°) — “Taper Angle” on Product Detail
Total hole length (e.g. .505”) — “Installed Length” × 1.5
Minor diameter (e.g. .196”) — The close fit for the screw size

Check the design

- Always have at least ⅛” of 3d printed material around the heat-set insert from its major diameter.
- Always make sure the depth of the hole where the heat-set insert sits is at least the specified minimum thickness
    - This depth does not include the chamfer added to guide the heat-set insert in — the heat set insert is not supported by the chamfer
- If at all possible, add some flats to the bottom of the part to make the heat-set insert easier to install





Procurement

We typically buy our heat-set inserts from Mcmaster.

Heat-set inserts can be bought for cheaper in metric sizes (e.g. on AliExpress), and the online 3d printing community (which use heat-set inserts extensively) has a greater online support for metric sizes. Consider switching to metric heat-set inserts in the future.

Final Notes

There are a few things specific to our 3d-printer that are incorporated into this document which may be different if you’re applying this for a different 3d-printer. Adding 0.01” to the maximum hole size is a manual offset for our 3d-printer, as is setting the minimum hole size to the through hole size for the screw. We found these settings work well for us.

Rivet Nuts

Overview

Material: Steel, Aluminum
To be used with: aluminum and steel sheet metal, occasionally plastic plating
Installation equipment: Rivet Nut Gun
Thread sizes: 6-32, 8-32, ¼-20

Applications

Rivet nuts should not be used where a simple threaded hole would serve well. For many applications, they are needlessly complicated, and require extra complexity and weight to install. They are tricky to install, and can ruin a part if the installer isn't careful.

To identify where rivet nuts are applicable, we should look at the common pitfalls of threading directly into the material, and how rivet nuts solve these problems

Insufficient Thickness

For regularly threaded parts, you should have at least 4 threads' worth of material. This means at least ⅛" for 6-32, 8-32, and 10-32 screws. For ¼-20, this means at least ⅕", and for ⅜-16, this means at least ¼". Having parts too thin can lead to the screw stripping out, or to destroying the threads.

For frequent maintenance points, (such as if you're using threads for your bumpers, or something else which is frequently taken apart/replaced), it's a good idea to have at least 6 threads, preferably 8.

If you're using materials thinner than this recommended value, rivet nuts are often appropriate. It depends on the rivet nut, but rivet nuts usually have anywhere from 6 to 12 threads, making them good for parts which require frequent screwing and unscrewing of threads

Fragile Material

Similarly to how heat set inserts are used because 3d-printed plastic is too fragile for regular use, rivet nuts are appropriate anywhere forming threads naturally in the part would be risky or ineffective.

Take Polycarbonate. Threading into polycarbonate works fine for low-load applications, but is undesirable for high-load applications, especially without retention compounds (recall that loctite 240 series [blue], 270 series [red] and loctite 609 [green] all lead to cracking when used on polycarbonate.) To increase the strength of these connections, you can use Rivet Nuts, although your mileage may vary on whether or not they increase the strength of the connection.

Rivet Nuts are not the best solution for all materials, however. Threaded inserts should be used for wood, to achieve a similar purpose. Furthermore, rivet nuts exert so much force on the material when installed that they use that they should not be used for fragile materials such as acrylic.

