Heat-set inserts for 3D prints: sizes, temperatures and installation

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Abstract. What brass heat-set inserts are, the M2 to M5 size families with hole and wall figures, the iron temperature rule, and the 181 kg M3 pull-out from CNC Kitchen's test.

Keywords: heat-set-inserts, threads-and-fasteners, part-strength

1 What are heat-set inserts and how do they work?

Heat-set inserts are knurled brass bushings with a machine thread inside. A soldering iron heats the insert, the plastic around a slightly undersized hole melts, and the knurls sink into the softened wall. Once cool, the plastic locks the insert in place. In CNC Kitchen's tests, an M3 insert in PLA (polylactic acid) held 181 kg before pulling out.

1.1 What they are, and why brass

An insert is a short metal sleeve with an internal thread and an external knurl, a pattern of ridges cut into the outside. Ruthex and CNC Kitchen both make theirs from brass, and Prusa Research's shop lists the CNC Kitchen version as a lead- and cadmium-free brass alloy. Brass conducts heat well, so the iron warms the whole sleeve fast, and it is soft enough to machine a fine thread and a sharp knurl.

The knurl pattern decides the grip. Ruthex describes its knurl as spiral. CNC Kitchen found that knurling in more than one direction resists pull-out: cheap injection-molding inserts with only vertical knurling pulled out at 39 kg, and an eBay insert with shallow knurling started rotating in softer ASA (acrylonitrile styrene acrylate).

1.2 Heat-set versus tapping, self-tapping screws and captive nuts

A thread cut or driven straight into plastic works until it is reused. DigiKey's guide puts it plainly: bare plastic can be threaded, but repeated use wears it until the thread fails. CNC Kitchen's numbers show the trade. A screw driven into a 2.7 mm hole in PLA pulled out at 142 kg, not far below an insert, but gave way at about 1 Nm of torque. All three tested inserts held 3 to 4 Nm until the bolt head sheared.

A captive nut trapped in a printed pocket avoids the melted joint altogether, but it needs a pocket modeled into the part and access from the back. A heat-set insert goes in after printing, from the front, into a blind or through hole.

1.3 Size families: M2 to M5, standard and short, straight and tapered

Metric inserts come in the same sizes as the screws they take. Each size has an outer diameter, a length, a hole diameter and a minimum wall around the hole.

Figures from the Ruthex table as published by 3DJake.

Short variants keep the outer diameter and cut the length: the Ruthex M3 short is 4.6 mm across but 4.0 mm long, for thin walls. The Voron style, named after the printer project whose parts use it, is fatter and shorter: 5.0 mm across, 4.0 mm long,

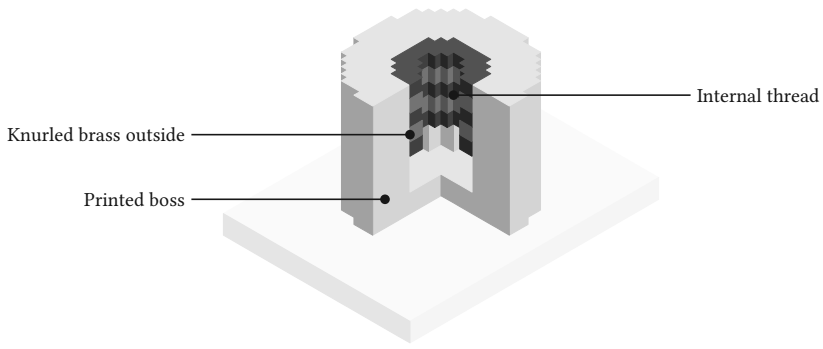


Figure 1. Cut in half, the insert sits in the boss with its knurled outside gripping the plastic and the thread open down the middle.

Table 1. Size families: M2 to M5, standard and short, straight and tapered

Size	Outer diameter	Length	Hole	Minimum wall
M2	3.6 mm	4.0 mm	3.2 mm	1.3 mm
M3	4.6 mm	5.7 mm	4.0 mm	1.6 mm
M4	6.3 mm	8.1 mm	5.6 mm	2.1 mm
M5	7.1 mm	9.5 mm	6.4 mm	2.6 mm

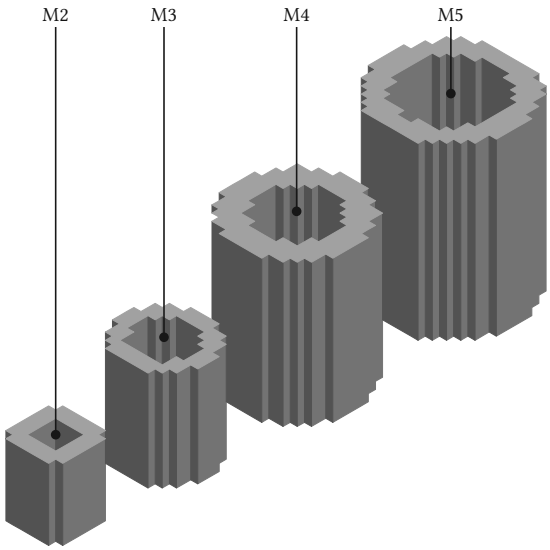


Figure 2. Outer diameter and length to scale from the Ruthex table, with the thread bore cut through each insert.

