# Helicoil or heat-set insert in a 3D print?

Asked 3D Content Team
Published October 10, 2026 · Last verified October 10, 2026

**Abstract.** In CNC Kitchen's M3 test in PETG, a Helicoil and a heat-set insert pulled out at the same load, but the Helicoil stripped at 1 Nm against 3 Nm for the insert.

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

**Table 1.** The number

| M3 fastening in PETG | Average pull-out | Torque to failure | How it failed |
|---|---|---|---|
| Wire thread insert (Helicoil) | 120 kg | 1 Nm | Plastic thread sheared |
| Heat-set insert (Ruthex) | 119 kg | 3 Nm | Insert rotated in the plastic |
| Screw straight into the plastic | 118 kg | 1 Nm | Plastic thread sheared |
| Nut in a bottom pocket | 166 kg | 2 Nm | Plastic under the nut crushed |
| Nut in a side pocket | 86 kg | 2 Nm | Plastic under the nut crushed |

## 1 Helicoil or heat-set insert: which holds better in a 3D print?

Neither on pull-out: in CNC Kitchen's M3 test in PETG (glycol-modified PET), a Helicoil wire thread insert pulled out at 120 kg, a heat-set insert at 119 kg and a plain screw at 118 kg. On torque the heat-set insert held 3 Nm; the Helicoil stripped its plastic thread at 1 Nm, the same as a bare screw.

### 1.1 The number

Figures are CNC Kitchen's averages from flat PETG samples printed with four perimeters and 100 percent infill, pulled and twisted to failure on its own test machine. CNC Kitchen's verdict on the wire inserts: they "don't add to pull-out or torque-out strength in comparison to directly screwing into the plastic".

### 1.2 Why the wire insert adds nothing in plastic

A wire thread insert is a coil of diamond-section wire, stainless steel in Böllhoff's standard version, wound into a tapped hole. Böllhoff, which makes the HELICOIL range, describes it as transferring forces "from flank to flank into the holding thread". The coil itself is strong, but the load still ends up on the thread you tapped into the plastic, and that thread is what fails.

That thread is not much bigger than a bare screw's. An M3 wire insert sits in a tapped thread about 3.65 mm across, from a 3.2 mm drill, per Böllhoff's catalog. CNC Kitchen's explanation: the coil's shear diameter is larger but it is shorter, so the plastic shear area "works out about the same". Same plastic and same area, so the same load.

A heat-set insert works another way. Melted plastic flows into the knurl and sets around it. On a straight pull that ring of plastic tore at about the same load as the others. Against twisting, the knurl had to turn a whole sleeve of bonded plastic, which took 3 Nm. For scale, CNC Kitchen notes that 1 Nm on an M3 bolt already gives more than 1500 N of pretension, "mostly plenty" for printed assemblies.

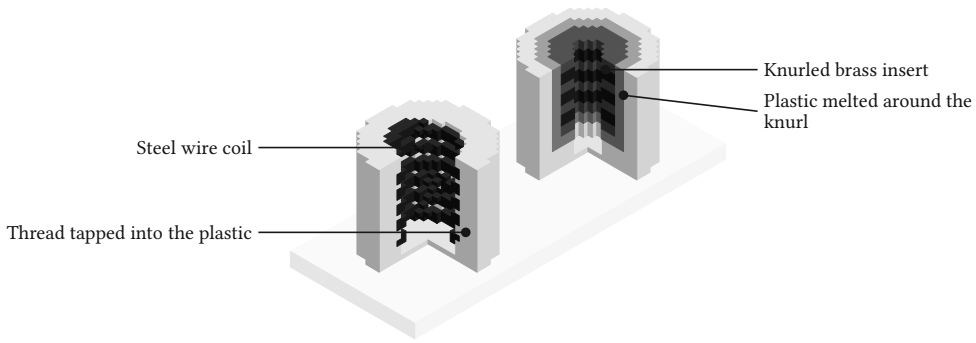



**Figure 1.** The wire coil still bears on the thread tapped into the plastic, while the knurl of the heat-set insert is locked in a sleeve of plastic that melted around it.