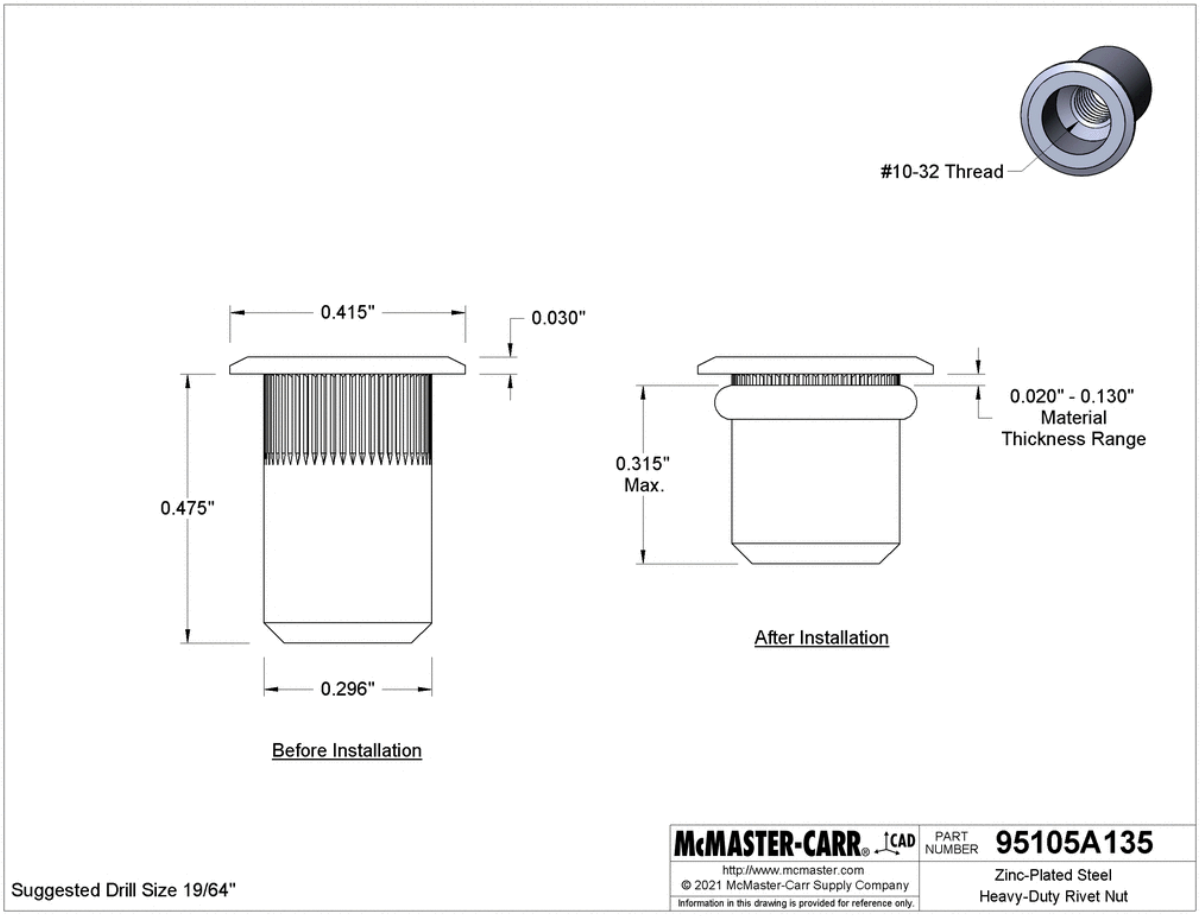
Design

Material Width

Rivet Nuts have a stated range of thicknesses where they function. Make sure to use rivet nuts that are sized for the correct thickness of material.

The hole

Rather than the complex geometry of a heat-set insert, a rivet nut uses only a hole. See the “drill bit size” section on the part’s drawing to find out how large this hole should be.



A 10-32 Rivet Nut from McMaster-Carr, with a drill bit size of 19/64” (0.2698”)

The Body

Mind the body of the rivet nut in your design. Unlike heat-set inserts, rivet nuts stick out of both sides of the plate in which they are installed.

