Heat-set inserts or captive nuts for printed parts?

Asked 3D Content Team
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Abstract. CNC Kitchen's M3 test in PETG: a bottom-pocket nut held 166 kg against 119 kg for a heat-set insert, but the insert took more torque. When each fastening wins.

Keywords: heat-set-inserts, threads-and-fasteners, petg

Table 1. The comparison

	Heat-set insert	Nut in a bottom pocket	Nut in a side pocket
Pull-out load, M3 in PETG	119 kg	166 kg	86 kg
Torque to failure	3 Nm	2 Nm	2 Nm
How it failed in pull-out	Plastic around the insert tore	Nut “ripped a huge crater out”	Nut “sheared mostly cleanly through the sample”
How it failed in torque	Insert rotated in the plastic	Plastic under the nut crushed	Plastic under the nut crushed
Access needed	Top of the hole only	The back of the part, or a print pause	A slot from the side
Tools	Soldering iron or press	None	None
Holds itself in place	Yes, bonded to the plastic	No, needs the screw or a closed pocket	No, drops out until the screw is in
Threads	Brass, reusable	Metal nut, reusable	Metal nut, reusable

1 Heat-set inserts or captive nuts: which is better for printed parts?

Load direction and access decide. In CNC Kitchen’s M3 test in PETG, a bottom-pocket nut held 166 kg against 119 kg for a heat-set insert. A side-pocket nut held 86 kg. The insert took 3 Nm of torque against 2 Nm for either nut, and CNC Kitchen called inserts “still the king” for repeated use.

1.1 The comparison

CNC Kitchen printed flat PETG (glycol-modified PET) test pieces with four perimeters and 100 percent infill, fitted each fastening for an M3 screw, and pulled and twisted them to failure on its own test machine. The loads are that test’s averages. The other rows come from how each fastening is built.

1.2 Why the nut wins on pull-out and loses on torque

A nut in a bottom pocket loads the whole slab of plastic between the pocket and the screw head. Pulling it out means tearing a plug the size of the nut through the part, which is why it left a crater at 166 kg. A heat-set insert is held by the plastic that flowed into its knurl, a thin ring around a 4.6 mm brass body, and that ring tore at 119 kg. A side-pocket nut is the weak case: the slot removes the plastic above the nut on one side, so the nut shears through what is left at 86 kg.

Torque loads the plastic differently. Tightening presses the nut’s face into the pocket floor, and PETG crushed under either nut at 2 Nm. The insert’s knurl resists rotation until 3 Nm, when the insert spun in its hole. For scale, CNC Kitchen notes that 1 Nm on an M3 bolt already produces more than

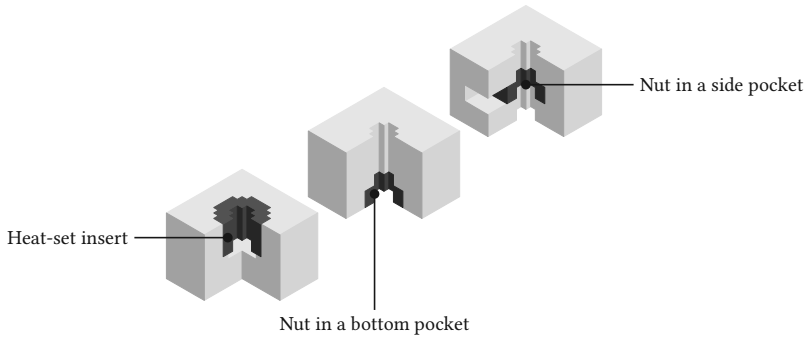


Figure 1. The insert is held by the plastic around its knurl, the bottom-pocket nut has the whole block above it, and the side slot removes the plastic above the nut on one side.

1500 N of clamping force, so all three fastenings pass the torque a printed assembly needs.

1.3 When each one fits

These are the conditions CNC Kitchen's results and design notes point to, not a ranking.

- **A joint you will open and close many times.** CNC Kitchen's conclusion was that heat-set inserts are "still the king for durable connection that you want to use over and over". The brass thread does not wear the way a printed or crushed pocket does, and the insert stays put when the screw is out.
- **A joint pulled straight out under load, with access from behind.** A bottom-pocket nut held the most, 166 kg. It needs the pocket printed open on the back or a pause in the print to drop the nut in.
- **A joint with only side access.** A side-pocket nut is the only one of the three that fits, and it was the weakest in the test.
- **No soldering iron on hand.** Either nut pocket works with no tools and no heat. The trade-off CNC Kitchen's readers reported is that nuts "constantly fall out during assembly" until the screw is in.
- **A thin wall.** An insert needs a 1.6 mm wall around a 4.6 mm M3 body, per the hole-size page. A nut pocket needs room for the nut's full width plus wall on each side, so it takes more space in the part.

1.4 Design notes

Size an insert boss from the manufacturer table and check it with a test print. The hole-size and installation pages cover it. For a nut pocket, no source here publishes clearance figures, so draw the pocket from the nut's measured width and thickness and print a test piece. A pocket that is too loose lets the nut spin, and one that is too tight cracks the wall when the nut is pressed in.

CNC Kitchen's test also covered Helicoil wire inserts, which held 120 kg but failed at the same 1 Nm as a plain screw and, in its words, "add nothing over simply screwing into the plastic". A plain M3 screw straight into PETG held 118 kg, almost the same as the insert, but stripped at about 1 Nm of torque. The reason to fit an insert or a nut is torque: a joint that survives being tightened and re-tightened, which a screw in bare plastic does not.

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