**Table 2.** Types of threaded inserts for printed parts

| Type | How it goes in | Tools and prep | Measured, M3 in PETG (CNC Kitchen) | Fits when |
|---|---|---|---|---|
| Heat-set insert, knurled brass | Melted into an undersized hole | Soldering iron or insert press | 119 kg, 3 Nm | The screw comes out and goes back many times |
| Press-in insert, barbed or screw-to-expand | Pressed cold into a hole; the expanding type spreads when the screw goes in | A press, no heat | None found in printed plastic | No iron on hand, or a resin print |
| Tapping (screw-in) insert | Its outer thread cuts into a drilled hole | Wrench on a bolt with two locked nuts, or an installation tool | None found in printed plastic | No heat, but you want metal threads |
| Wire thread insert (Helicoil) | Wound into a hole tapped for it | Drill, insert tap, installation tool, tang break-off tool | 120 kg, 1 Nm | Repairing or reinforcing a thread in metal |
| Captive nut | Dropped into a modeled pocket | None, but the pocket must be designed in | 166 kg bottom, 86 kg side, 2 Nm | Straight pull with access from behind |
| Screw straight into the plastic | Forms its own thread in an undersized hole | None | 118 kg, 1 Nm | The joint is assembled once |

Wire inserts are built for metal. McMaster-Carr sells them to "restore, reinforce, or create threads in metal". Böllhoff names aluminum, aluminum-magnesium alloys and fiber-reinforced plastics as the materials they reinforce. There, it says, the coil gives a thread that stays "wear-resistant even in cases of frequent use".

Böllhoff's catalog does list a tap for soft thermoplastics, but no published test we found covers a wire insert in fiber-reinforced or engineering filament.

A second test points the other way. Thomas Sanladerer compared M5 insert alternatives on video. Hackaday's write-up says the heli-coils "performed better than expected in the strength tests", but it gives no figures. CNC Kitchen's M3 PETG result is the only measured comparison here.

### 1.3 Types of threaded inserts for printed parts

These are the categories McMaster-Carr sells for plastic, plus the two fastenings CNC Kitchen tested without an insert. Where no test in printed plastic was found, the cell says so.

Installation details come from McMaster-Carr's catalog. It calls tapping inserts for plastic "a more durable solution than threads cut directly into plastic" and says the hex-bodied press-in type "resists loosening and twisting in a round hole".

Resin prints are thermoset, so a heat-set insert will not melt in. Formlabs has it glued in instead, and notes that a screw-to-expand insert presses its knurl into the print, "creating a strong friction fit".

### 1.4 Alternatives to a heat-set insert

If the reason to skip the iron is no tools, a captive nut is the measured alternative. Its bottom-pocket version held the most on a straight pull in the test above. The trade-offs are covered in heat-set inserts or captive nuts.

If the joint is assembled once and never tightened hard, a screw in an undersized hole pulled out at almost the same load as an insert in PETG. The PLA (polylactic acid) comparison is on the pull-out strength page. The wire thread insert is the one that costs a tap, a tool and a drill size and still stripped at the bare screw's torque.

### 1.5 How to check it on your own print

1. Print a test block in your filament with two bosses: one hole at the heat-set insert's datasheet size (4.0 mm for M3 in the Ruthex and CNC Kitchen tables, see the M3 hole-size page), one hole for the wire insert.
2. Drill the second hole to the kit's drill size, 3.2 mm for M3 per Böllhoff, and tap it with the kit's insert tap. Wind the coil in with the installation tool until it sits below the surface. Break the tang off with the break-off tool if the screw has to pass through.
3. Melt the heat-set insert in at 10 to 20 °C above your printing temperature, the CNC Kitchen rule on the temperature page.
4. Tighten an M3 screw into each with a torque screwdriver, raising the setting in small steps. Note where each one stops clamping and starts to turn. If the wire insert gives way near where a bare screw would, the plastic is the limit, as it was in CNC Kitchen's PETG test.

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**Cite as:** Asked 3D. "Helicoil or heat-set insert in a 3D print?." October 10, 2026. https://asked3d.com/answers/helicoil-vs-heat-set-insert. Last verified October 10, 2026.