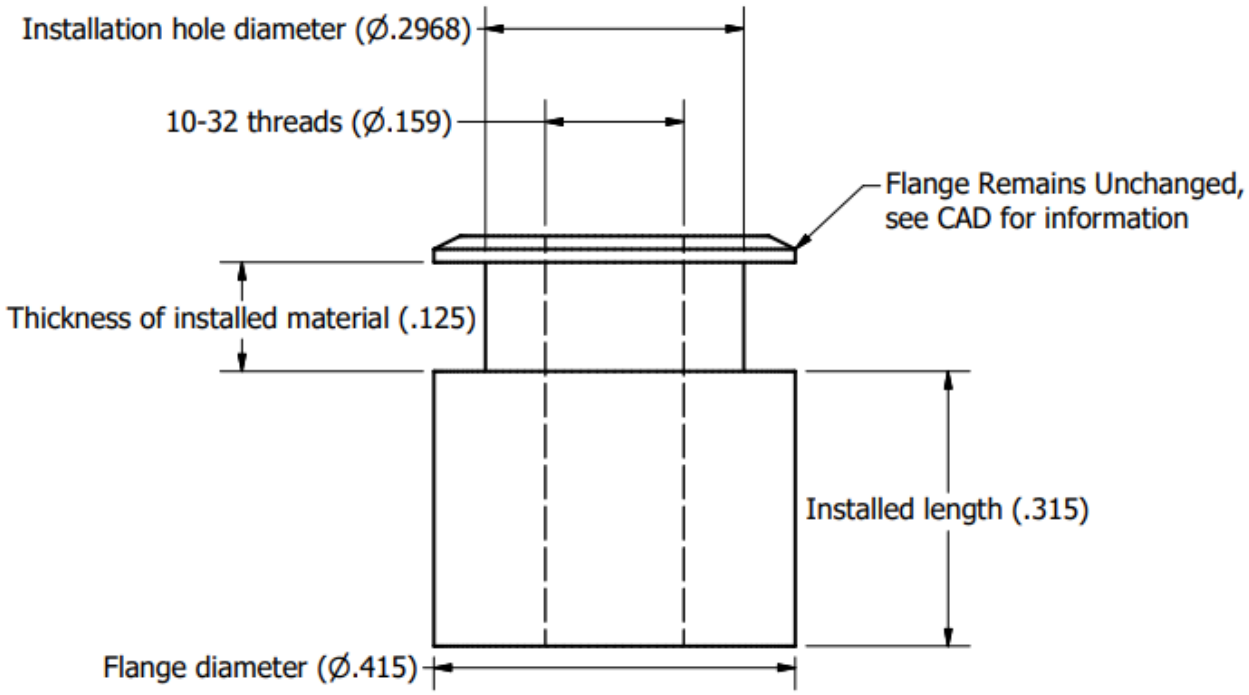
After installation

When a rivet nut is installed, its body bulges out. The extent to which it bulges out varies depending on the rivet nut and on the torque applied during installation. The “Installed Length” dimension in the drawing specifies the maximum length of the bottom end of an installed rivet nut. The installed diameter of a rivet nut is always less than the flange diameter.

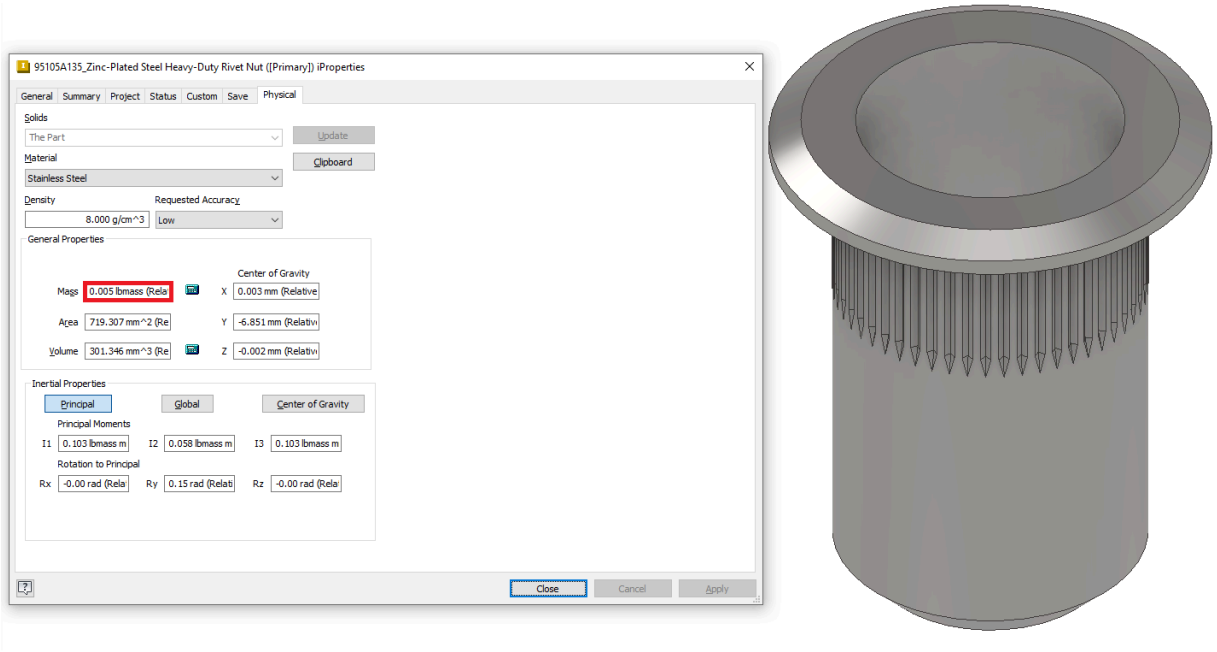
Modeling

Unless the body of a rivet nut is close enough to other parts that the exact profile of its body after installation matters, using the posted CAD files (which are of the rivet nut before installation) is usually appropriate because modeling the shape of the rivet nut following installation is usually a waste of time. That said, if you need to, you can just model the body as if it were a cylinder with diameter equal to the flange diameter and length equal to the maximum installed length

Here is an example cross section of a rivet nut I’d put in CAD if I wanted to make sure it didn’t interfere with anything else



Finally, if you want to be more accurate about the mass of these modeled installed rivet nuts, adjust their mass such that they have the same mass as an uninstalled rivet nut, which you can find by using the uninstalled rivet nut part file and applying the appropriate material.



Since the mass of a regular rivet nut is 0.005lbs, you can edit the mass of the installed rivet nut you modeled to also be 0.005lbs. This level of accuracy is very rarely needed, and is usually more effort than it's worth, considering the fasteners are one of the lowest-weight parts of the robot.

Procurement

Rivet Nuts can be bought from Mcmaster or Bolt Depot, with comparable prices. Bolt depot lets you buy individual rivet nuts for testing purposes, and can get you better deals on bulk shipments, but which one's cheaper varies from rivet nut type to rivet nut type. Both Rivet Nuts are of comparable quality.