4.4 mm hole, 1.3 mm wall. The M3 hole figures per maker are in What hole size does an M3 heat-set insert need?.

Some inserts taper at the leading end. UltiMaker notes the taper is there to make starting easier, and Hackaday calls it helpful but not necessary. The hole itself should not taper: CNC Kitchen asks for a straight hole, no chamfer, and a blind hole about 1 mm deeper than the insert.

1.4 Choosing between M3 and M4

Pick the screw first, then the insert to match. An M3 insert is 4.6 mm across and needs 1.6 mm of wall, so its boss can be under 8 mm wide and fits in thin printed parts. It is also the size Ruthex makes in a dedicated Voron printer-part variant. An M4 needs a 5.6 mm hole and 2.1 mm of wall, so the boss is nearly 10 mm across. Use M4 where the screw carries load and the part has room for the boss, M3 where space is tight.

1.5 Temperature

CNC Kitchen and Prusa Research's shop page for the same inserts give one rule: set the iron 10 to 20 °C above the material's printing temperature. That works out to about 225 °C for PLA, 245 °C for PETG (glycol-modified PET) and 265 °C for ABS (acrylonitrile butadiene styrene). The per-material table, with a second maker's rule, is in What temperature should the iron be for PLA, PETG and ABS inserts?. PETG has its own page, because it strings around the tip: Do heat-set inserts work in PETG?.

1.6 Installation

Melt the insert most of the way with the iron, then finish the last stretch with a flat tool and hold it for a moment. CNC Kitchen found that inserts creep back out right after melting. Iron tips with a centering pin keep the insert square. The full procedure is in How do you install heat-set inserts straight without a press?.

1.7 When it goes wrong

A tilted insert can be reheated and pressed flush with a flat face, and a wrong-size insert can be pulled with a heated screw. Once the insert is out, drill the hole back to size or up to the next insert; a split boss gets reprinted. Steps and limits: How do you remove or fix a crooked heat-set insert?.

Questions answered in this guide

- Are heat-set inserts reusable?
  https://asked3d.com/answers/are-heat-set-inserts-reusable
- Which way up does a heat-set insert go?
  https://asked3d.com/answers/heat-set-insert-direction
- How deep should the hole be for a heat-set insert?
  https://asked3d.com/answers/heat-set-insert-hole-depth
- What is a heat-set insert press and do you need one?
  https://asked3d.com/answers/heat-set-insert-press
- Do you need a special soldering iron tip for heat-set inserts?
  https://asked3d.com/answers/heat-set-insert-soldering-iron-tip

- What temperature to set the iron for heat-set inserts in PLA, PETG and ABS
  https://asked3d.com/answers/heat-set-insert-temperature
- Do heat-set inserts work in TPU?
  https://asked3d.com/answers/heat-set-inserts-in-tpu
- How to install heat-set inserts without a soldering iron
  https://asked3d.com/answers/heat-set-inserts-without-soldering-iron
- Helicoil or heat-set insert in a 3D print?
  https://asked3d.com/answers/helicoil-vs-heat-set-insert
- What hole size does an M2 heat-set insert need?
  https://asked3d.com/answers/m2-heat-set-insert-hole-size
- What hole size does an M4 heat-set insert need?
  https://asked3d.com/answers/m4-heat-set-insert-hole-size
- What hole size does an M5 heat-set insert need?
  https://asked3d.com/answers/m5-heat-set-insert-hole-size
- What hole size does an M6 heat-set insert need?
  https://asked3d.com/answers/m6-heat-set-insert-hole-size
- What size heat-set inserts does a Voron use?
  https://asked3d.com/answers/voron-heat-set-insert-size
- How strong are heat-set inserts in PLA? Pull-out figures
  https://asked3d.com/answers/heat-set-insert-pull-out-strength
- Heat-set inserts or captive nuts for printed parts?
  https://asked3d.com/answers/heat-set-inserts-vs-captive-nuts
- Do heat-set inserts work in PETG?
  https://asked3d.com/answers/heat-set-inserts-in-petg
- How to install heat-set inserts straight without a press
  https://asked3d.com/answers/install-heat-set-inserts-straight
- How to remove or straighten a crooked heat-set insert
  https://asked3d.com/answers/remove-crooked-heat-set-insert
- What hole size does an M3 heat-set insert need?
  https://asked3d.com/answers/m3-heat-set-insert-hole-size

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